CORLISS-ENGINES

AND ALLIED

STEAM-MOTORS WORKING WITH AND WITHOUT AUTOMATIC VARIABLE EXPANSION-GEAR

INCLUDING THE

MOST APPROVED DESIGNS OF ALL COUNTRIES

WITH SPECIAL REFERENCE TO THE

STEAM-ENGINES OF THE PARIS INTERNATIONAL EXHIBITION OF 1878.

A TREATISE ON THE DEVELOPMENT,

PROGRESS AND CONSTRUCTIVE PRINCIPLES OF THESE ENGINES

FOR

ENGINEERS, MACHINISTS, STEAM-USERS AND ENGINEERING COLLEGES.

A TRANSLATION OF **W. H. UHLAND'S** WORK WITH ADDITIONS

BY

ANATOLE TOLHAUSEN,

CIVIL ENGINEER,

FOUNDER OF THE SCIENTIFIC AND MECHANICAL SOCIETY, MANCHESTER ETC.

WITH NUMEROUS ILLUSTRATIONS,

AND AN ATLAS OF PHOTO-LITHOGRAPHED WORKING-DRAWINGS.

VOL. I.

LONDON

E. & F. N. SPON, 46 CHARING CROSS.

NEW-YORK: 446 BROOME STREET.

1879.

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PREFACE.

The want has long been felt by our Mechanical Engineers, as well as by the Engineering profession at large, that the prodigious advance made of recent years in the construction of Steam Engines — resulting in an affluence of patterns both surprising and perplexing — called for the compilation of a comprehensive work, bringing the most remarkable and latest approved Engine designs of all countries within easy reach.

This progress has manifested itself chiefly, among Engines working with "Automatic variable expansion gears", and the conspicuous place which Corliss-engines occupy amongst these, may entitle them to the foremost position which they hold in the present work. Alone, there were other reasons, which recommended this arrangement, for notwithstanding that Corliss-engines have been largely imitated, they are still comparatively little understood; besides, this classification offers itself as the most convenient method of comparing various Engines working expansively, with other highly approved constructions. This arrangement is *not* therefore in any way intended to imply *"unquestionable superiority"* of the Corliss-types over all other Engines, for there are Steam-motors working without "automatic variable cut-offs", which are certainly not inferior to the first-named, on this account.

For these reasons, the present work is intended to offer, a systematic record of the progress hitherto made in the construction of Engines, working either with or without Expansion-gears, as set forth in the Title-page. The work in no wise confines itself to the discussion of valve-gear motions, but fully describes numerous improvements, relating to Engine-details.

In this manner, the original work has systematically arranged the most notable stationary Engine constructions, and its Author has collated about *140 different Engine types,* some of which are described in various modifications. The present Edition, has been supplemented with a number of Engines, not included in the original publication. *Working drawings* of over 50 of these Engines are appended in Atlas-form to the work. This Atlas contains about *60 Plates,* with all the necessary working dimensions inscribed for the immediate use of the Pattern Room or the Drawing Office. The great *practical utility* which the work will prove to *Mechanical Engineers*, is thus placed be-

a*

yond doubt, as it will afford them, the information, as well as the experience of others, so essential to their own continued success.

To ensure *strict accuracy,* the large Atlas-Plates (16 in. × 22 in.), have been directly transferred to stone by photo-lithography, from actual working-drawings four times the size they appear in the Atlas. In addition, the working of each Engine is *graphically* represented, by shewing the main positions of the valve-gear, corresponding with certain crank-positions.

The descriptive portion of the work has been confined to the *"practical requirements"* of the Engineer. It is profusely illustrated, and is treated under the three different heads of —

I. Descriptions of the various Engine-types.

II. Constructive principles and differences of these Engines, and economical results obtained in working them.

III. Method of calculating and constructing the different Engine parts, exemplified by practical examples.

The international character of this work, — treating as it does, of the latest approved Engine-designs of all countries — is well calculated to reveal the progress made in the construction of Steam-motors, and to keep our English and American Engineers thoroughly informed, on the degree of perfection attained by the various competing nations.

In conclusion, it is perhaps needless to observe the help, the work will also be, to Patentees and others engaged in Steam-engine improvements, as it will show them in a concise manner, what is really new and what is old.

Partington, August 1879.

Anatole Tolhausen.

List of Plates and Working-drawings.*)

Vol. 1.

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*) The Roman numbers, as applied to the Plates, refer to the small sketches, whilst ordinary numbers denote the large working-drawings.

Index to Vol. 1.

NB. The English-equivalents of the French measures, mentioned in the Work, will be found appended to the second Volume.

A. Engines working with Corliss Valve-gears.

I. Engines fitted with Corliss Trip-gear.

1. Engines designed by Geo. H. Corliss of Providence.

The first Corliss valve-gear.

The Centennial Exhibition of 1876 in Philadelphia contained a model of the first steam-engine which was fitted with the now well known Corliss valve-gear as patented by Geo. H. Corliss of Providence (U. S.) on 10 March 1849*) in the United States. This model shows us a Beam-engine in which the distribution of steam in the cylinder is effected by flat slide-valves.

The annexed text-figure 1 gives us a sketch of this original construction, and though according to our present knowledge, it appears in a very crude form, yet it embodies the main principle now adopted in all conceivable practical variations.

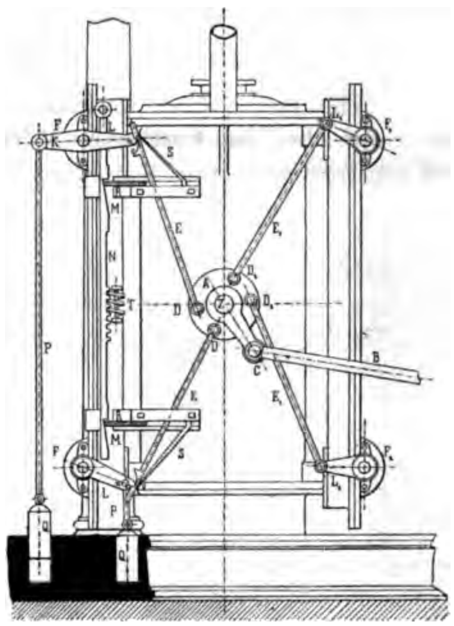


Fig. 1.

Our illustration shows that the arrangement of this gear, excluding the application of the governor, fulfils more or less all the requirements of a modern improved cut-off gear. The inlet and outlet ports are separated, and so arranged as to render them as short as possible; the opening of the slides takes place quickly, whilst their closing according to the cut-off, is instantaneous. The 'cut-off' is adjustable at pleasure, during the working of the engine — though it does not yet involve the direct application of the governor for this purpose.

The admission of steam takes place on the left side of the cylinder. *FF* are small rollers which transmit their motions to the slides by levers or toothed segments; levers *L* resp. *LK* attached to these rollers, are provided with a catch *n* at one of their ends which grip into notches *o* of the motion-rods *EE*. The latter are connected at *DD* with the oscillating gear-disc *A*. In a similar manner the rollers $F_1 F_1$ of the exhaust-ports are connected with the same oscillating gear-plate *A* by the levers $L_1 L_1$ and the motion-rods $E_1 E_1$. Motion is imparted to the gear-plate by the crank *C* being worked from the tail-rod (*B*) of an eccentric placed on the engine crank-shaft.

The movement of the gear-plate, in the first place, imparts motion to the exhaust-slides $F_1 F_1$, much after the same manner as the working of the ordinary steam-engine slide. The same would take place with the inlet slides *FF*, if the rods *EE* were rigidly connected with the levers *LL*, or if a disengagement of the trip-gear at *n* did not ensue. This assumption is at times verified,

*) According to Prof. Radinger's work on 'Engines and power of transmission in the United States', the first engine working with variable expansion under the direct application of the governor was built by Corliss in 1848. Its cylinder-diameter was 813 mm., the stroke 1830 mm. and it indicated 260 HP.

inasmuch as the rods EE are pressed against the levers LL by the springs SS, so that a disengagement can only ensue, when a special counter-pressure is brought to bear against the springs, the rods EE being thereby so far pressed from the levers LL, as to slip the catches nn out of the notches oo. This is done by the bolts RR which playing on inclined sides of the bar N, force the motion-rods EE in their return, from the levers LL. On the disengagement of these levers from the motion-rods EE by the bolts RR, the weights QQ to which the levers are connected by the rods PP, pull the latter down which has the effect of closing the slides, whilst the pull of the motion-rods opens them.

The higher the position of the rod N is, the more do the bolts RR approach the motion-rods EE and the sooner are the latt erpressed back and disengaged; consequently the sooner will the inlet-valves be also closed by the falling action of the weights. The position of the rod N may be adjusted by the rack and endless screw T (or by the application of the governor); by this arrangement the cut-off may be varied at pleasure within certain limits.

Though from our present stand-point, the construction we have just explained merely possesses historical value, yet it is interesting to the engineer as involving the characteristic principle of the Corliss valve-gear.

The second Corliss valve-gear.

The first engine working with circular-slide, or with Corliss valve as it is now called, was constructed by Corliss in 1850. We have a sketch before us representing one of these first constructions. Our text-figure 2 is here inserted to exemplify this second Corliss valve-gear. It is fitted to a horizontal cylinder, and its arrangement not merely betrays analogy to the first-named Corliss valve-gear, but it forms without doubt the connecting link to the constructive arrangement of the first Corliss engine subsequently introduced in Europe.

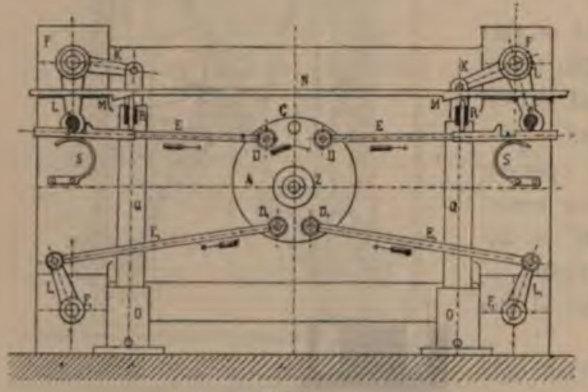


Fig. 2.

The reference-letters used in our fig. 2 correspond to those inserted in our fig. 1; the difference between the two arrangements is thus rendered all the more discernible, inasmuch as the main contrast consists in the introduction of Corliss valves in place of the flat slide-valves used in the first construction.

Referring to fig. 2, FF are the spindles of the inlet-valves, while F_1F_1 correspond to those of the exhaust-valves. The latter are connected to the gear-plate A by the levers L_1L_1 and the rods E_1E_1. The spindles of the admission-valves are loosely attached to the same disc by the levers LL and the rods EE; this is effected by the pin n playing into a slot of the rod EE, when the springs S press the rod against the levers. If the bolts RR are, however, forced out by the action of the governor pulling the rod N with its inclined planes at MM, then the counter-pressure of the springs SS on the rods EE is overcome, and the pin n becomes disengaged from the slot of the rods EE. Simultaneously, the falling weight Q comes into action and brings the lever L into the position shewn to the right of our engraving. In order to check any shock that might be caused by the falling weight, the latter is cushioned by the air in the cylinders O. As in the first construction so also in this second arrangement, the inlet valve-spindles are fitted with bent levers LK, whilst the weights QQ are connected with the arms KK; as a rule these bent levers are cast in one piece.

The gear-disc A is moved by an eccentric attached to it at the point C.

The valves are so arranged, that the steam-ports are closed, when the corresponding motion-rods are disengaged, or when the levers LL are in their extreme positions (vide fig. 2 to the left); the disengagement of one rod is always immediately followed by the closing of the corresponding valve.

The whole of this gear-mechanism is symmetrically arranged, so that barring the slight variations of the eccentric, the motions on both sides of the cylinder are equal.

The third Corliss valve-gear

appears to have been designed by Corliss in 1851 or 1852. It is the first Corliss valve-gear which became known in Germany, where it was adopted by the Magdeburg Steam Navigation Company of Buckau-Magdeburg and by the Wilhelmshütte near Sprottau. These two firms exhibited this Corliss valve-gear at the London International Exhibition of 1862, and for this reason it is oftentimes called in Germany the Corliss construction of 1862.

The same arrangement slightly modified is practically carried out at the present time with the best success as we will show later on. In fact, it is preferred by many competent engineers to all the other subsequent arrangements. We shall therefore be justified in submitting it to a more careful consideration; this the more so, inasmuch as it has become the starting point of the majority of subsequent imitations of Corliss valve-gears.

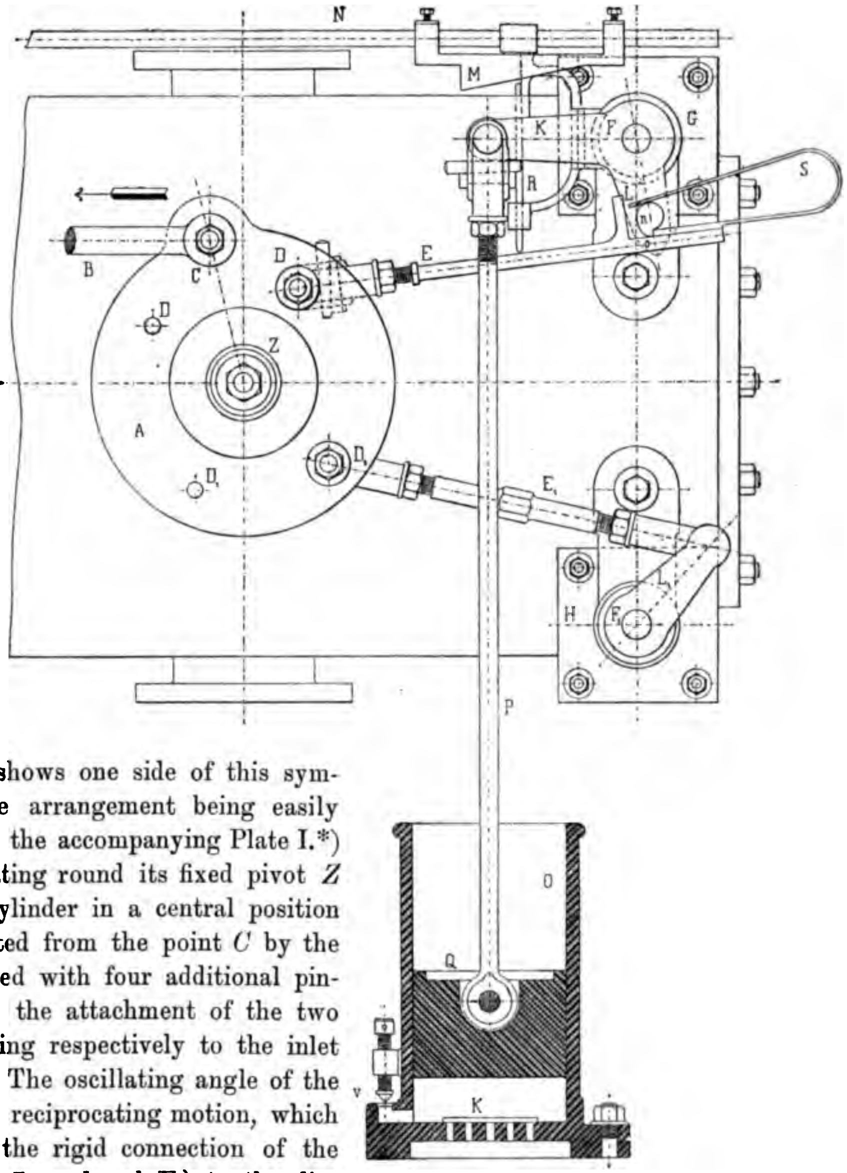


Fig. 3.

The annexed figure 3 shows one side of this symmetrical valve-gear, the whole arrangement being easily seen from our text-figure 5 and the accompanying Plate I.*)

The gear-disc A oscillating round its fixed pivot Z is placed at one side of the cylinder in a central position to the four valves; it is actuated from the point C by the eccentric rod B, and is furnished with four additional pin-holes at D, D, D_1, and D_1 for the attachment of the two pairs of rods (E and E_1) leading respectively to the inlet and outlet valves (G and H). The oscillating angle of the disc is about 90^0, and it is this reciprocating motion, which works the valves. Owing to the rigid connection of the exhaust-valve H (by the lever L_1 and rod E_1) to the disc

*) The roman numbers as applied to the Plates, refer to the small Plates, whilst ordinary numbers denote the large Plates.

A_1 the alternate movement of the latter is imparted to the exhaust-valve. The inlet-valve G has a bent lever LK fixed on its spindle; the arm L carries a toothed pin n, against which the rod E rests in such a manner, that its catch-plate o by working against the pin n carries the lever-arm L in its moving direction. A corresponding strong spring S partly holds the rod tight up to the pin, or prevents the rod from falling (vide fig. 4) when disengaged, by holding it up and keeping it in position, so that the pin n may catch it again at the proper moment.

As long as no disengagement of the rod E takes place, so long does it maintain a regular reciprocating motion, in which course it is not only assisted by the spring S, but also by the counter-weight Q attached to the arm K of the valve lever. This weight is suspended from the rod P, and works air-tight in a cylinder O, the air of which cylinder regulates the descent of the weight and prevents sudden shocks or jarring from taking place. With this object, the bottom of the cylinder or dash-pot O is perforated, and furnished with a flap-valve, so that air enters the cylinder in the ascent of the weight which in descending forces the air out again by the valve v at the side of the cylinder. By adjusting this last-named valve, — i. e. by opening or shutting it more or less — ready means are afforded of regulating the speed of the weight-descent, or what is just the same (on account of the relation existing between the weight and the inlet-valve), the closing of the admission-port.

It is readily understood, that the weight Q has a constant tendency of turning the bent lever LK from right to left, and of pressing the pin n against the side of the catch-plate o, so that this tendency, aided by the action of the spring, offers a sufficient guarantee for the regular and proper working of this trip-mechanism. We may therefore conceive, that the opening of the inlet-valves is due to the pull of the rod E whilst their closing may be attributed to the action of the falling weight.

The problem now resolves itself in rapidly effecting the cut-off at any point of the stroke, by disengaging the rod E from the lever L in such a manner as to free the pin n from the catch-plate o and allowing the falling action of the weight Q to come into action so as to bring the bent lever LK into an extreme position corresponding to the shutting of the steam-inlet-port. This is done by causing the rod E, in its ascending motion from right to left to be restrained from following the rising movement of the pin n, when as a consequence the latter presses against the spring S and subsequently becomes disengaged from the catch-plate o. At this moment, the lever is liberated, and following the pull of the weight assumes its extreme position, so shutting off the admission-port.

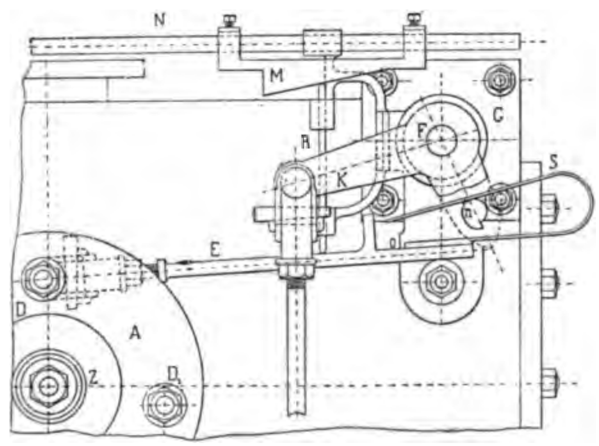


Fig. 4.

The resistance to the continuation of the ascending movement of the rod is obtained in this instance by a bolt R moving vertically. This bolt rests with its lower end on the rod E, and is carried up and down by the movement of the rod, provided this vertical motion is not prevented. An adjustable wedge-shaped bracket M is fitted on a rod N leading to the governor, to prevent, if need be, the rising of the bolt R. From fig. 3 it is evident, that the upward motion of the bolt R will be the sooner arrested, the more the bracket M is moved to the right. These parts are so proportioned, that according to the position of this bracket, resistance is offered sooner or later to the rod E which causes its disengagement; in the example before us, the bracket would move to the left — vide fig. 5 — with the falling of the governor-balls, and it would advance to the right were the governor-balls rising, and the cut-off would ensue accordingly later or sooner. The whole arrangement of this mechanism is exceedingly well adapted to such a method of disengagement; alone it possesses what may be termed in many cases the detrimental property of allowing at the utmost a cut-off at $^3/_5$ths of the stroke on account of the disengagement only ensuing with the return-stroke, — i. e. with the ascending movement of the rod E, as may be seen on referring to text-figures 5, 6 and 7.

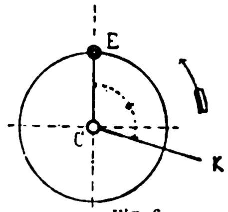


Fig. 6.

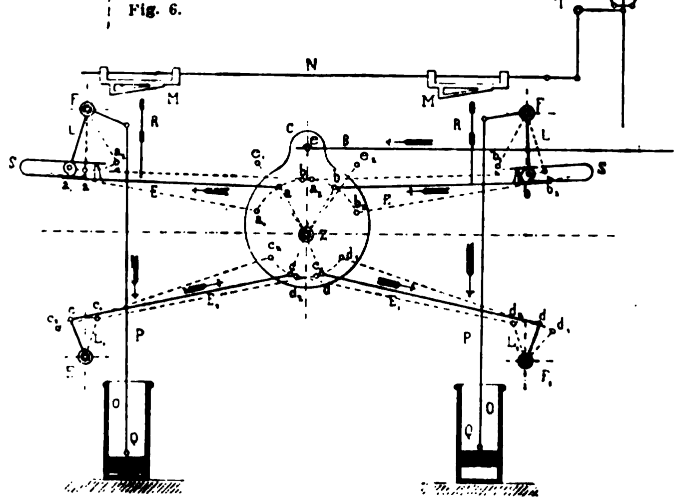


Fig. 5.

For the purpose of rendering these woodcuts plainer the mechanism is merely denoted by simple lines, and the same reference letters as used in fig. 3 and 4 have been retained. The extreme position of the lever and the rod is marked b_2 (fig. 7); II resp. b represents the central position of the mechanism as drawn in fig. 5, and III denotes the position when the crank is on its dead-centre with the piston at the end of its stroke. In this position the valve has somewhat opened corresponding to the lead. The distance from I—III corresponds, as we shall presently prove to the valve-lap + the lead. The position III and the extreme position b_1 resp. VI are the limits within which the direct automatic application of the governor for regulating and varying the cut-off, may be utilised.

Our fig. 7 shows that the ascending movement of the rod at the beginning of its motion is a very rapid one inwards; it decreases however, the more its travel approaches its inner limit. The distance

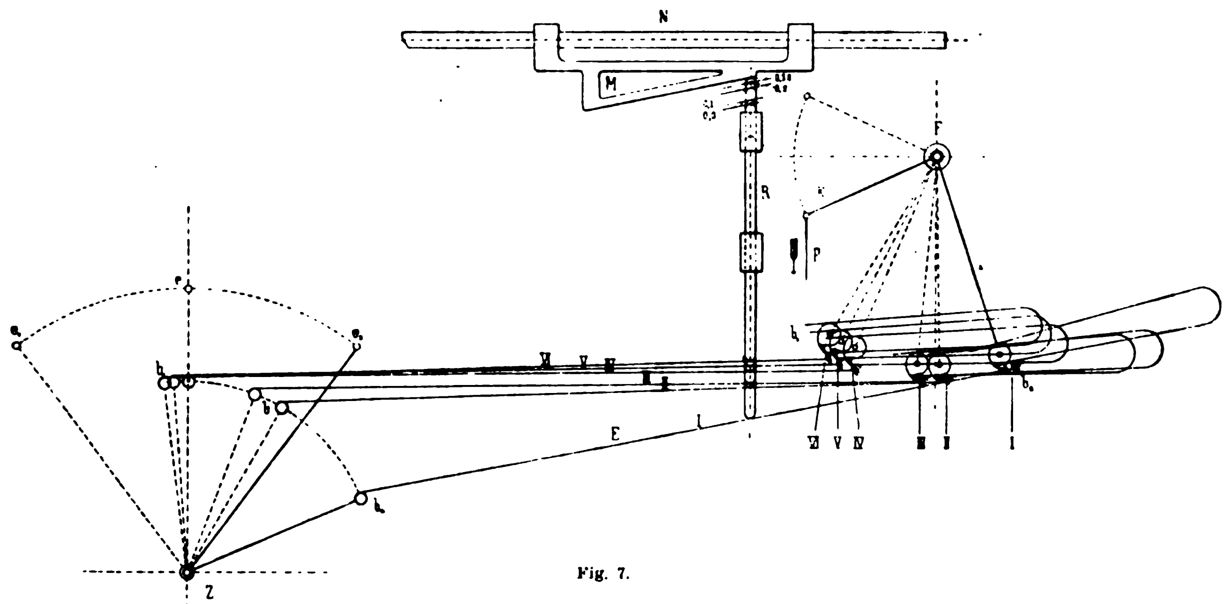


Fig. 7.

between the initial and end-positions of both the lever L and the rod E from each other is therefore much greater between the earliest cut-off and a cut-off at $^1/_{10}$ of the stroke than the distance between the positions corresponding to an additional cut-off of $^1/_{10}$ of the stroke. As a consequence the regulating will be more exact with low or early cut-offs, than with high or late cut-offs, and this is very advantageous inasmuch as Corliss engines are now generally made to work with high-pressure steam and early cut-offs.

Fig. 8.

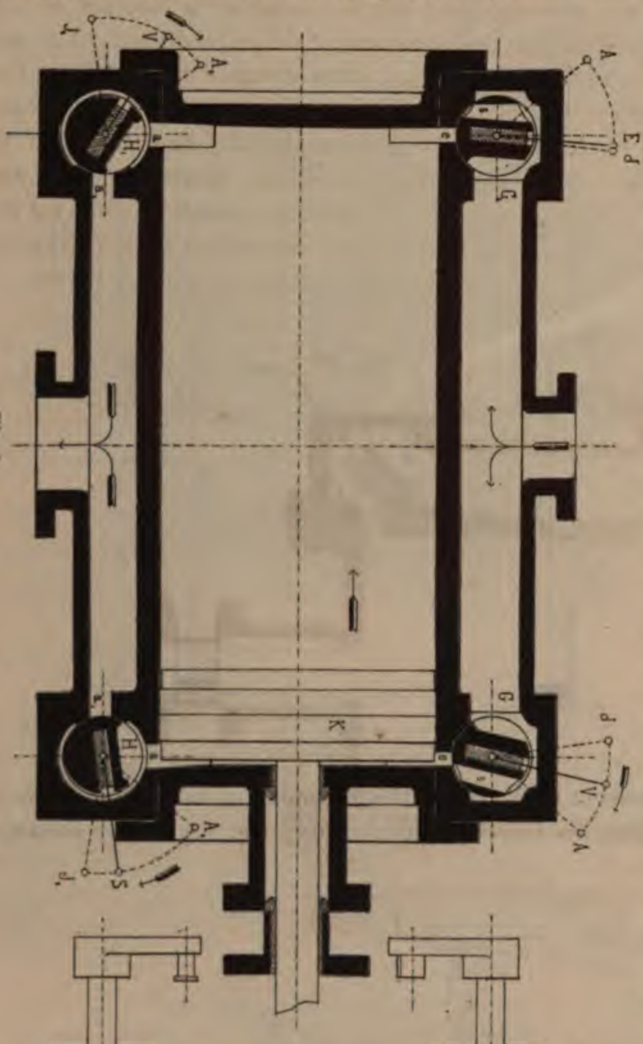
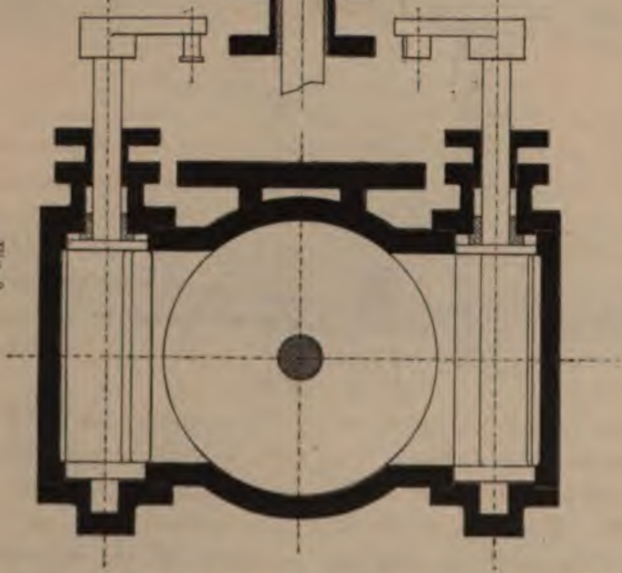


Fig. 9.



The properties of the Corliss valve-gear we have just discussed, are however less favourable, when the engine is subjected to largely varying working loads, where a cut-off up to $^2/_5$ of the stroke does not suffice. Recourse may then be had to driving the admission and exhaust-valves by two gear-discs in place of the one; the inlet-valves and outlet-valves are then each driven by two separate and differently set eccentrics. The gear-plate driving the admission-valves may be so regulated, that the time of cut-off may be nearly doubled to what it was before, or brought up to nearly $^7/_{10}$ of the stroke. Another method of extending the 'cut-off', in cases where an increase of $^1/_{10}$ of the stroke or thereabouts is only required, consists in a suitable setting of the air-valve on the air-cylinder O (Fig. 3) whereby the falling of the weight Q and the closing of the steam-port is retarded; this enables a cut-off corresponding to half the stroke to be obtained, though at the last with throttled steam. If the bracket M is placed so far to the left, so as not to interfere with the bolt R, then no disengagement takes place and the engine almost ceases to work expansively the 'cut-off' taking place very near to the stroke-end.

The central position designed in our fig. 5, corresponds to the middle position of the eccentric E — vide fig. 6 — and the crank-position K.

We shall refer later on to the effect of the lever-motions on the travel of the valves, and having so far confined our observations to the external valve-gear, the annexed figures 8—10 will enable us to extend our investigation to the internal arrangement of this valve-gear. Thus fig. 8 and 10 give us a longitudinal section of the steam-cylinder, through the circular-valves, and in fig. 9 we have a transverse section of the cylinder showing the valves in plan. As represented in our figure 8, the position of the valves corresponds to the commencement of the piston stroke when the crank is on its dead-centre; it is also in this position that the external valve-gear is drawn in our fig. 3.

The admission-valve G is shown open to the extent of its lineal lead ($^1/_{32}$" to $^1/_{16}$ in) whilst the exhaust-valve H though long closed is still moving and shutting off steam. In order to render the circular travel of the valves more feasible, the corresponding angular measure is inserted in our figures, though it must not be confounded as indicating the position of the valve-levers. The arc AJ represents the full circular travel of the valve, corresponding to the distance traversed by the respective motion-rods. The angular travel of the admission-valves is, however, reduced to the arc AE, and the extreme shut-off of the valve G_1 indicated in our figure by the line E drawn to valve-centre no longer coincides with the centre-line drawn from J which corresponds to the arc described by the resp. motion-rod. This difference in the two circular travels is due to the disengagement of the motion-rods, and consequently owing to the rigid connection of the exhaust-valves with the gear-disc no such dissimilarity exists in the travel of the last-mentioned valves.

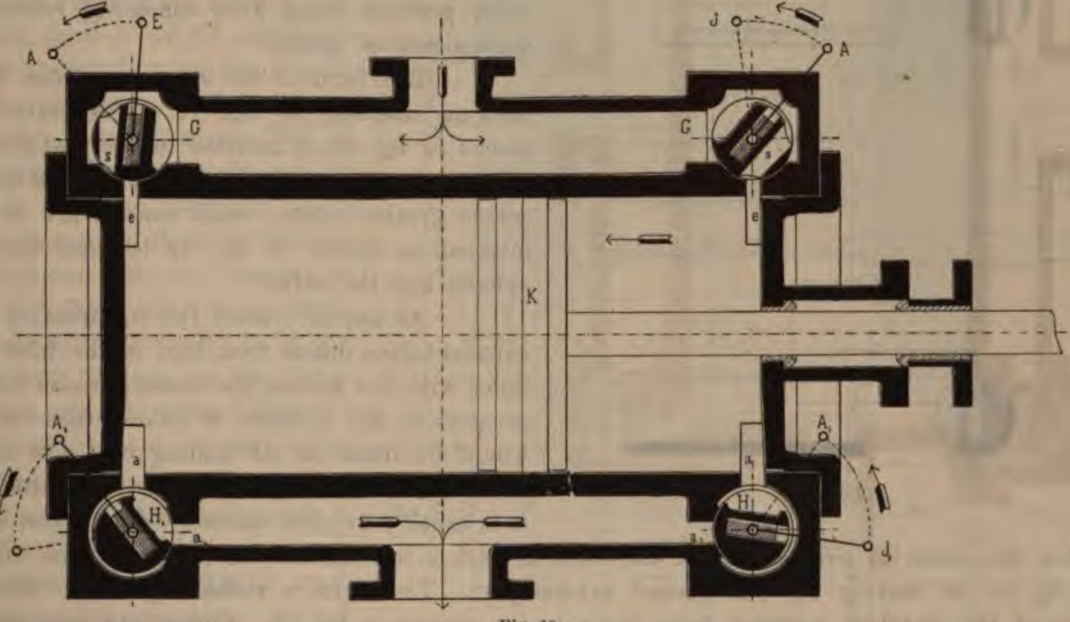


Fig. 10.

Our fig. 10 is drawn on the supposition of the piston having travelled about one third (0,35) of its stroke, i. e. of its having reached a limit within which a disengagement is still possible through the direct intervention of the governor. In this case, the gear-disc has assumed its extreme position in the direction pointing left, which is also the case with the open inlet-valve G, so that the latter would begin its return-travel quite independent of any disengagement ensuing. The corresponding exhaust-valve H has arrived at its extreme 'shut-off' position, whilst the opposite exhaust-valve H_1 has similarly attained its maximum open position. The inlet-valve G_1 drawn to the left of our engraving is still closed, but is just on the point of opening as its motion-rod is now about to begin its return-stroke.

The valves are made almost as long as the cylinder diameter, as our fig. 9 shows; the steam-passages correspond and are of a long rectangular cross-section. This form is very advantageous for the rapid in-letting and shutting-off of the steam, inasmuch as the valves require very little travel to open out the passage to its utmost. The exhaust-ports are of course made larger than the inlet-passages, though it is necessary to observe that the shutting of the exhaust-passage is effected in quite a different manner to that of the inlet-passage, on account of the dissimilar construction of the valves themselves. Corliss valves do not work as ordinary valves, but they are absolutely circular-valves which travel over a concave surface. As in the case of the common slide-valve, these circular-valves are pressed against their seatings by the pressure of the steam, and are thus rendered steam-tight. This exigency is attained in the most simple manner with the inlet-valves, inasmuch as the pressure of the steam has already the tendency of keeping the valve close up to its seating; all that is necessary for providing inlet-valves constructed as shown in fig. 8 and 9 with suitable guide and bearing surface, is the addition of the sector *s* to the valve which forms a suitable passage for the steam through the valve. This arrangement may however be evaded, if the bearing surface from the steam-port *e* is somewhat enlarged towards the cylinder-centre, so that the valve may have sufficient bearing-surface even when placed in its extreme open position (vide fig. 10 top right-hand corner). The outer surface of the valve is merely worked up at its ends and seatings, the other portions being kept somewhat recessed for convenience of casting.

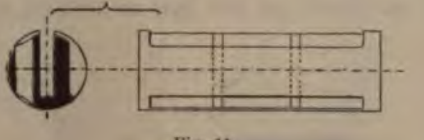


Fig. 11.

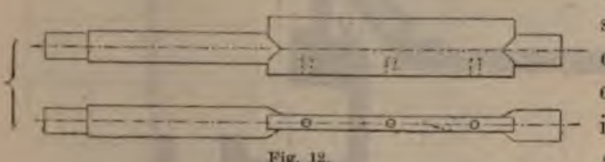


Fig. 12.

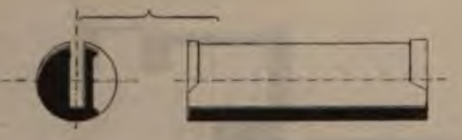


Fig. 13.

The form of the admission valves is best seen on referring to fig. 11. The valve-spindle shown in fig. 12 is inserted in the cast-iron body of the valve, into which it is accurately fitted. To ensure greater safety, small springs are at times inserted as shown in fig. 12 between the valve-spindle and the valve.

As already stated the construction of the exhaust-valves differs from that of the inlet-valves. Since with the former, the steam-pressure is always greatest in the cylinder, it follows that the valve would be lifted off its seating if it was made to rest on the exhaust-port *a*. Owing to this reason it is usual*) to place another exhaust port a_1, and to allow the steam to circulate round the valve in such a manner that its pressure keeps the valve close up to its seating on this second exhaust-port. To ensure a sufficiently large exhaust, a portion of the metal is removed from the valve as shown in fig. 13. Covers are screwed on to each side of the valve-box, the front one of which serves as a stuffing-box for the valve-spindle, and also forms a bearing for the end of this spindle.

Our woodcuts show that the admission-valves are arranged with a considerable lap, in order to secure an efficient shutting-off. This lap corresponds to the one we are accustomed to give to the ordinary flat slide-valve.

The travel of the working valve-edges, and their position in respect to the ports, with special regard to the valves arranged to the right of the gear-plate, are shown in our annexed figures 14, 15, 16 and 17 which also refer to the machine represented in our Plates 2 and 3. The diagram drawn in fig. 15, shows graphically the travel of the admission-valves as referred to the piston-motion: thus from *A* to *B* we have the distance travelled by the working edge of the inlet-valve during the forward piston-motion, while *B* to *C* represents the travel of the same valve-edge during the return-stroke of the piston. This graphical representation in connection with the indicator-diagrams to which we shall again refer, is a very convenient way of arriving at a ready and correct estimation of the valve of this gear, and the method is in itself so easy as to be intelligible to the least experienced engineer. If we examine the curve described by the working

*) We shall eventually refer to another arrangement of the steam exhaust.

edge of the valve in relation to the progressive movement of the piston, then *y* (provided the valve-edge, is supposed to continue its travel as indicated by the dotted line pertaining to the preceding piston-stroke) denotes the opening of the port, corresponding to the distance of the piston from its dead centre, which depends on the lead-angle of the eccentric and gives a lineal lead *v* of about $^{1}/_{16}$ in. The valve now continues its travel to the left; with the arrival of the piston *b* on its dead-centre, the valve has opened according to the lineal measure of its lead, and continuing its travel to the left, the valve is constantly opening out the port, till at *f* the limit *cc* of the admission port is exceeded, when the steam-port is quite open. In this position the piston is at about one fifth of its stroke. The valve continues to move in the same direction, till it arrives at *g* when it commences its return-stroke. The last moment at which the valve can become disengaged, is when the valve is in the last named position, as no disengagement can take place during the return motion; but as the disengagement of the draught-rod from the valve-spindle levers demands a certain amount of travel, the limit of automatic disengagement must take place sooner and we have marked this limit with the line *mm*, which we may further observe corresponds to $^{9}/_{25}$ of the piston-stroke or to a little more than a third of the stroke. If the valve is not disengaged at this limit, then the connection between valve and gear-plate is maintained and the valve begins its return travel to the right. At the point *h* the valve-edge begins to throttle the port which it continues to do till at *i* or nearly at $^{19}/_{20}$ of the piston-stroke when the steam-port becomes quite closed. Hence it follows, that provided no disengagement takes place, a maximum cut-off of $^{19}/_{20}$ of the piston

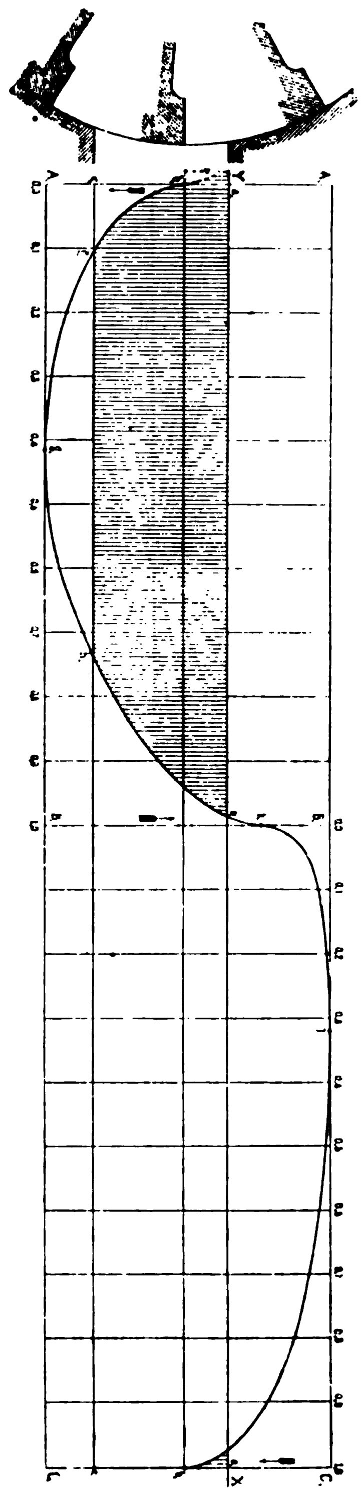


Fig. 14.

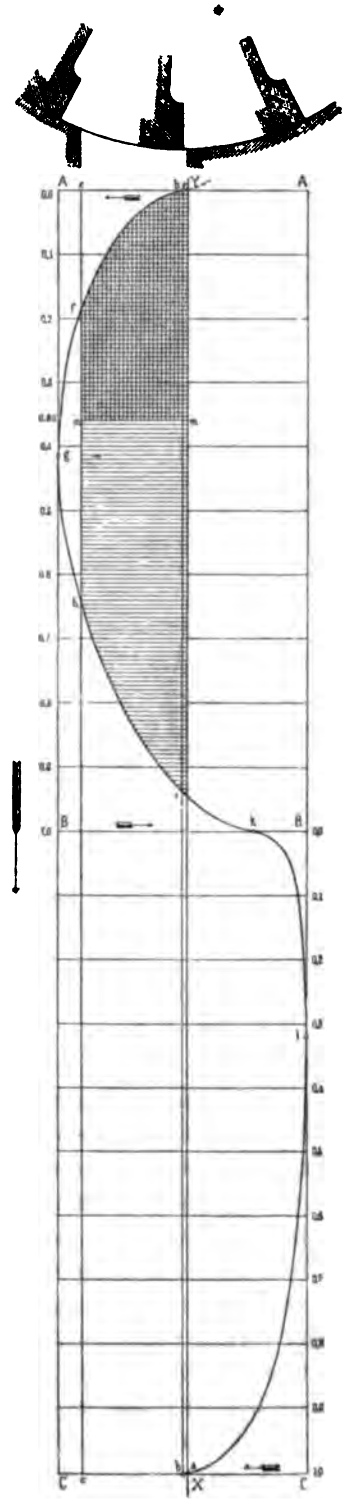


Fig. 15.

stroke is rendered possible, though it is at once apparent that towards the approach of the cut-off, the steam is much throttled. Continuing its travel the valve progresses to lap rapidly, so much so that the lap is already $^{15}/_{16}$ in. at the stroke-end. The return-travel begins at first very slowly, but is accelerated towards the stroke-end, so that it may open comparatively rapidly for a fresh steam-supply.

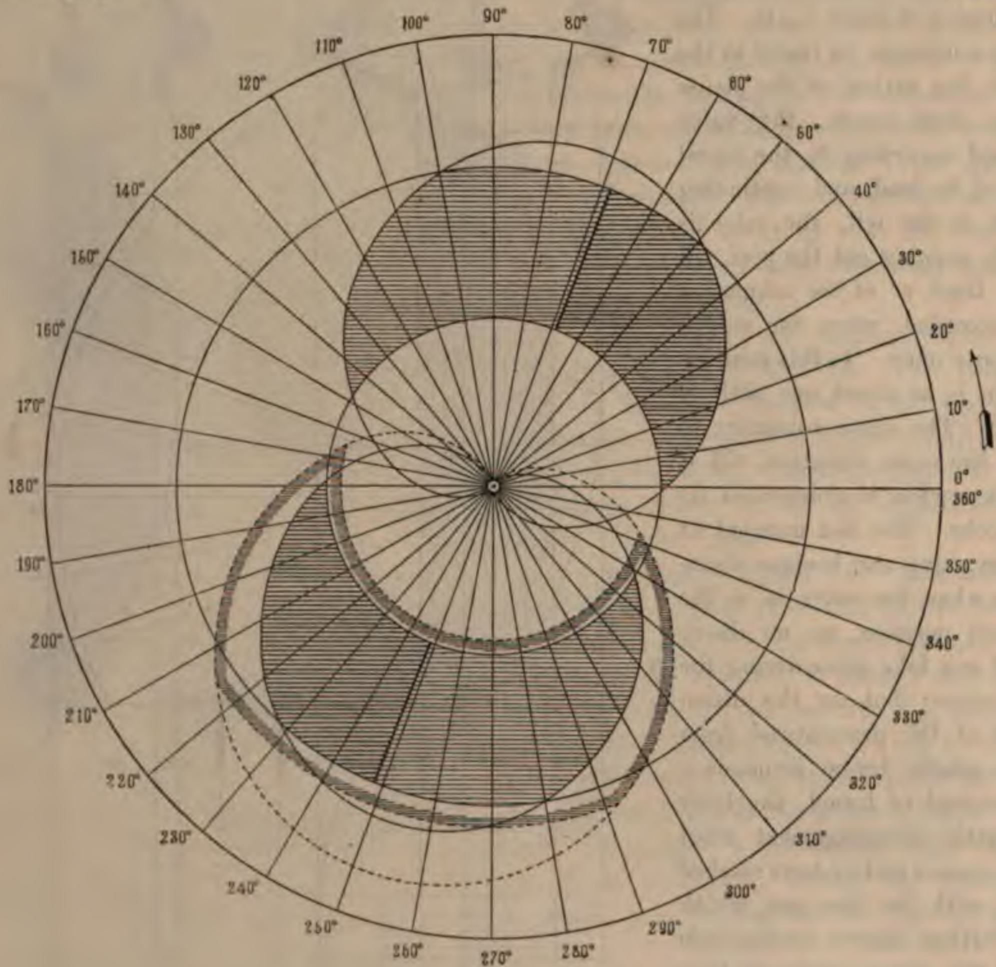


Fig. 16.

Without in any way anticipating the issue of our subsequent investigations, in which we shall compare the various valve-gears with each other, the diagram just alluded to confirms, apart from the additional proof supplied by the practical working of this Corliss valve-arrangement, that its distribution of steam is exceedingly favourable, though a rapid complete opening of the steam-ports, as affirmed by many, does not actually take place. On the contrary, the diagram shows that with an early shutting off of the valve, the port is not completely opened, a defect which becomes all the more serious, since Corliss engines are generally made to work with an early cut-off, so that under certain conditions such an engine would never work with its steam-ports fully open. A remedy to this defect suggests itself in the application of narrow and very long steam-passages without interfering with the travel of the valves.

The diagram represented in our fig. 14, and referring to the exhaust steam-valve, explains quite similarly the travel of the latter, the distance A_1 to B_1 corresponding to the forward, while B_1 to C_1 gives us the return-stroke of the piston.

In this figure the lead v is much larger than it is represented in fig. 13, as it amounts to nearly one third of the width of the port. Moreover the slide has a very rapid downward motion, enabling the exhaust-port to be already fully opened at $^1/_{10}$ of the stroke. This port remains open up to $^7/_{10}$ of the stroke, and the valve-edge attains its greatest downward declination at the point g_1 which corresponds to between $^3/_{10}$ and $^4/_{10}$ of the piston-stroke. The valve now again ascends,

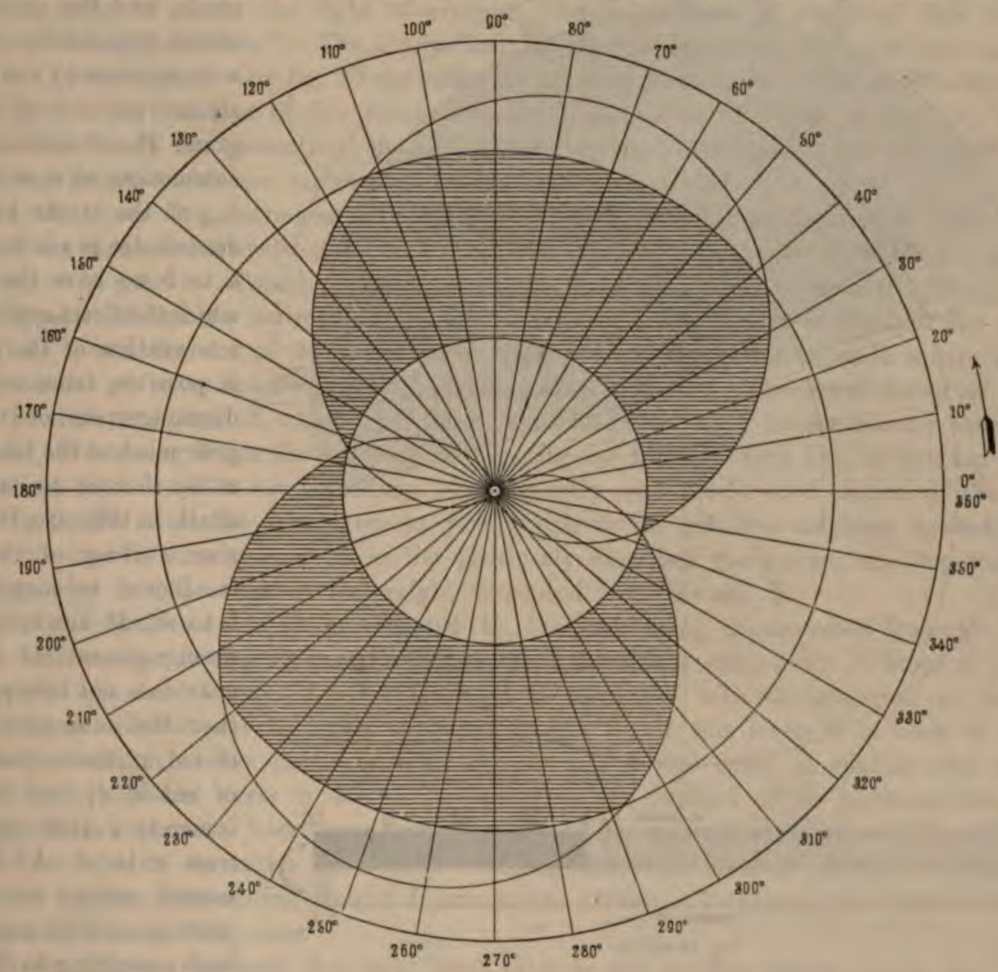


Fig. 17.

and commences to shut off the exhaust port at h_1, completely closing the same at i_1. With the return of the piston, the exhaust-valve is at k_1, and having attained its maximum ascent at l_1, the exhaust-port begins to open after $^9/_{10}$ of the piston-stroke.

We may also perceive by comparing the two diagrams, that the ports are quite closed, the moment the steam-exhaustout of the cylinder ceases, since the exhaust-valve is shut, and the inlet-valve has not yet begun to open. During such periods compression of the steam takes place in the cylinder, and it is therefore the task of the machinist to arrange his constructive arrangement in such a manner that the pernicious effect of back-pressure may be least felt.

The position of the inlet- and exhaust-valves in relation to the crank-position is referred to in our fig. 16 and 17, the first of these diagrams relating to the inlet-, and the second to the exhaust-valve. In order to show clearly the working positions of the two valves during one stroke, the travel of the exhaust-slide is also indicated by the dotted line in our fig. 16. This diagram explains very effectively the limits of the adjustable cut-off, as well as of the ordinary rate of expansion, exhaust, or compression.

These working conditions are still better represented in our fig. 18 and 19, which similarly refer to the engine shewn by our plates 1 and 2. The radii drawn in the circle refer to the position of the crank at certain stroke-portions — i. e. piston-positions — which are indicated by the figures appended to the circumference of this circle, and the using of the steam expansively or otherwise is shewn by the different shaded portions of our diagram. The admission of steam commences at *a* or at about $^{1}/_{100}$ of the stroke before the dead-centre is reached. From *a* to *b* we have the limit in which the direct application or intervention of the governor is possible, inasmuch as the disengagement of the trip-gear must at the latest ensue at *b*, if it is to take place at all. In this case, the expansive working of the steam is allowed to continue from *b* to *d*. If however such a disengagement of the trip-gear does not take place at *b*, then the inlet-port is only closed at the ordinary point of cut-off *c*, and the steam is merely worked expansively from *c* to *d*. At this last-named point, the exhaust-port opens with considerable lead amounting to $^{3}/_{100}$ of the piston-stroke. The exhaust continues to *e* where the exhaust-port closes, and since both inlet- and outlet-valves are closed from *e* to *a*, the piston is compelled to compress the steam which may have remained in the cylinder and compression takes place during this period. Our fig. 19 will help to elucidate our diagram (fig. 18), inasmuch as the forward piston-stroke is represented by the upper half of the drawing. The admission of steam commences at *a* (fig. 19) on account of the lead, and as already explained, we find the admission of steam to be from *a* to *b*, or eventually to *c*, and we note the expansion to take place from *b* to *d* or only from *c* to *d*, whilst we have emission (exhaust) of steam from *d* to *e* which is followed by compression from *e* to *a*.

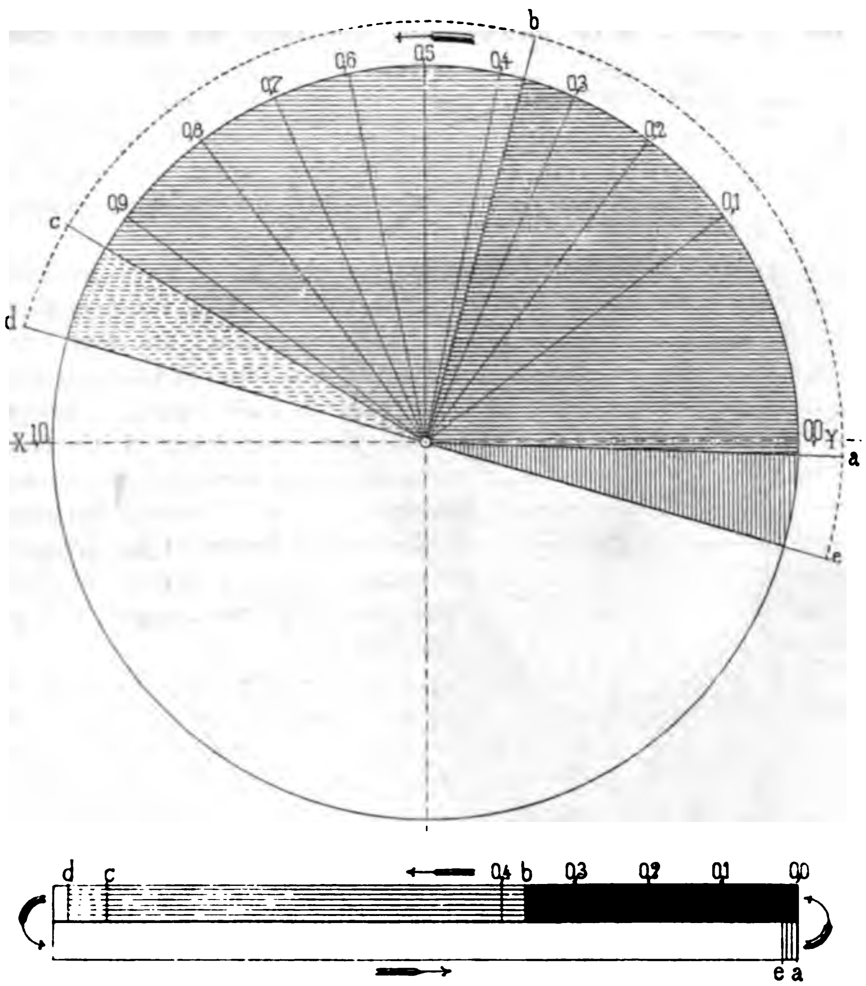


Fig. 18 and 19.

Perhaps it need not be observed, that the cut-off may happen at any point between *a* and *b*, so that the admission of steam to the cylinder may be cut off to any extent, whilst the steam will accordingly be worked all the more expansively. In conclusion we may add that the motion-rods may be lengthened or shortened, for adjustment purposes; the same remark applies especially to the eccentric rod, the lengthening or shortening of which augments or decreases the lead.

The fourth Corliss valve-gear.

In 1858, Corliss designed a valve-gear which was neither patented, nor often constructed by him. On the other hand this valve-gear has been largely repeated in America in engines of the Harris-Corliss type which, if our information is correct, are used by several engineering firms. Probably in order to secure the right of priority, Corliss exhibited a model of this mechanism at the Philadelphia Exhibition.*) The illustrations fig. 20—23 represent this valve-gear as attached to a Harris-Corliss-engine. Our fig. 20 shows us an external view of the valve-gear to the right of the gear-disc: a part section of the admission-valve mechanism is shewn in fig. 21, whilst in fig. 22 we have drawn the geometrical connection between the gearing-parts, and the chief positions of the disengagement-tackle are represented in fig. 23.

In the main this valve-gear is identical with the preceding mechanism to which we have referred as the third Corliss-valve-gear; it differs, however, in the manner in which the disengagement of the trip-gear is effected, as well as in the working of the valve-lever. The bent lever *KL* (fig. 20 and 21) on the valve-spindle is here retained, but a collar *n* is fitted to the lever-arm *L* into which collar the end of the draught-rod *E* fits loose. The latter is made square in section behind the collar so as to receive a fork *J* pivoting on a centre *m*. The lower prong of this fork, carries a steel-plate *o* against which the collar *n* is made to catch in the manner shewn in our illustration. The spring *S* has the tendency of pressing the fork upwards i. e. of keeping the same in the position represented in our engraving. Consequently with the forward motion of the draught-rod, the fork will cause the valve-lever to turn owing to the collar *n* catching against the fixed steel-plate *o*. In this arrangement as in the previously described valve-gears, the trip-gear is kept in working order by the action of the weight suspensed from the rod *P*.

The disengagement is simply effected by the fork being disconnected from the collar *n*. It will be noticed, on referring to our illustration, that there is a small lever *M* fitted to the valve-spindle behind the bent lever *KL*; this lever *M* is connected with the governor by the rod *N*, whilst its lower side is provided with a projecting pin *R*. If this lever *M* is made to swivel in the contrary direction to the hands of a watch, the pin *R* will come in contact with the upper prong of the fork *J* and press it down. According to the position of the governor this pin will prevent the fork sooner or later from continuing its rising motion with the rod *E*, and so cause the fork *J* to turn on its centre *m*, thereby bringing the collar *n* clear of the steel-plate *o*. As soon as this happens, the falling weight *P* comes into action, and carrying the bent lever with it, causes the admission-port to close.

In fig. 22 we represent the right hand valve in the position shewn in our fig. 21, whilst on the contrary the left hand valve is represented as being disengaged.

The conditions implying a disengagement are nearly the same as in the third Corliss valve-gear, which assertion becomes self-evident on comparing the two sketches shewn in fig. 5 and 23.

This fourth Corliss valve-gear does not therefore greatly vary from the preceding arrangement. The two differ chiefly in the putting in and out of gear of the trip-gear, the first of which is somewhat more complicated, though the latter — the disengagement-method — is undoubtedly much simplified.

The fifth Corliss valve-gear.

At the Paris International Exhibition of 1867, Mr. Corliss presented an entirely new Corliss engine construction. This arrangement differed considerably from the preceding ones, the fundamental principle alone being retained, whilst great difference was shown in matters of form and detail and

*) An account of this model appears in Dingler's polyt. Journal vol. 222, part 2.

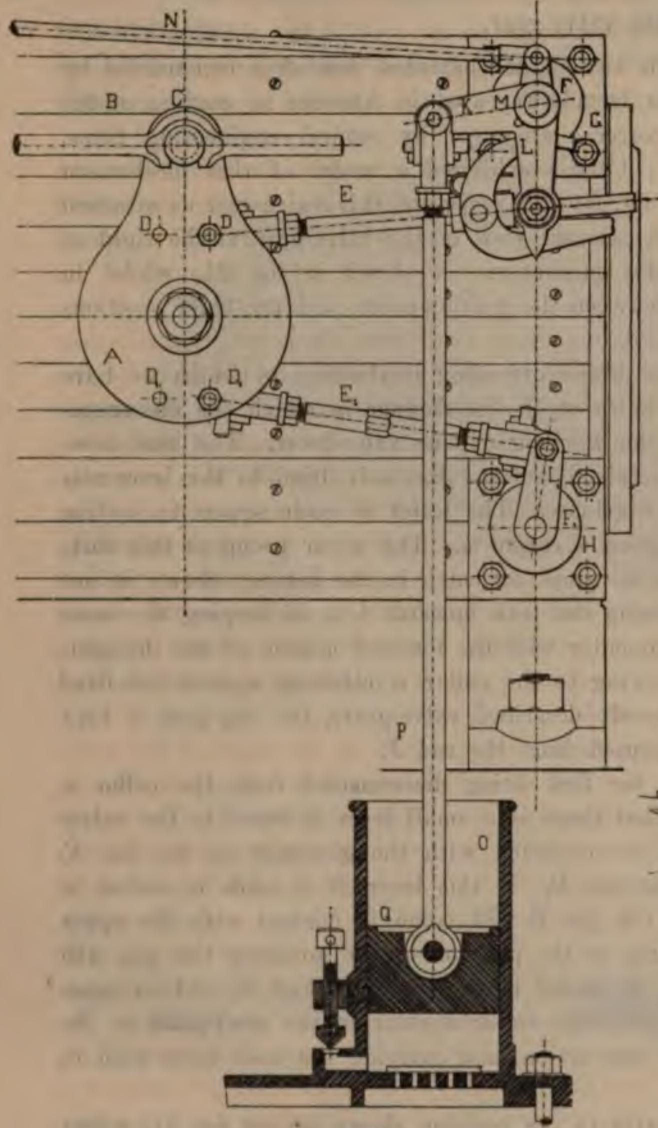


Fig. 20.

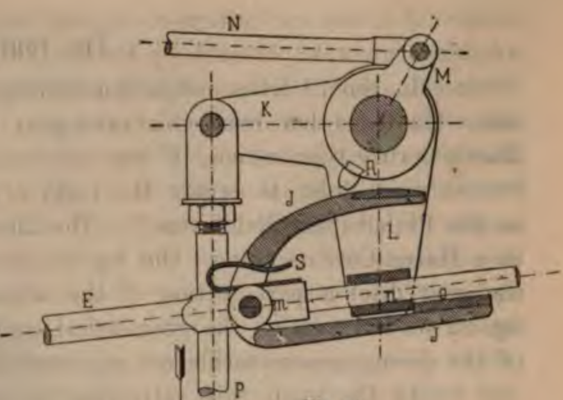


Fig. 21.

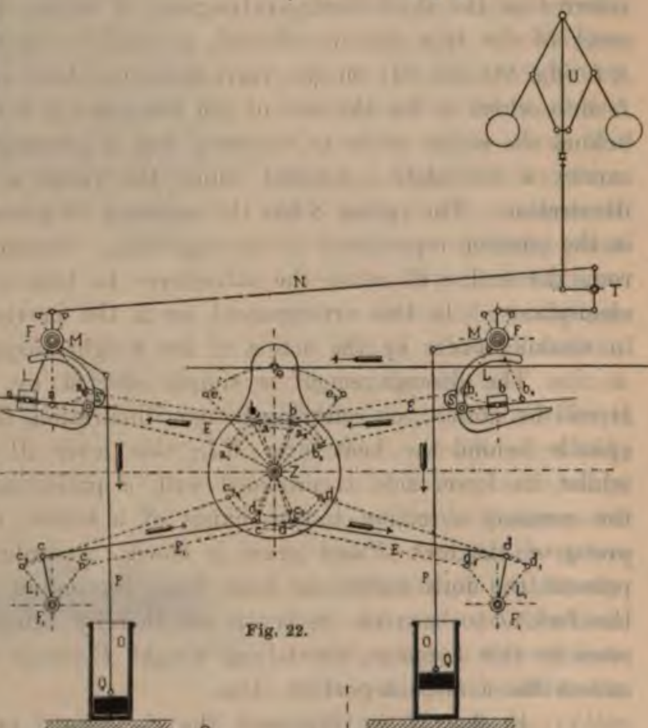


Fig. 22.

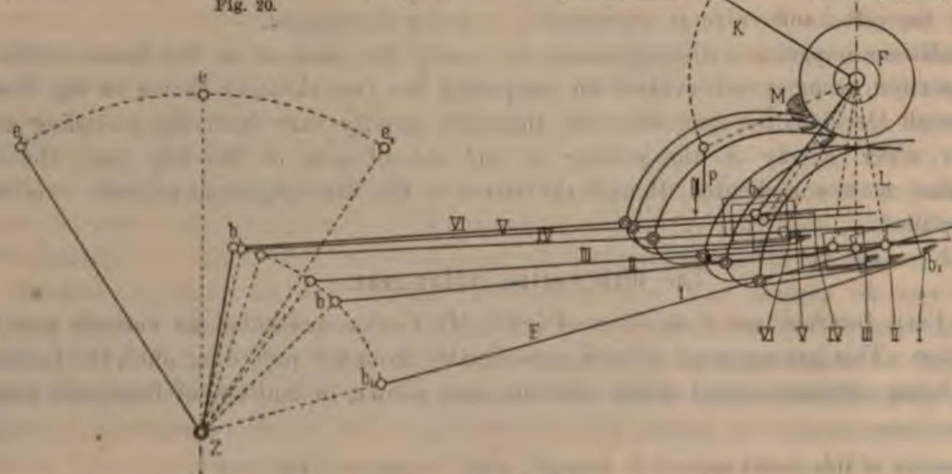


Fig. 23.

especially in the application of springs instead of weights for the closing of the valves. This fifth arrangement was patented by Corliss already in 1859, though on account of the time at which it became known in Europe it is sometimes called the Corliss valve-gear of 1867. Additional importance is attends this arrangement owing to the first application of a bayonet-formed support commonly known as the Corliss engine frame.

Our illustrations fig. 24—30 give sketches of this fifth Corliss valve-gear as drawn from an engine constructed at the machine works of the Wilhelmshütte near Sprottau. Fig. 28 represents the geometrical relation of the various working parts of the valve-gear, whilst fig. 24—27 illustrate the gear-disc and the spring link-mechanism in connection with the two valves nearest to the gear-disc.

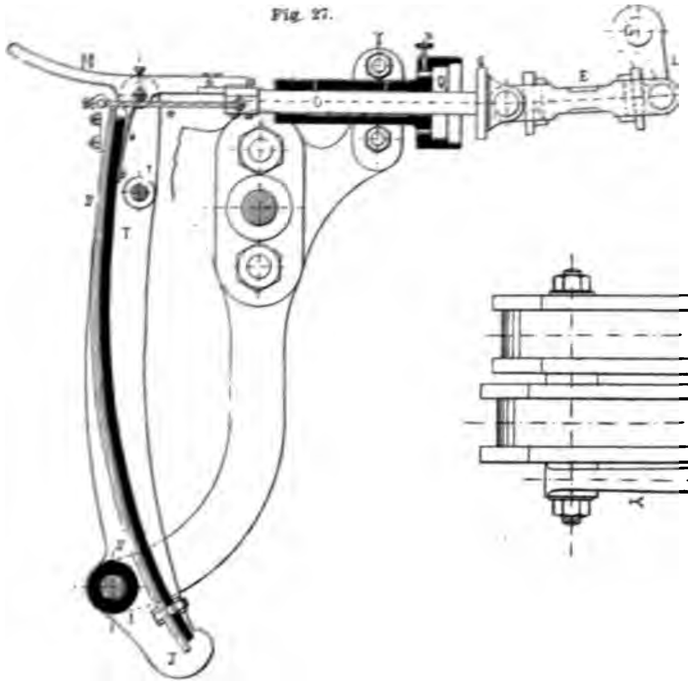
We observe at the outset, that the gear-disc, together with the whole of the trip-gear has been shifted from the central-position it formerly occupied on the cylinder, to the front of the latter, whilst the governor is placed in close proximity to the gearing mechanism. To the engine bed is screwed a Y-formed frame Y, for the purpose of attaching thereto the whole of the valve-gear mechanism. In the first place the gear-disc A swivels round its centre-pin Z; it is generally made somewhat triangular in form and is actuated by the crank C and the eccentric rod B. The position of the crank C to the gear-disc A is so chosen that while the motion of the crank extremity is almost horizontal, the resulting travel of the external pivots on the gear-disc is almost vertical or perpendicular to the former. In the engine here selected as an example, the horizontal centre line of the gear-disc is in one plane with the cylinder axis; this is however not always the case, as at times the gear-disc is placed somewhat higher, especially when the valve-spindle levers, instead of pointing downwards as in this example, point upwards.

The two rods $E_1 E_1$ are rigidly connected through the pivots $D_1 D_1$ to the right of the gear-disc A, and connect the latter with the exhaust-valves; as these rods cross each other, the one is fastened to the front while the other is attached to the under-side of the gear-plate A. Two small rods ee similarly attached to the front and hind faces of the left side of the gear-disc (fig. 24) impart the motion of the latter to two I-formed links TT round their centre t. Spring-plates SS are inserted in such a manner along the rib-backs of these links that while their lower extremities are fastened thereto, the top ends are left free to move, though connected by small rods $e_1 e_1$ to the rods OO. Immediately over these rods and attached by centre-pins to the links TT, are two spring-latches NN, the right ends of which are furnished with steel-plates n which catch against the projections o of the rods OO (vide fig. 27). The latter are made to slide in long sleeves $Q_1 Q_1$, and are provided with air-buffers QQ, the intermediate links EE connecting the admission valve-levers with these rods OO. We may also add, that in the construction we have illustrated, the two latches NN are provided with springs (weights are sometimes substituted for these springs) which press the steel-plates nn against the projections oo, whilst the action of the springs SS have a similar tendency in drawing the rods OO against the spring-latches NN; consequently the latter may be considered rigidly connected with the rods OO, so long as the spring latches are not disengaged.

Assuming no disengagement to ensue, then the working of the engine causes the links to oscillate to and fro, imparting an alternate horizontal motion to the rods OO and on to the links EE, which motion is thence transmitted to the valve-levers LL causing the latter to swing round their valve-spindle centres, as is plainly shown in fig. 28. In this manner the circular slides work similarly to the ones we have already described, and if these spring-latches are not disengaged, then the cut-off of the steam takes place at nearly the stroke-end.

The disengaging mechanism consists of a double-lever M, having a plate R at its right end whilst its other extremity is connected with the sliding collar of the governor. According to the declination of the governor-balls, the plate R will be moved higher or lower, and accordingly

Fig. 27.



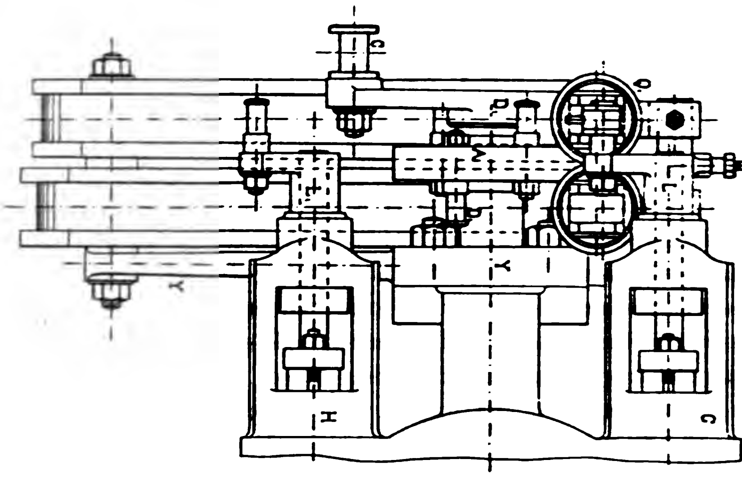
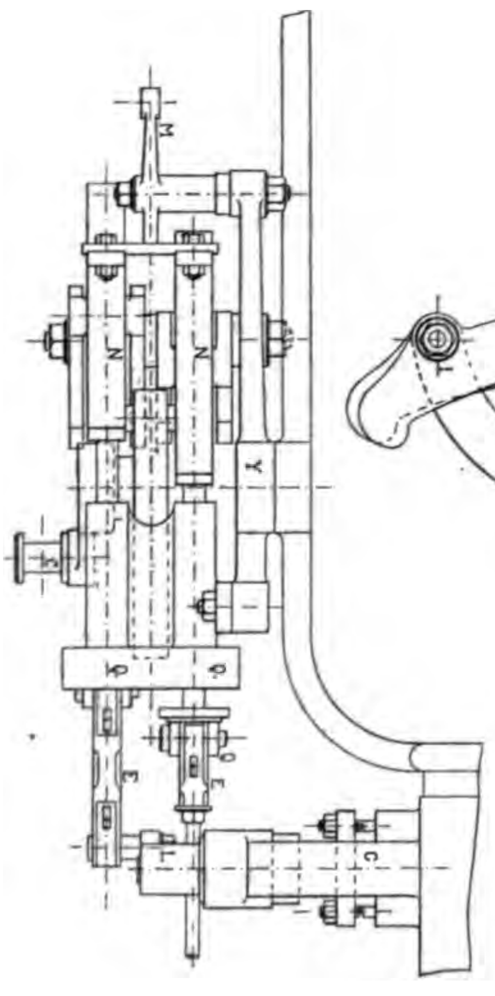


Fig. 25.

Fig. 26.



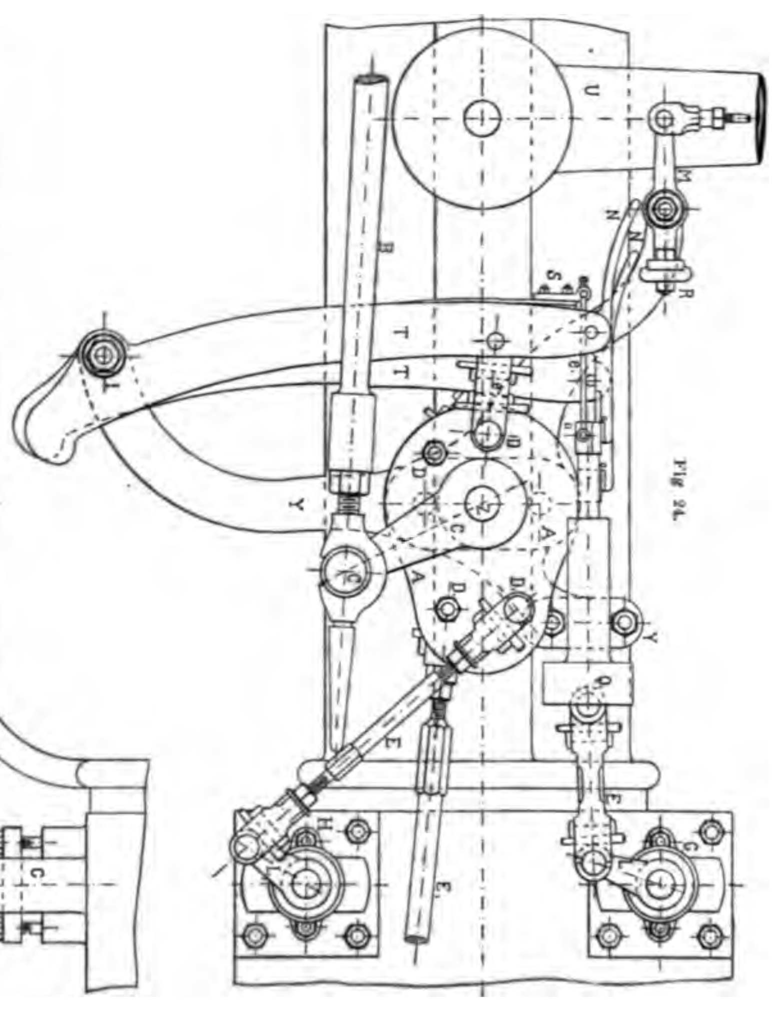


Fig. 24.

the spring-latch will come in contact with it later or sooner whilst oscillating, which contact corresponds to the disengagement of the spring-latch. As soon as the latter relieves the rods *OO*, the springs *SS* act all the quicker owing to their having been pressed back through the movement of the links *T*; consequently the rods *OO* are rapidly thrust back and this motion is transmitted to the valves. For staying the force of this shock, air-buffers $Q_1 Q_1$ are introduced and are adjustable by small valves *v*.

The conditions under which disengagement ensues, may be read off the fig. 29 which has reference to the engine represented in our Plates 6 and 7. Our illustration shews that with the present arrangement as before, the various positions of the spring-latch in relation to the piston-stroke, are further apart at earlier than with later cut-offs. In the last named diagram, *I* indicates again the initial and *II* the middle position, *III, IV* and *V* refer to cut-offs at respectively $^1/_{20}$, $^1/_5$ and $^9/_{20}$ (0,46) of the piston-stroke, the last being the maximum limit of steam-admission at which automatic disengagement may still ensue.

The arrangement of the admission and exhaust-valves is represented in our fig. 30 and 31. On account of the two admission-valves *GG* each moving in the same direction (and not in symmetrical directions as in the preceding Corliss valve-gears) the valves must be so designed that the opening of the ports may ensue on turning the valve to the right, which is simply done in the case before us by a corresponding widening of the slide-face (see also Plate 7).

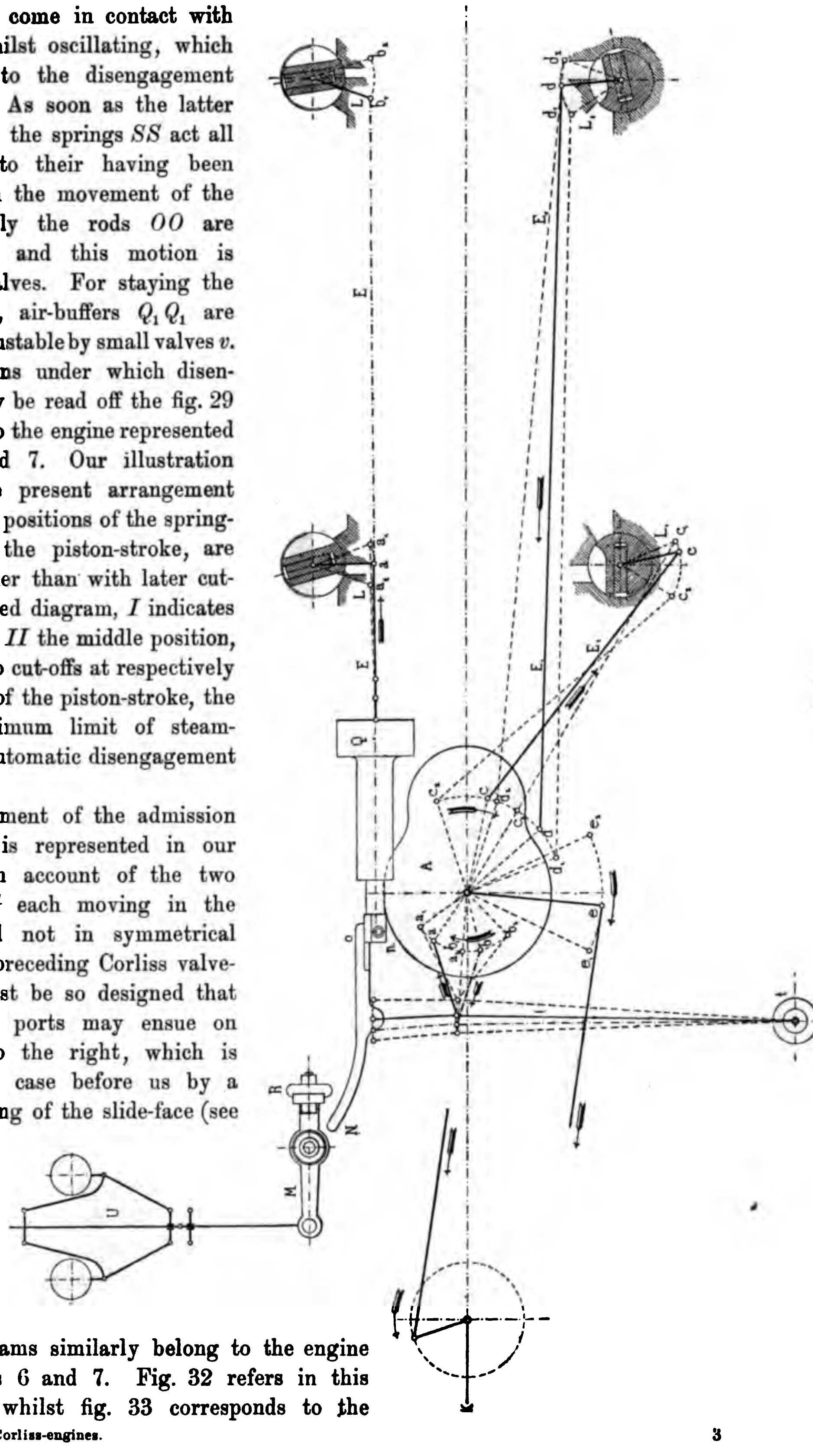


Fig. 28.

In our fig. 32 and 33 we illustrate the progressive travel of the inlet and exhaust-valves in relation to the piston-stroke. These diagrams similarly belong to the engine shewn in our Plates 6 and 7. Fig. 32 refers in this sense to the inlet, whilst fig. 33 corresponds to the

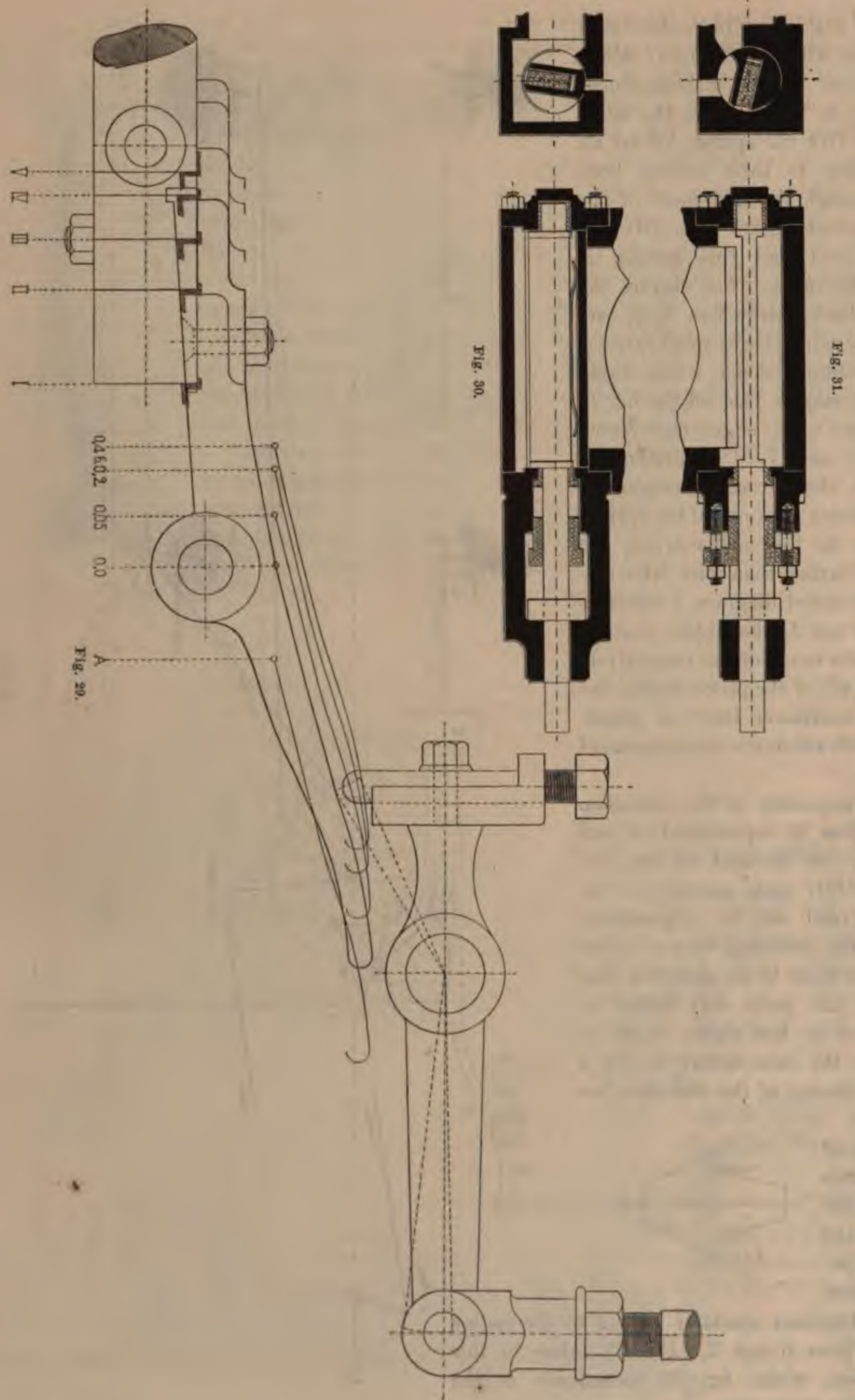


Fig. 29.

Fig. 30.

Fig. 31.

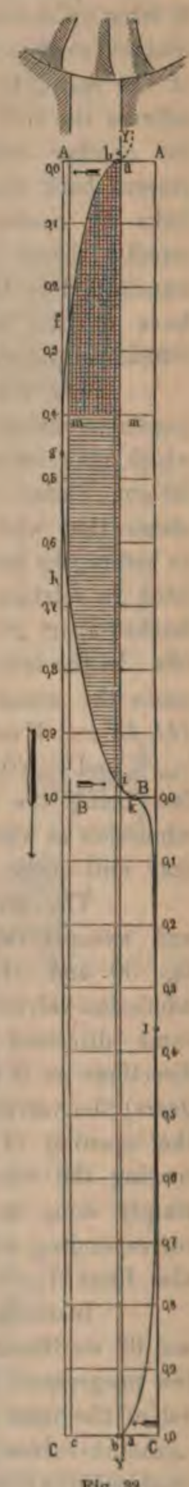


Fig. 32.

exhaust-valve. The lineal lead of the first amounts to $^1/_{16}$ in. (2 mm.) so that the steam enters through a passage of corresponding width when the crank is on its dead centre. With the advance of the piston, the valve continues to open the port, though not so rapidly as was the case with the previously discussed diagram, since the port is only fully open at F or at $^1/_4$ of the piston-stroke. The port remains fully open till the piston has travelled about $^7/_{10}$ of its stroke, when it begins to close slowly, the complete shutting of the same only taking place at about the end (0,99) of the stroke. This would form the limit of the admission of steam to the cylinder, if it had not been cut off before, either by the disengagement of the spring-latch or the shutting of the valve.

The limit, however, at which automatic disengagement may ensue is somewhat high in the engine-type under discussion, inasmuch as the greatest declination of the admission-valve is at g or at about $^9/_{20}$ (0,46) of the piston-stroke, enabling the disengagement to still take place at a cut-off of $^2/_5$ of the piston-stroke.

The admission-valve remains a considerable time in its end-position, owing to its travel being infinitely small during $^1/_5$ to $^3/_5$ of the piston-stroke.

Less favourable is the travel of the exhaust-valve. At the beginning of the piston-stroke it opens with a lineal lead of $^1/_8$ in., but merely oversteps the port at about $^1/_3$ (0,34) of the piston-stroke, in order to already begin to shut it at about half the piston-stroke. The closing of the port is certainly very slow and so late, that any compression of the steam is almost out of question.

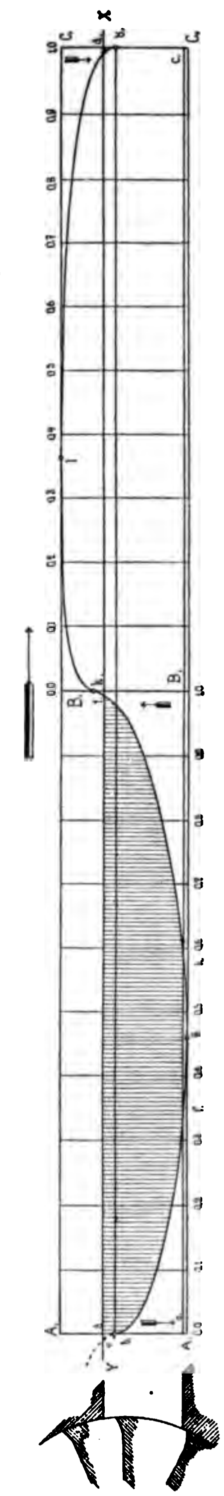


Fig. 33.

The sixth Corliss-valve-gear.

We are indebted to Prof. Radinger*) for the first reliable information which reached Europe concerning this sixth Corliss-valve-gear. We illustrate on Plate IV an engine fitted up with this gear, which the reader will find supplemented by our figures 34 to 36.

Corliss has applied this arrangement to all his engines since 1875, and the large Beam-engine which was so much admired at the Centennial Exhibition (Philadelphia) was fitted up with a valve-gear identical in principle with this sixth arrangement.

We may first observe, that Corliss here again places the gear-disc about the centre of the cylinder, whilst the shutting of the inlet-valves is no longer done by weights or springs, but on the contrary by the application of atmospheric pressure. Moreover the gear-disc has also undergone a change, as it merely carries two pins for the attachment of the motion-rods, which is rendered possible by connecting these in pairs to one stud as hereafter explained.

The gear-disc is mounted eccentric fashion on the pivot Z, and receives its motion in the usual manner by an eccentric rod B through pin-connection C. To the lower part of the gear-plate and close to its pivot Z, two studs DD are let in at its back, which take up the four motion-rods in pairs. The rods $E_1 E_1$ lead direct to the exhaust-valves, and are each placed next to the gear-plate.

The rod E — confining ourselves to one set of valves as shewn in fig. 35 — though working in and out of gear, is not connected as before with the

*) Vide Prof. Radinger's work: 'Dampfmaschinen und Transmissionen in den Vereinigten Staaten' which has been kindly placed at our disposal by its author.

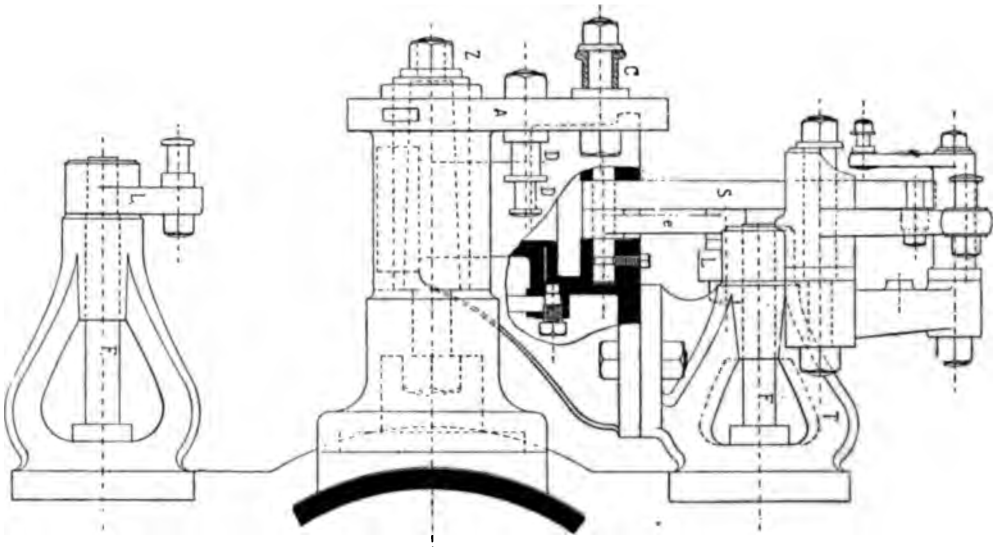


Fig. 34.

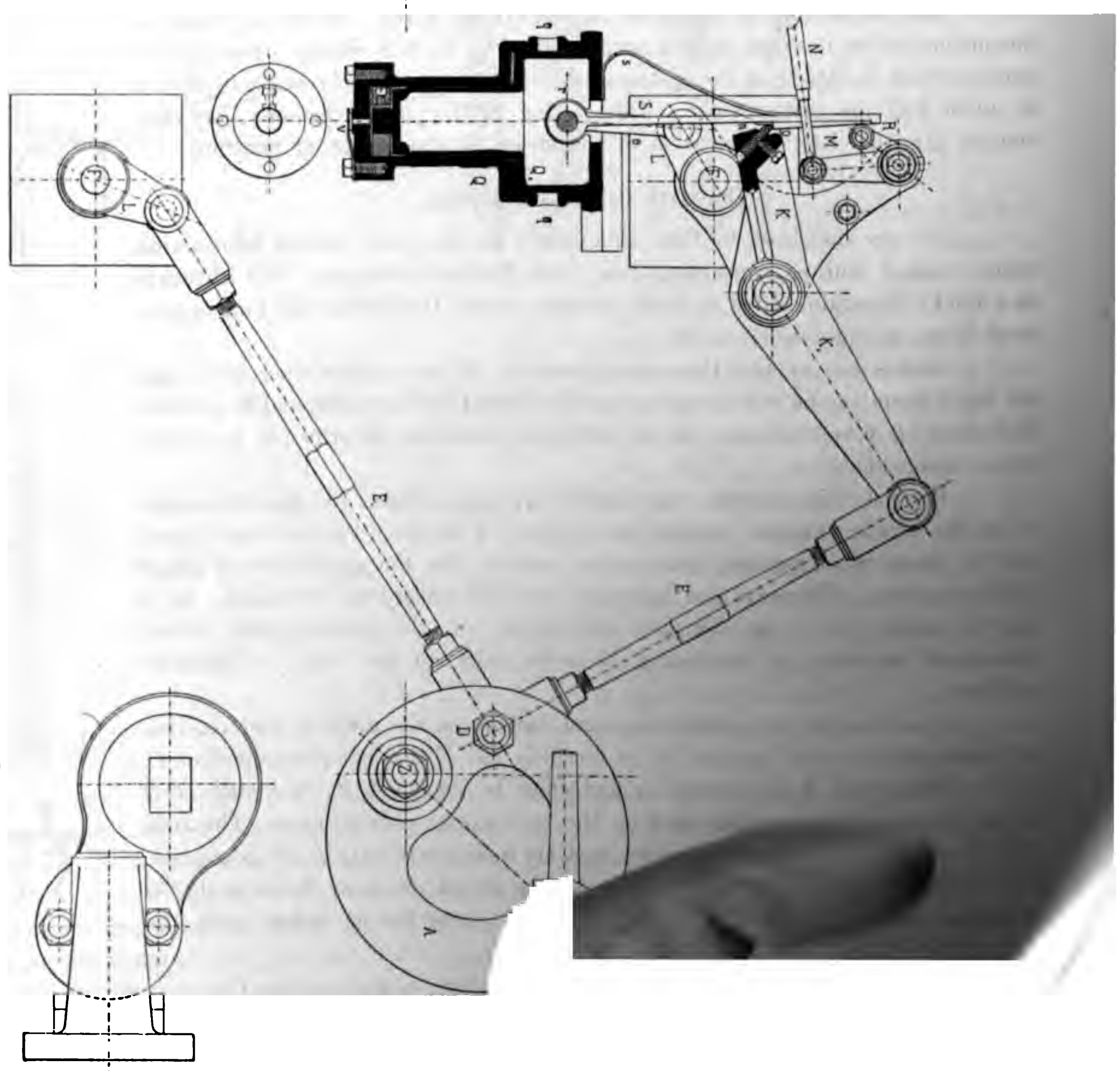


Fig. 35.

Fig. 36.

inlet-valve, but it acts on an intermediate link-combination arranged in the following manner: A lyre-formed bracket TT, cast in one piece with the valve-box cover, carries the valve-spindle as well as a triangular frame, to the lower end of which, is an air-cylinder Q. The latter is fitted with an air-tight differential piston Q_1, the lower portion of which is much smaller in diameter. With the rise of the piston a vacuum is formed underneath it, whilst air enters into the intervening space (caused by the upper part of the piston) through the openings qq.

In this manner, the upper part of the piston acts as an air-buffer during its descent, whilst the pressure of the air outside the cylinder, aided by the vacuum under the piston, causes the latter to descend rapidly. A small valve V is placed at the bottom of this cylinder for the escape of any air that may be taken in through faulty or deficient packing during the rise of the piston. To prevent any knocking of the piston against its cast bottoms, a leather-plate is laid on the top-bottom, against which the piston may strike, if not previously air cushioned.

A small link e connects the piston Q with the valve-lever L in such a manner, that the ascent or rise of the piston opens, whilst its descent closes the valve. The pin r is also made to hold a flat rod S, which is furnished with a steel catch o at about two thirds of its length; a bolt n fitted on the bent-lever KK_1 is arranged to correspond with this catch. A light spring presses the rod S against the lever, and holds the catch o against the bolt n.

From the arrangement of this mechanism, it follows that the oscillating movement of the gear-plate A is transmitted by the link E to the lever KK_1 whence a vertical alternate motion is transferred to the rod S the connection of which with the link e conveys a rocking motion to the valve-lever L.

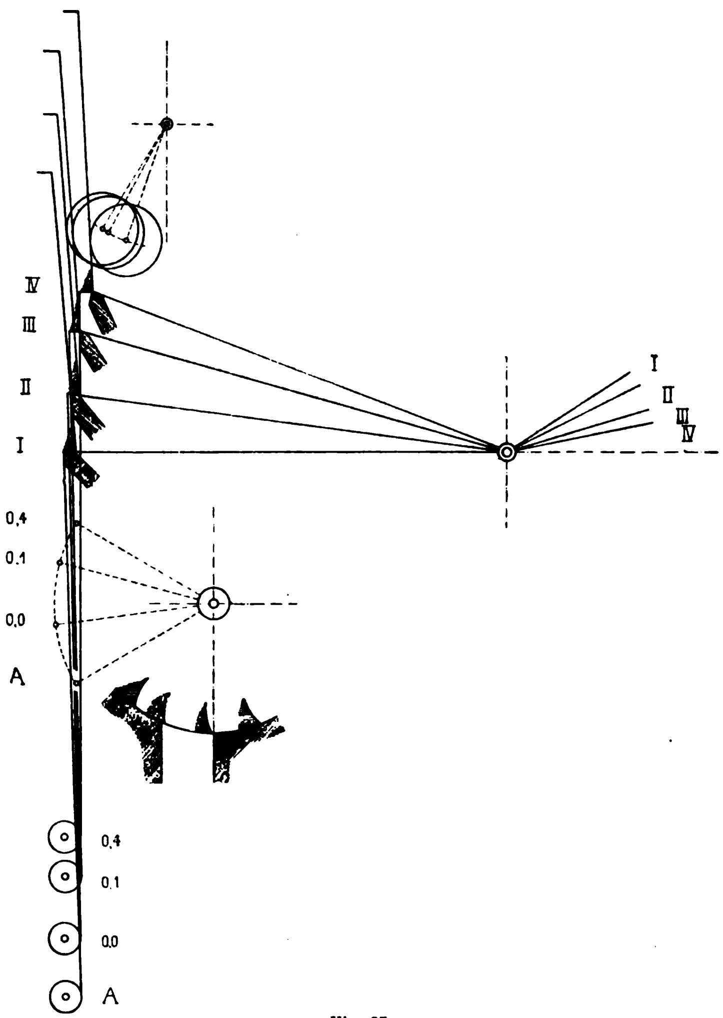


Fig. 37.

From this description it would appear that the regular working of the valve is obtained in a very round-about way, and we have now to explain the disengagement mechanism applied thereto.

As complicated as the valve-working-mechanism appears, as simple is the disengagement-arrangement. The wrought-iron rod N leading to the governor, is connected with a small bent-lever RM, the smaller arm of which is provided with a steel friction-roller against which the wedge shaped end of the rod S slides. On referring to the figure it will be seen, the catch o moves at the beginning in an arc from right to left; it may therefore be easily pressed away from the bolt n in case its travel should be impeded. This resistance is offered by the friction-roller R. According to the position of the governor-balls, this roller R is moved more or less to the left, and the steel rod accordingly comes sooner or later in contact with it, so causing disengagement to ensue. The air-buffer now comes into action; the atmospheric pressure, forces the piston Q to descend quickly, the lever L is turned accordingly, and the valve is shut.

We see therefore, that we thus again obtain an almost instantaneous detachment, which is certainly more complete and of better design.'

On Prof. Radinger's authority this valve-gear has already been applied to about one hundred engines, — amongst which is one of 300 horse-power driving a spinning mill — and it is said to work so well that it may be considered as the most perfect of its kind.

In Corliss's latest engine-designs, the air-cylinder is no longer attached to the steam-cylinder, but is placed on the engine-bed similar to the dash-pot already mentioned; the rods S and c are thereby considerably lengthened, so giving freer motion to the mechanism.

The main advantage of this arrangement — according to Prof. Radinger's report — lies in relieving the valve-rod completely from all external forces. For whereas in the preceding arrangements the valve-rod carried a bent-lever, each arm of which was subjected to a pulling force which became transferred to the valve-rod, in the present arrangement the valve-rod end is merely subjected to the simple pull or force required to overcome friction. The whole force or pull exerted by the shutting action of the vacuum-piston is borne direct by the catch o. This formed Corliss's chief-motive in the radical change he here introduced, though he found nothing more to improve upon.

We have supplemented our annexed wood-cuts, by illustrating on Plate IV a Corliss-engine fitted with this valve-gear according to the latest best approved design, though after the preceding description, it will not be necessary for us to enter into further explanations.

The seventh Corliss valve-gear.

Exception may perhaps be taken at treating separately what we propose to name the seventh Corliss valve-gear, for reason that it forms merely a modification of the preceding valve-gear. On the other hand the variation and the arrangement of the various details of construction betray such additional originality as compared with the preceding systems, that we may well discuss it separately, and treat it, as representing the seventh Corliss valve-gear. By way of exemplifying this construction, we shall refer to the heavy pair of Beam-engines, which at the late Centennial Exhibition attracted the admiration of the engineering public, as forming one of the grandest engineering works of the world. This credit was well deserved. For even if Corliss had not rendered his name immortal to the engineering profession by his preceding engine-constructions, the present machine would have borne ample testimony to his high talent.

Though we could only obtain rough sketches of this engine, we have attempted to give an exact drawing of the whole machine on Plate 1 which we supplement by the annexed wood-cuts fig. 38 and 39. These Beam-engines were used for driving the shafting of the Exhibition machinery-department; they were delivered to the order of the Exhibition-Commission, by which it was sought to establish the finest conceivable 'memento' to American inventive talent. The imposing effect of this large Corliss-engine was applauded by all the Exhibition visitors; both its ornamental design and the unusual yet duly proportioned engine parts, as well as the excellent workman, ship and the regular and silent working of this machine, left a most favorable impression on those parties who were best able to judge of its comparative merits. On the other hand, Corliss is said to have constructed several large engines of a similar pattern, so that the machine exhibited was an example of a tried construction, and not as many believed, a mere lucky chance.

Proceeding to its description, we find two single cylinder Beam-engines coupled in the usual way, with the two cranks set at right angles to each other. Each cylinder-bore is 3' $4\frac{7}{8}$" (= 1016 mm.)

with a corresponding stroke of 10 feet (3050 mm.); the length of the beam is 27′ 1⁷/₈″ (8230 mm.), and its depth at centre is 8′ 10⁷/₈″ (2700 mm.). The beam-centre is about 29′ 8³/₈″ (9000 mm.) off the floor-line and the two machine-centres are set about 12′ 6″ (3800 mm.) apart. The length of the connecting rod is nearly five times the crank-length or 24′ (= 7308 mm.). The centres of the A-formed uprights are in line with the cylinder and crank-shaft centres, so as to reduce the tendency of transverse strains. On the cylinder-side, the base of the upright is made somewhat shorter than it is on the crank-side, so as to enable it to be bolted to the cylinder feet, with which the upright is fastened to the engine-bed. The foot of the opposite upright is bolted direct to the foundation-plate or to be more exact it is bolted as shewn in fig. 6 (Plate 1).

A similar bedding arrangement is repeated on the cylinder-side, and as these foundation supports are connected together by I-beams, the latter complete a triangle with the uprights. In order to protect the latter from side-strains or displacement, long vertical tie-rods are introduced and made to pass down through the stone foundation; they simultaneously serve the double purpose of forming neat cast iron staircasing. Lastly, the whole engine-framing is rigidly kept together, by an upper platform carried on supports from the main uprights. Simple as the whole arrangement appears, the idea of masking the tie-rods, by making them appear as suited to quite a different purpose than they were originally designed, is a capital one. Corliss is said to have applied this original idea to a number of engines. The beam-centre rests on adjustable journals, and the huge plumber-blocks belonging to them are fitted to and surmount the main uprights. The beams are of the butterfly-wing pattern; they are well apportioned to the engine-type, and their form has a pleasing effect on the spectator below. The weight of each beam is stated at 10³/₄ tons (11000 Kilogr.).

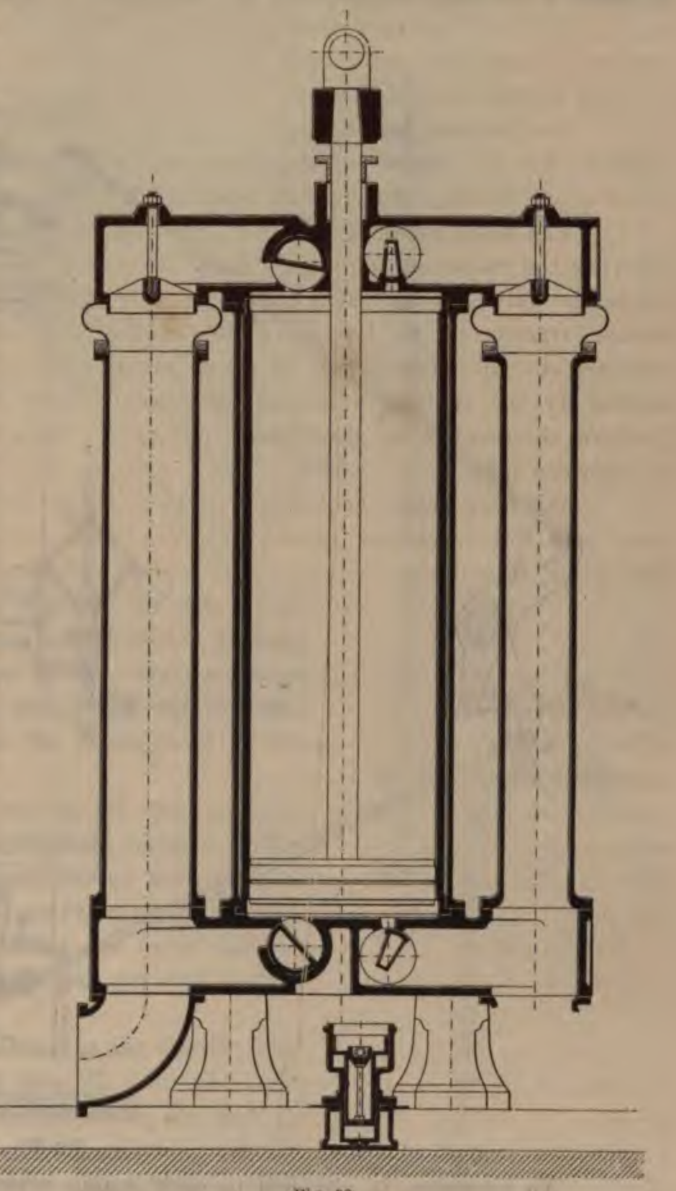


Fig. 38.

The toothed fly-wheel is 29′ 10¹/₂″ (9052 mm.) in diameter, and 2′ (609 mm.) on its face; the number of teeth is 216 set out to a pitch of 5¹/₄″ (131,6 mm.). The wheel is fitted up in segments, the boss forming two symmetrical halves to which twelve spoke-segments of each 18 teeth are bolted. The wheel-arms (vide fig. 8, Plate 1) are of cross-section, and are bent at their boss ends to ensure greater rigidity, than is otherwise usually obtained.

The fly-wheel gears into a pinion of 72 teeth, and of 9′ 11¹/₂″ (= 3017 mm.) diameter.

Both are fitted with iron teeth, and their working proved that iron to iron teeth could be worked silently and without shock if care is taken to provide proper bearing-surface for the shafts, and to make the teeth of correct form and what is also important to secure good workmanship in fitting up. The crank-shaft diameter is 1′ 6″ (450 mm.) running at 36 revolutions per min.

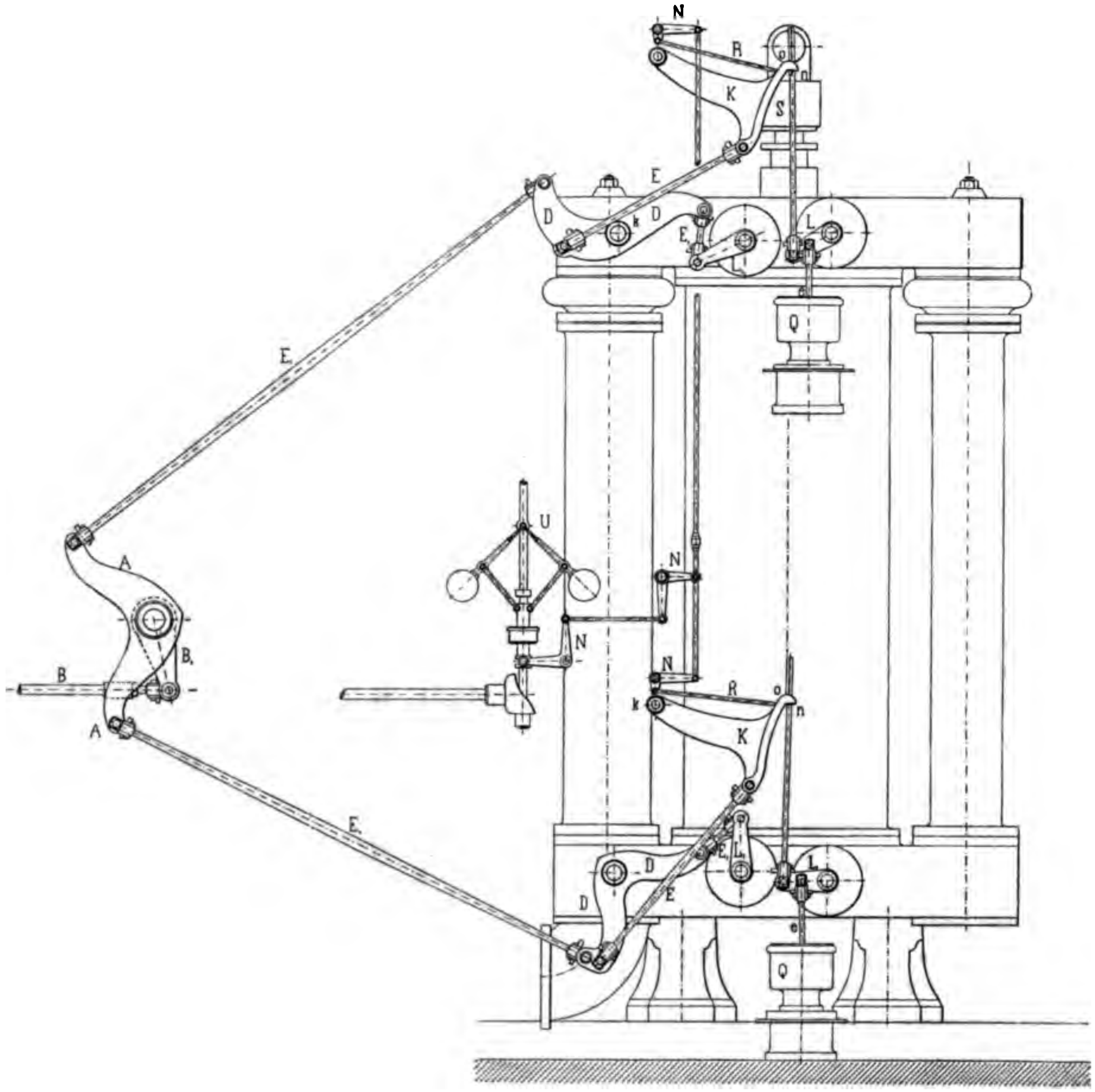


Fig. 39.

An air-pump is attached to each beam, which is constructed in the now long approved Corliss-style; its diameter is 2′ 9″ (863 mm.) with a stroke corresponding to 2′ (609 mm.). Our Plate IV fig. 4—6 give us a sketch of one of these air-pumps. Corliss adheres to the air-pump being placed vertical. The air-pump as a rule, is driven from the cross-head by means of a crank-lever, the one arm of which — namely that connected with the cross-head — is made four times longer than the other driving the pump. The cast-iron air-cylinder is brass-lined, whilst sycamore is used in the manner shewn in our Plate IV for the packing of the piston and of the stuffing-box. The piston, as well as the valve-plate and the hollow piston-rod, are made of brass.

The forementioned valve-seat plate is fastened by screws, let in from the top. The piston and this plate are each furnished with six caoutchouc valves, arranged as shewn in our drawings.

We may now proceed to a description of the steam-cylinder and of the valve-gear, for which purpose, reference may conveniently be made to our fig. 38 and 39.

The cylinder-bore is, as previously mentioned 3′ 4″ (= 1016 mm.) and its stroke, 10′ (3050 mm.). The latter, though rather long in proportion to the cylinder-diameter, contributes largely to the power and the silent steady working of the engine. The cylinder is furnished with a double jacket.

A section of the cylinder and of the steam-passages is drawn in our fig. 38, which sectional arrangement may also be compared with fig. 5, on Plate 5. The Corliss valves are placed in the hollow cylinder-covers, with a view of getting them as close as possible to the cylinder. They are cast separately in one hollow piece and are 4′ 3″ (1300 mm.) long and 12″ (305 mm.) in diameter. Characteristic is the peculiar fastening of the valves to their spindles, as shewn in fig. 7 Plate 1; by this arrangement, the straining of the valve is obviated, whilst better packing is ensured. Attention may further be drawn to the steam-passages placed at the side of the cylinder in column-form; they are provided with ornamental cornice tops, which allow for contraction or expansion of the metal.

The external valve-gear is shewn in our fig. 39. An eccentric, set with a throw of 8″ (203 mm.) on the crank-shaft, imparts motion by the intermediate link B to the crank B_1, and thence from the bent lever AA on to the upper and lower valve-gears, through the two connecting rods EE_1, as shewn. As both motions are equal and the upper and lower valve-gears are similarly arranged, we may confine our remarks to the bottom valve-gear.

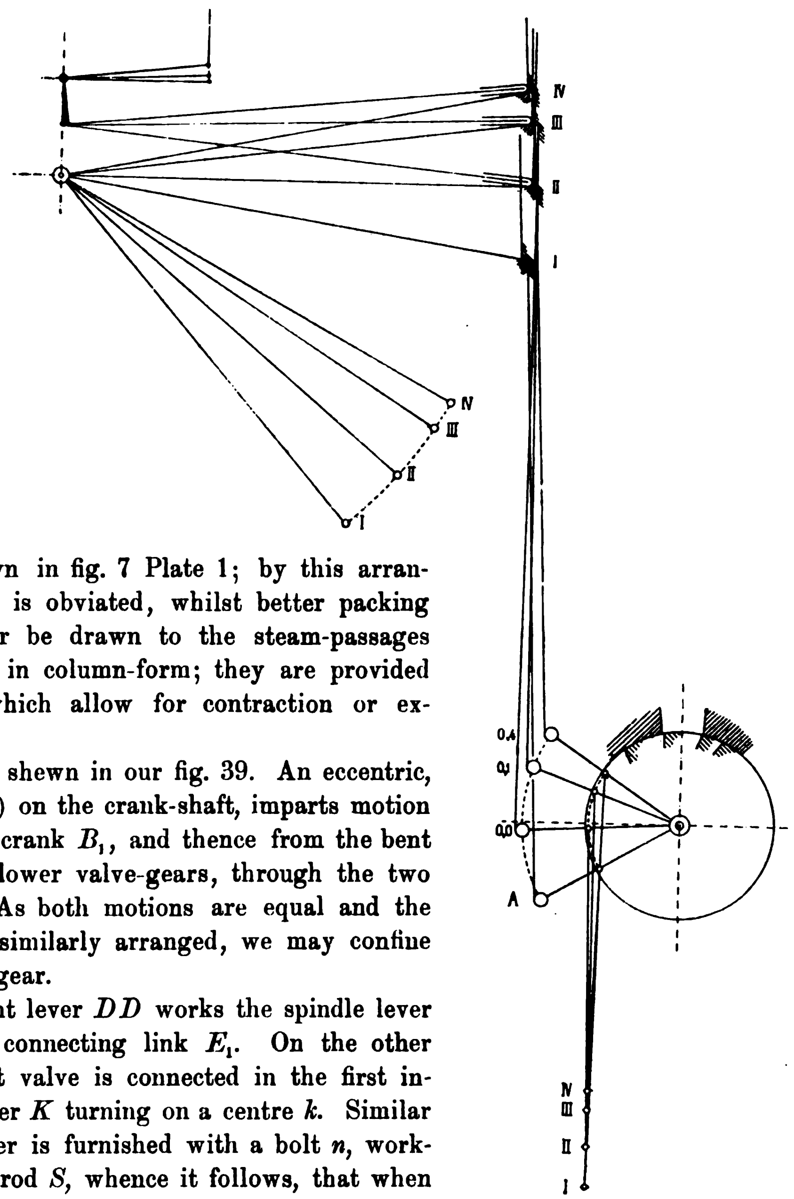


Fig. 40.

The upper arm of the bent lever DD works the spindle lever L_1 of the exhaust-valve, by the connecting link E_1. On the other hand, the rod E, working the inlet valve is connected in the first instance with a peculiarly formed lever K turning on a centre k. Similar to the sixth Corliss-gear, this lever is furnished with a bolt n, working under the catch o of the steel-rod S, whence it follows, that when the lever rises, it will have a tendency of lifting the rod S. As the latter is however connected with the valve-lever L, the valve is opened by the upward stroke of this rod S. The same lever L also carries a small rod e to which is attached the piston of an air-cylinder Q, exactly constructed as explained on page 21, and illustrated in fig. 35. As soon as the bolt R (connected as shewn by the link-mechanism with the governor) begins to play on the inclined surface of the steel rod S, the latter becomes disengaged from the lever K, and as a consequence the valve is closed by the action of the air-piston. The working of this method of disengagement will be better understood on referring to fig. 40, and we need only add that the disengagement is as certain as it is exact.

In bringing our remarks on this Engine to a close, we may add that it was estimated at 2500 horse-power, working at 36 revolutions per minute, although with an effective steam-pressure of 30 lbs. (= 2 atm.), the indicated horse-power calculated itself to only 1585 horse-power. The total weight of these Beam-engines exceeded 600 tons.

We have now described all the known Corliss valve-gears. It is true, we have not always had Mr. Corliss' original views at our command, which we regret the more, since his uncommon power of invention has often been mis-represented. In particular, it is the desire to create something new, which so often causes us to ignore and forget the advantages of matured inventions, and so induces us to supplant the latter, without in any way presenting anything better.

In our opinion, the latest Corliss valve-gears deserve the greatest attention, and our machinists will therefore do well to submit these to a careful and minute study. All the reports that we have seen, tend to prove, that the latest modifications of the Corliss valve-gear, are results of a mature experience, without the least chance-work about them. Corliss, figuratively speaking is 'conservative' and with full right. For though the majority of American engine-shops still show preference for the flat slide-valve, Corliss has retained his 'Circular-slides', not because the flat slide-valve was inferior to the Corliss-valves — for certainly good work of whatever kind, deserves credit and attention — but merely for reason that his circular slides have been found to answer well, so rendering it unnecessary to substitute another arrangement in their place.

Granting that the future will bring us a new engine-type, both excelling and supplanting the Corliss-engine, the latter even when removed from the engineering world, will still retain its value as having largely contributed to such an improvement. Certain it is, that Corliss' merit of having planned a new rational course of engine-building, will thereby suffer no detraction. At the present time the Corliss engine-type enjoys a good and undisturbed reputation, so that Corliss well deserves to have his name carried down to posterity, as one of the main pioneers and greatest improvers of the Steam-engine. May his engineering activity and energetic talent become a stimulating example for, and be also emulated by our young rising engineers! With this wish, we take leave of the engines designed by

Geo. H. Corliss, of Providence.

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2. Corliss-engines, as constructed by different Engineering firms.

a. Working with the III. Corliss valve-gear.

The 'Wilhelmshütte' Machine-works near Sprottau.

It is always a bold step on the part of an engineering firm to attempt the introduction of a machine shewing such great dissimilarity with existing patterns, so as to demand new experimental data, for testing and determining the comparative merits of the new construction. The 'Wilhelmshütte' machine-works near Sprottau, found itself in this position, when in 1860 it began to build Corliss-engines, exhibiting these at the London International Exhibition of 1862.

The 'Wilhelmshütte' has very nearly adopted the third Corliss valve-gear for its engines. The reader will find illustrated on Plate I fig. 1—3 an elevation and section of one of these engines shewn from the gearing side. The working of the valves is almost identical with the valve-gear already described on page 3 and illustrated by our fig. 3—19, so that we may confine our present remarks to a discussion of its characteristic features.

These engines differ mainly from the preceding and subsequent types by the application of a bed in place of the former flat-foundation plate, and the engine-trunk subsequently introduced by Corliss in his fourth valve-gear. This foundation-plate is bedded on two stone-blocks, and is bolted with the latter to the masonry work; it is of the box-pattern, and is made to carry the crank-shaft at one end, whilst its other extremity supports the cylinder on the one side and the gearing-tackle on the other.

The cylinder is bored to 1' $5^1/_2$" (442 mm.) with a 2' 10" (858 mm.) stroke. The steam-inlet-passages are 13" (338 mm.) long and $^7/_8$" (23 mm.) wide, whereas the outlet passages though of equal length are $1^1/_2$" (40 mm.) wide; the diameter of the valves is 5" (130 mm.).

The slide-bars are bolted to the side of the bed-plate in front of the cylinder; the slide-block is made to slide in V-formed grooves.

The Condenser is placed midway under the cylinder, whilst the air- and the cold water- and feed-pumps are brought forward and placed a little beyond the centre of the machine; the pumps are driven from a separate oscillating beam, receiving its motion by means of a connecting rod from the crank-pin. The centre of this beam, is attached to the cover of the air-vessel belonging to the cold water-pump. The feed-pump is placed $9^3/_4$" (250 mm.) behind the cold-water pump.

The diameter of the air-pump is 1' (312 mm.) and its stroke 1' $3^1/_4$" (390 mm.). In our sheet of illustrations, the water is taken from the condenser by the pipe *a*, and is pumped out by the pipe *b*; *c* is the cold-water inlet-pipe, whilst *d* is the steam blow-off pipe, for use when the engines are not working on the condensing principle.

An eccentric with $7^1/_2$" (190 mm.) throw, works the gear-disc direct, by means of motion-rods, giving it an oscillating angle of 78 degrees.

The Watt's governor is driven from the top of the spindle by a strap, $4^1/_8$" (104 mm.) wide on the face. Due care is paid to the proper lubrication of the governor, so as to ensure uniform motion. The governor-spindle is driven at 85 revolutions per minute. Special care is also taken to provide the external valve-gear with ample bearing surface, where required.

In the machine before us, anti-friction rollers are used for the disengagement, though in later constructions these have been discarded, on account of their uneven wear, which was found to prevent them from turning. The disengagement bolt is fitted with an adjustable set-screw to limit its stroke.

The fly-wheel is arranged for belt-driving, and is $14^1/_2$' (4390 mm.) in diameter. Working at 30 revolutions per minute, these engines are said to throw off 25 horse-power.

The United Hamburg-Magdeburg Steam-navigation Company of Buckau, near Magdeburg.

This Company started the manufacture of Corliss-engines about the same time as the Wilhelmshütte, and in this speciality it has hitherto met with much success. At the London International Exhibition of 1862, the Company exhibited one of their Corliss-engines, and contributed in no small measure to the appreciation of the German mechanical industry.

The Corliss-engines as subsequently built by this firm, shew little difference from those of the Wilhelmshütte, and we have therefore confined ourselves to illustrating a side elevation of these engines (vide fig. 4, Plate I). The main difference indeed, is the Porter-governor and the arrangement of the pumps and of the condenser. The latter is of a pear-form and is placed immediately under the steam-cylinder; the pumps are mounted together on one base-plate and are placed somewhat lower. The pump next to the Condenser is the air-pump, the cold-water pump being placed in front of the other; the two pumps are connected by one piston, which is worked from an oscillating lever attached to the crank-pin, by a connecting rod.

Otto H. Müller, C. E. of Buda-Pesth.

It may perhaps cause surprise, that we illustrate a Corliss-engine in our Plates 2 and 3, which though only recently constructed, should be working after the somewhat antiquated third Corliss valve-gear. Alone, a mere glance at our illustrative sheets will show, that the engine in reality represents an entirely modern construction, which according to all accounts appears to be working very favorably as the annexed indicator diagrams fully confirm.

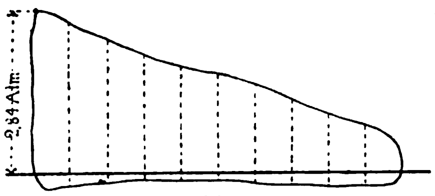

Fig. 41.

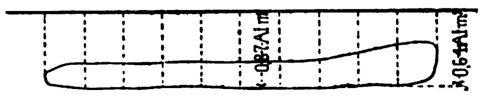

Fig. 42.

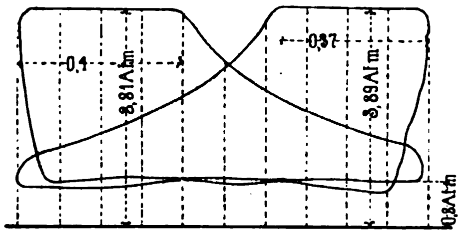

Fig. 43.

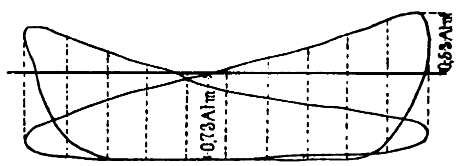

Fig. 44.

The general arrangement of the machine is shewn in our Plate 2, fig. 1 and 2 Originally built as a Woolf's engine, it was afterwards converted into a Compound engine, and the small cylinder was fitted up with Corliss valve-gear. As a Woolf's engine, it worked up to 303 indicated horse-powers, the diameters of the large and the small cylinders being respectively 4′ 8″ and 2′ $6\frac{1}{4}$″ with a corresponding stroke of 5′ 6″. The engine speed was $31\frac{1}{3}$ revolutions per minute and with a boiler pressure of 65 lbs. (4.2 atm.) the engine gave off the indicator diagrams shewn in fig. 41 and 42.

The stipulations set forth in the reconstruction of this engine, were that with a boiler-pressure of 75 lbs. (= 5 atm.) and a cut-off at $^{9}/_{20}$ the stroke in the small cylinder, the engines should indicate 500 HP. These demands were amply fulfilled in the newly constructed engine; for after replacing the small cylinder with a new one of 2′ 4″ (710 mm.) bore, and fitting up the same with Corliss valve-gear, the large cylinder was furnished with expansion cut-off, as well as with a receiver and the necessary pipe-fittings etc. after which the indicator diagrams shewn in fig. 43 and 44 were obtained from these engines. The small cylinder with a mean pressure of little more than $28\frac{1}{2}$ lbs. indicated 178.8, whereas the low-pressure cylinder working at a mean pressure of $9\frac{1}{2}$ lbs. indicated 249.4 horse-powers. The engine was worked at the same speed of $31\frac{1}{3}$ revolutions per minute, thus resulting in a piston-speed of 5′ 9″ (1,77 m.) per sec.

For comparing the circular-travel of the inlet and exhaust valves, with the indicator-curves, we reproduce in fig. 45 and 46, the valve-travels in similar diagrams, to those already explained.

For the sake of facilitating comparisons, our fig. 41—44, are all drawn to one scale. The annexed table explains best, the advantages gained in the new reconstruction.

	Old engines. Woolf's system.	New engines. Compound system.
Boiler-pressure	63 ℔.	63 ℔.
Mean pressure in small cylinder	26.1 „	28.6 „
„ „ „ large „	4.44 „	9.5 „
Indicated horse-powers by small cylinder	189.5 „	178.8 „
„ „ „ large „	113.5 „	249.4 „
Total indicated horse-power	303 „	428.6 „
Number of expansions	5.3 „	10 „

The steam is generated in six Lancashire-boilers each of $785^1/_2$ sq. ft. (73 sq. m.) heating surface. The steam-supply pipe (1) is 6" (154 mm.) in diameter, and the exhaust-pipe (16) $10^3/_4$" (275 mm.).

The valve gear of the high-pressure Cylinder is worked by the III. Corliss valve-gear arrangement, excepting that the bright turned dash-pots, instead of being placed below, are fitted at the side of the cylinder. The three main positions of the valve-gear mechanism are shown in fig. 4 Plate 3. The valves are here drawn in their mean or central position, which almost corresponds to the position of the engine crank shown in fig. 1, Plate 2; the valve-levers are at *a*, *b*, *c*, *d*, and the eccentric at *f*, whilst the crank is only about 16° off the dead-centre, so leaving the forward stroke of the piston still incompleted.

In the position of our fig. 4 (Plate 3), the right hand exhaust-valve is just about closing, whilst the other exhaust-valve is about opening. The extreme left position of the inlet valves is represented at $a_1 b_1$, the corresponding extreme right position of the exhaust-valves being shewn by $c_1 d_1$; similarly the contrary or opposite positions of these valves are denoted by $a_2 b_2 c_2 d_2$.

The throw of the gear-disc amounts to $9^1/_4$" (238 mm.), and corresponds to a lead-angle of about 9 deg.

The lineal lead of the inlet-valve is only $^1/_{32}$" (1 mm.), though the exhaust-valve is about $^1/_3$ open when the crank is on its dead-centre. The limit of the 'cut-off' not controlled by the governor, lies between 0.0 and 0.9 stroke. Whilst discussing the third Corliss-valve-gear, the limit of automatic cut-off actuated by the governor was put down at $^2/_5$ of the stroke; in

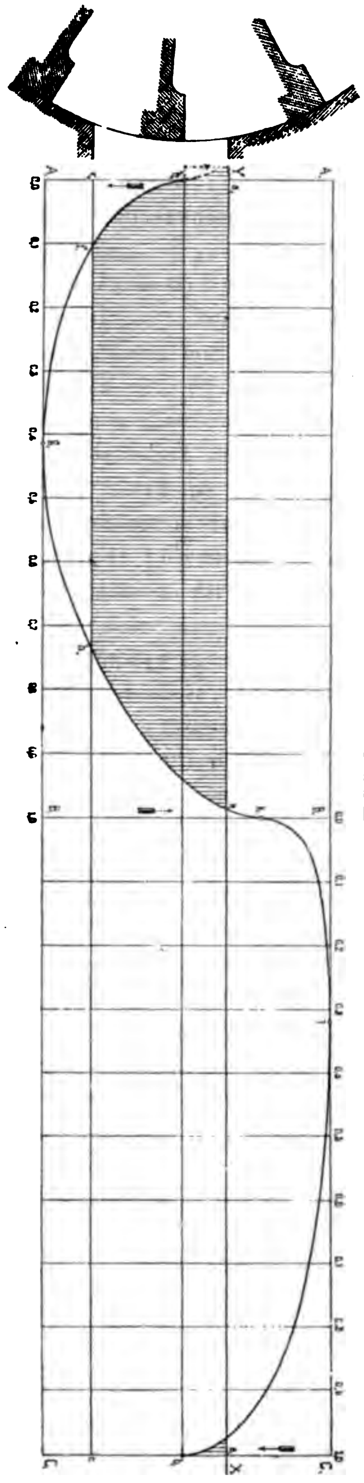

Fig. 45.

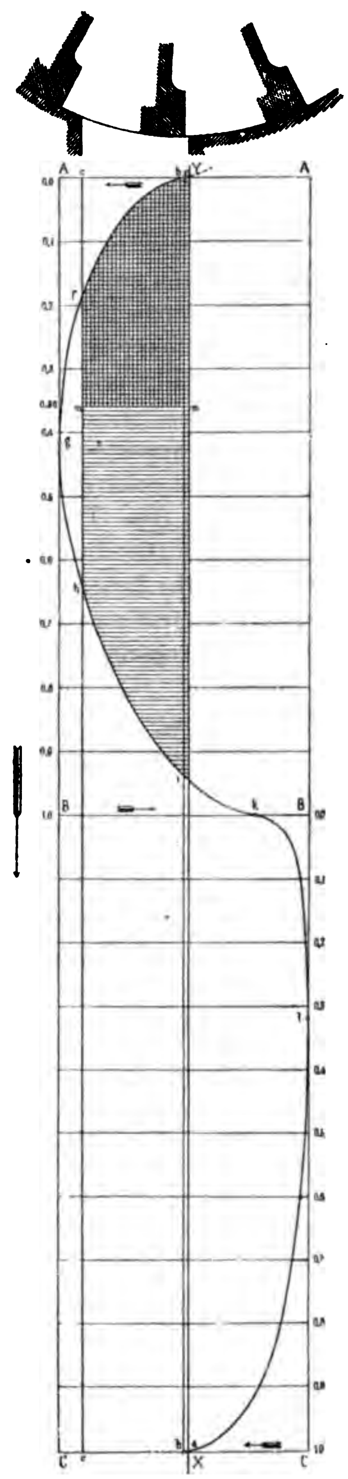

Fig. 46.

the engines now before us, a corresponding maximum cut-off, slightly in excess of half the stroke can be obtained, owing to the falling-periods of the weights being very accurately regulated. In this Müller engine-type, special care has been taken to effect a slow closing of the inlet-valves, — i. e. a rounding-off of the indicator-curves, as quick shut-offs, involve noise and excessive wear and tear; by this slow-closing, a silent-working of the engines is obtained, with very slight wear and tear.

The ratio of the width to the length of the inlet-passages is $^1/_{14}$, and $^1/_{11}$ for the exhaust-passage. Comparing the cylinder cross area to those of these passages, we should get $^1/_{17}$ for the inlet-, and $^1/_{14.2}$ for the outlet-passage.

The eccentric has a throw of $5^5/_8$" (140 mm.) corresponding to a lead-angle of 16°.

Porter's governor is here used on account of its great simplicity and sensitiveness.

The construction of the dash-pots may be seen from our drawing. As the lowest fall of the weight or piston still leaves a clearance of $^3/_8$" (9 mm.) of compressed air, the slide valve must therefore be so arranged, that the piston may shut it off, immediately compression is to take place. The lift of the bottom-valve is adjustable, and in this manner a silent and rapid fall of the piston is secured.

The high-pressure cylinder-exhaust-pipe (16) with which the branch-pipe (15) communicates, leads to a receiver and interheater (19) fitted with a manometer (20). In this receiver, the exhaust steam of the small cylinder is superheated by boiler steam from branch steam-pipe (2); the heating surface of this receiver is 247 sq. ft. (22,97 sq. m.). The condensed water is let-off by a water discharge-pipe (9). The low-pressure cylinder steam-supply pipe (17) is fitted with a small steam discharge-pipe (14) for the purpose of connecting the receiver with the exhaust of the large cylinder, and the latter is also furnished with a steam-trap (12) for automatic drainage and with a water discharge-pipe (28).

The superheated steam enters the large cylinder through the expansion valve-box (18) and the main-slide (27), and exhausts from the steam-pipe (25) — similarly connected with a small cylinder drainage-pipe (29) — into the condenser (24).

Both cylinders are furnished with all the usual fittings. The high-pressure cylinder steam supply-pipe is fitted with a Wilson's lubricator, and a manometer, both of which are screwed on to this pipe immediately over the throttle valve placed at the top of the small cylinder.

The steam-cylinders are entirely steam-jacketed through the branch-pipes 3 and 4, and the water-discharge-pipes 5 and 6. Pipes for indicator purposes (30) fitted with three way-cocks, and air-valve (13) attached to the steam-jacket of the low pressure cylinder, complete the cylinder-fittings. The water-discharge-pipes (5, 6, 7, 8 and 9) lead to a receiver (11) whence the condensed steam or water is passed off through pipe 10. The feed-pumps are shewn at (26).

The cylinders and all the steam-pipes are covered with Spencer-Boiler-Composition.

The cylinders are bolted direct to the foundation, and the ordinary top slide bars are dispensed with, the piston-block merely sliding in bottom guides.

The connecting rods which are about five times the length of the crank are forged with closed ends. The air and feed-pumps are driven from the low-pressure cylinder crank.

The main-slide of the large cylinder is worked from the eccentric rod (23), whilst the expansion-slide (18) is geared by link-work from an eccentric (22), fitted on the Corliss gear-side. The expansion eccentric-stroke may be regulated by an adjustable link-piece.

The transmission of the engine-power is effected by a toothed fly-wheel mounted midway between the two cranks. This wheel weighs $24^1/_2$ tons (25,000 Ko.) and is 23' (7000 mm.) in diameter and 10" (260 mm.) wide on the face; the teeth are set to 3" (75 mm.) pitch.*)

*) We may add that these engines were first erected in 1869 at the Pesther Walzmühle of Buda-Pesth, driving according to 'Engineering' 24 pairs of stones 50 in. in diameter, 102 pairs of rolls, $8^1/_4$ in. in diameter by $9^3/_4$ in. and the usual dressing machinery suitable for a daily production of 69 tons of flour. A greater power being required by the owners of the Mill, led to the above-mentioned re-arrangement of these engines.

b. Working with the IV. Corliss valve-gear.

William A. Harris, of Providence, U. S.

Although unable to confirm the opinion expressed in a trade-circular now before us, asserting that 'the Harris-Corliss-engine is the best of all engines', we have reason to devote further attention to it. In describing the fourth Corliss valve-gear, we explained the constructive principles of the Harris-Corliss engines, the details of which are clearly illustrated by Plate 4, though on account of not being able to procure working-drawings direct from the Engineers, the inscribed dimensions on Plate 4 will perhaps be found to differ from the original construction. It was only after the completion of our drawings that a descriptive Circular of the Harris-Corliss engine reached us, which certainly supplemented the data we had obtained from other sources. According to this Circular, these engines are constructed from 13 horse-powers upwards, and the small patterns show an extraordinarily long stroke equalling three times the cylinder-diameters. This proportion decreases however with the increased size of the engine, as may be seen on referring to the annexed table:

	Small powers.		Medium sizes.		Large (heavy) sizes.	
Cylinder-diameter in inches.	8	10	16	20	32	36
Cylinder-stroke in inches	24	30	48	42	60	60
Revolutions per minute	70	70	60	60	50	50

The piston-speed increases however, very irregularly from $4^1/_2$' (1,4 m.) to 8' (2,5 m.). According to the reports, with which we are favored, the Harris-Corliss works admirably at these speeds, and this fact probably accounts for the extended use which these engines enjoy in America, though their working principle has been abandoned by Corliss.

The general arrangement of the Harris-Corliss engines varies little from the IV. Corliss valve-gear. We meet here with the Corliss trunk-frame again, which though not cast in one piece with the crank-shaft support, is nevertheless bolted to it and to the cylinder. The cross-head slide is V-formed, with a view no doubt of either evading Corliss' patent rights, or of laying claim to some originality.

Similar to the original Corliss-type, the ordinary Watt's governor is placed in the middle of the cross-head slide. The governor acts on a bent lever, the two extremities of which are separately connected with the inlet-valves by two rods effecting the disengagement of the trip-gear when necessary; the application of two rods is owing to the symmetrical arrangement of the valve-gear.

In order to prevent too great a throw of the eccentric, its motion is transferred to the gear-disc by an intermediate lever.

The construction of the valve-gear has already been fully described on pages 13 *et. seq.* which will be further explained by our figs. 7 and 8 on Plate 4.

The Inlet- and Exhaust- slides are shewn in figs. 5 and 6. Small spiral springs are used for keeping the slides tight on their working surface. The packing of these valves is effected by inserted rings, etc.; to drain off any condensed steam, the otherwise closed hollow valve-spindle bearings are provided with water-outlets.

The internal arrangement of the valve-gear, when in the position shewn in fig. 2, is represented in our fig. 4, the inscribed reference letters being the same as those used on page 29 when describing the Müller-engine. For preventing any wrong impression, it may be observed that the valve lever of the left inlet-valve, is shewn as rigidly connected with the motion-rod, whereas the valve itself is disengaged and represented in its extreme left-position.

Ignoring the length of the cylinder, and the other dimensions depending thereon, our illustration on Plate 4, will be found to show very few discrepancies — if any, with the original Harris-Corliss engine. To correct our drawings we should have to show the inside cylinder-length 4' (1220 mm.) in place of the 3' (950 mm.) and to prolong our slide-bars and rods accordingly, in order to obtain a 81 horse-power Harris-Corliss-engine of 16" cylinder diameter, 3' 6" stroke, running at 60 revolutions per minute, and working at 75 lbs. pressure.

Robert Wetherill & Co. of Chester, U. S.

The engineering firm of Messrs. Robert Wetherill & Co. were the sole exhibitors of the Harris-Corliss engine at the Centennial Exhibition. They exhibited a Horizontal Steam-engine of the type represented in our Plate II.

These engines do not greatly differ from the Harris type just described. In our fig. 21, on page 14, we have represented the somewhat altered form of the trip-gear or disengagement-fork, and we similarly note, that the bearings of the valve-spindles are constructed in a different manner, to that we described in the Harris-engine. The main characteristic is however, the peculiar construction of the governor.

The cylinder-diameter and the stroke of the engines exhibited, were respectively 12" (305 (?) mm.) and 2' (610 mm.).

In the engines now under discussion 'Watt's governor' is used with a compensating spring. The sliding collar is retained as in the ordinary construction, and this remark similarly applies to the transmission of its travel on to the inlet-valves, through the three armed lever plainly shewn in fig. 1 (Plate II). The same rod working this lever, has two loose bevel-wheels which are driven by a third bevel-wheel as shewn. The two bevel-wheels, thus revolve in contrary directions to each other, and between them a clutch-box is keyed fast to the vertical rod. The two inside surfaces of these bevel-wheels are moreover furnished with protruding pegs, which correspond to a slotted groove in the clutch-box. The lower-end of this vertical rod is attached to the regulating lever by means of a screw-joint, which is obtained by the lower end of this rod working in a nut attached to the vertical lever arm. From this description it follows, that the rising or falling of the rod, will act on the regulating lever, whilst simultaneously, the rod will commence revolving in the direction of the upper or lower bevel-wheel, owing to the pegs of the top or of the bottom bevel-wheels coming in contact with the grooves of the clutch-box fitted fast on the vertical rod; the revolving of the latter, will similarly alter the position of the nut, and consequently that of the lever.

The working of the governor is as follows: Supposing the engine is running away, the vertical rod will be lifted, and the trip-gear so becomes relieved. Simultaneously the pegs of the upper bevel-wheel grip into the clutch-box and so cause the rod to revolve with the top bevel-wheel, which rotation has the additional effect of causing the bottom nut to rise, and so to increase the motion of the regulating-lever. After thus throttling the steam, the engine would resume its normal working speed, and though the governor-balls would fall, the movement of the regulating lever would not entirely follow the travel of the governor-collar, on account of the vertical rod being shortened, from the rising of the nut. In other words, a cut-off would approximately be maintained, corresponding to the working-load which caused the governor to react.

The Wetherill governor thus secures a uniform engine-speed, and whilst allowing the governor to return to its normal position, it retains the relieving-rods in the position they acquire, through the action of the governor.

According to Prof. Radinger's report, the action of this governor is remarkable. After a few vacillations of the governor-balls, causing a slight alternate vertical motion of the collar as well as a reciprocating rotary movement of the vertical rod, the governor soon secures its steady working, by finding the proper position of the relieving-rods; it thus exactly proportions the cut-off, to the normal engine-speed.

Prof. Radinger states that he saw engines working with this governor, experience sudden take-offs and put-ons of the load, when he noticed the governor to act instantaneously on the valve-gear. The governor then proceeding to turn the vertical rod quickly, a number of very delicate rotations brought the nut in the proper position corresponding with the engine-requirements, after which the governor continued to rotate steadily.

It would be well, if this mechanism allowing itself to be applied in various arrangements, were more generally introduced amongst engines working with automatic variable expansion gear; for then no doubt, a degree of perfection would be attained, which would fall little short of the theoretical ideal.

C. Working with the V. Corliss valve-gear.

'Wilhelmshütte' Machine-works near Sprottau.

As far as we are aware, the engines built by this firm, show little difference from the original Corliss-construction, which we described on pages 13 et seq. and illustrated by fig. 24—31. The reason of their superiority over many other engine-types, is attributed to the exactitude of manufacture, which this firm displayed, at a time, when good material and precision were not considered absolutely essential.

E. Reinicke of Königsberg.

A somewhat peculiar Corliss-engine type was exhibited at Vienna, in 1873, by E. Reinicke of Königsberg, which we illustrate on our Plate III (fig. 1—3).

In the first place, it differs from the Corliss-original by the introduction of an I-shaped foundation-bed inserted beween the cylinder and the valve-gear, somewhat after the manner represented on our Plate I. In our opinion, the use of such a beam is far more justified in the first-named example than in the present engine; for in that arrangement, all the machine parts were bolted to this beam resting on a firm foundation, — thus forming the bed-plate of the engine, — whereas in the present engine, the corresponding beam merely forms a connection between the cylinder and the crank-bearings, which are bolted separately to the engine foundation. It is true, the fifth Corliss valve-gear shows the same arrangement, because on account of the trunk, the cylinder and crank-shaft bearings are alone bolted to the foundation; in this case, the trunk is either cast in one piece with these parts, or it is so rigidly connected as to make the whole appear as one.

In the example before us, the trunk is bolted to the cylinder by 10 screw-bolts, though the drawings placed at our disposal, do not show what provision has been made, to prevent these bolts from being shorn asunder. The guide-block runs in single slide-bars. The valve-spindles are remarkably long, and in the place of the forementioned supports, elliptical plates are used which are screwed to the trunk, and through which the valve-spindles are made to pass. It is needless to observe that the fitting up and dismounting of the machine is thereby rendered all the more difficult; and in our opinion the greater accessibility so gained to the piston, is too dearly bought.

The constructive details of the valve-gear, favor the Corliss-original, and they are well proportioned. In order to ensure the action of the trip-gear, small weights are added, though it is rather singular, that the spindle-levers of the inlet-valves are placed pointing upwards, as it necessitates the whole arrangement to be kept somewhat high.

The engine is worked on the condensing principle, the horizontal air-pump being placed behind the steam-cylinder. Running at 40 revolutions per min. with a stroke of 2' 10" (860 mm.) and 1' 5" (432 mm.) cylinder-diameter the power of these engines is stated at 42 HP.

In the machine exhibited, an extra toothed wheel was keyed on to the crank-shaft at the side of the strap fly-wheel, (12' 2" in diam. and 12" on the face), for transmitting a portion of the engine power.

The "Gräfl. Stolberg-Wernigerode" Factory, Ilsenburg.

The engine similarly exhibited by these machinists at the Vienna Exhibition of 1873, bore greater resemblance to the Corliss-original, than the engine last described: this may be seen on referring to Plate 5, (fig. 1 and 2).

The cylinder, valve-box, and cylinder-legs are cast in one piece, and the trunk, slide-bars, and crank-shaft-bearings (similarly cast together) are bolted to the front cylinder-cover. The slide-bars are Y-formed; the form of the trunk is scarcely recommendable.

The valve-gear, greatly projecting outwards, does not make a favorable impression. The arrangement resembles the one adopted by Reinicke: on the other hand Reinicke's gearing parts and especially the Y-frame are so proportioned, that the high placing of the valve-gear is easily accounted for. In our present engine-type on the contrary, the distance from the foundation is so great, that no reason can be assigned for the high building-up of the valve-gear.*)

The constructive details too, show certain deviations, which can only be accounted for, by presuming that a change was merely desired. The characteric Y-frame, appearing as support for the whole of the gear-mechanism in the original Corliss-construction is totally ignored, and in its place, we find the gear-mechanism attached to three separate brackets, bolted to the trunk. It is evident that by such an arrangement, neither the durability is increased, nor is the engine-construction simplified. We should observe that the plate fitted on the regulator-lever for working the trip-gear, can be adjusted to a nicety, by set-screws.

The longitudinal section of the cylinder differs from the ordinary construction by the scanty allowance made for the valve-box, which is not rectangular, but circular in section. For the reception of an unusually long stuffing-box, taking up the hind projecting portion of the piston, the end cylinder cover is much bellied outwards. In the place of the ordinary crank, a balanced crank-disc is used. The arranging of the condenser and of the air-pump, may be seen from the drawing.

The engine is described as of 45 horse-power making 55 revolutions per minute. Its cylinder-diameter is 1' 6" (445 mm.), and the stroke = 2' 6" (800 mm.). The fly-wheel diameter is 12' 10" (3900 mm.): a driving pulley 11" (280 mm.) wide on the face, is bolted to its arms for transmitting the engine-power.

Erste Brünner Machine-works Co. Lim. Brünn.

A third Corliss-engine, which became more generally known by the Vienna-Exhibition of 1873 is illustrated on Plate 5, and fig. 47. It was built by the Erste Brünner Machine-works Company Limited of Brünn, and is considered one of the best interpretations of Corliss-engines. The whole design as well as the carefully devised details, produce a most favorable impression on the observer, which impression becomes in no wise lessened by a more exact examination. The simple yet solid engine parts and the judicious free arrangement of all the constructive details largely contribute to the beauty of the engine-design.

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*) The latest authorised Corliss-engine constructions, work without exception, with the gear-disc centre placed in a horizontal plane through the cylinder-axis.

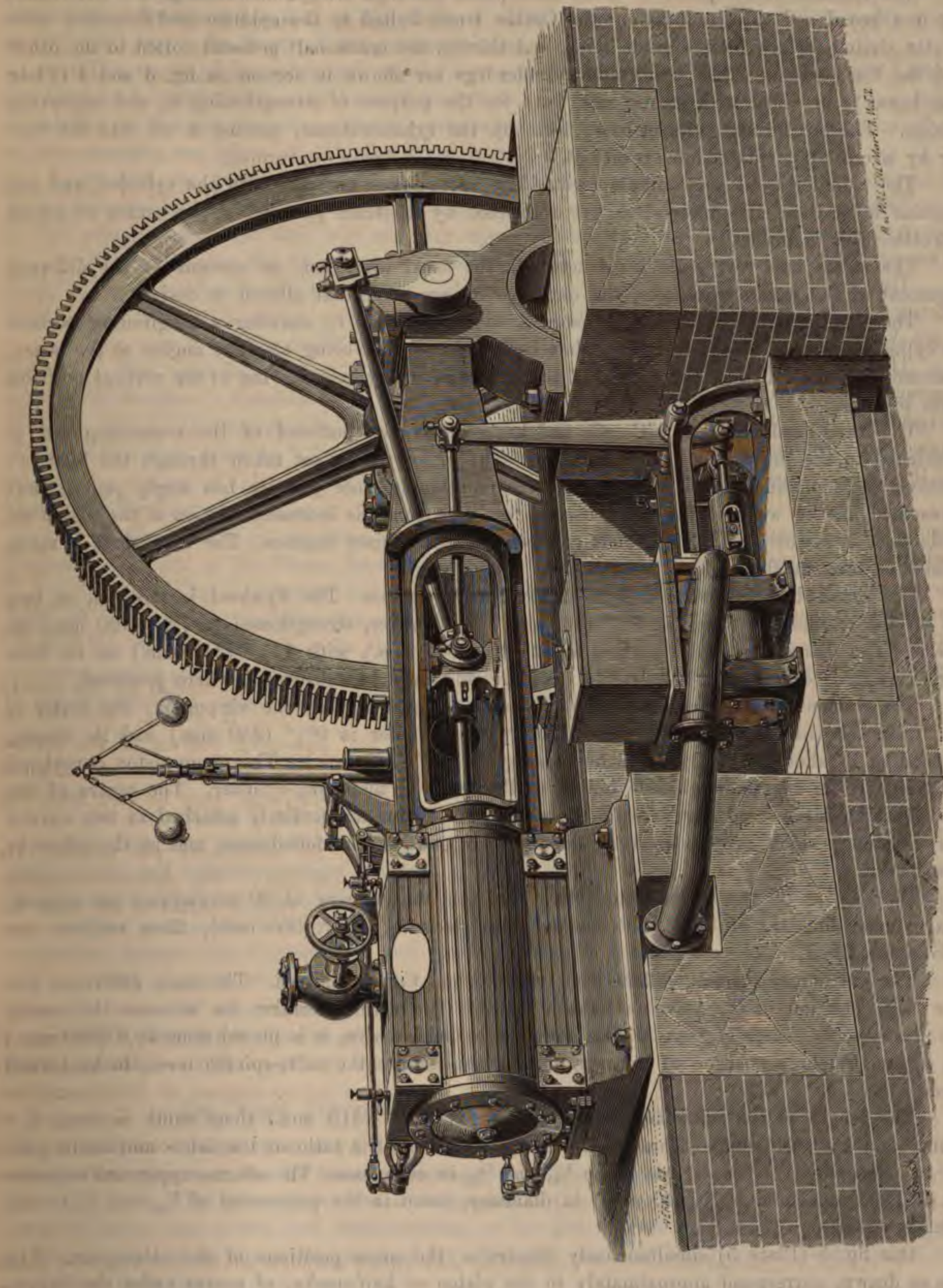


Fig. 47.

The machine is composed of three main pieces namely: the cylinder resting on a box-frame, giving it a broad and solid foundation: the Corliss trunk bolted to the cylinder and furnished with a circular sliding-surface for the guide-block, and thirdly, the crankshaft pedestal bolted to the other end of the Corliss-beam. The trunk and cylinder-legs are shown in section in fig. 3 and 4 (Plate 5); the beam is provided with strong ribs, both for the purpose of strengthening it, and improving its design. The box-formed cylinder-base, takes up the exhaust-steam, passing it off into the condenser by a cross-pipe placed underneath it.

The cylinder is of very simple form. The valve-boxes are cast with the cylinder, and are rectangular in section; the inlet-valves are connected by a steam-passage, in the centre of which the throttle-valve is placed.

The steam inlet-valves are constructed in the usual way, but on account of the different arrangement of the exhaust-passages, the outlet-valves are somewhat altered in design.

These outlet-passages, as may be seen from fig. 5 (Plate 5) shewing a longitudinal section of the cylinder, are placed opposite the exhaust-ports, instead of being at right angles to the latter. The advantage gained lies in the more rapid drainage of the cylinder, owing to the vertical position of these passages.

The cross-head is fitted with gib and key, whilst the butt-end of the connecting rod is also fastened to the piston-rod by gib and key. The piston-rod is not taken through the hind cylinder-cover; this modification is all the more recommendable since practice has amply proven that the presumed uneven wear of the cylinder-core resulting from the increased friction of the piston on its underside, is almost 'nil' with small and even moderate-sized engines. The crankshaft is made five times as long as the crank.

The crank-shaft is arranged with ample bearing-surface. The flywheel is mounted in two halves on the crank-shaft which is $6^{1}/_{4}$" (162 mm.) in diameter, strengthened to $7^{3}/_{8}$" (190 mm.) at its necks. The diameter of the fly-wheel is 12' 2" (3800 mm.), with $13^{1}/_{2}$" (345 mm.) on its face. Though arranged to serve for belt-driving, teeth-gearing may be substituted where preferred.

The condenser, arranged under the engine, is connected with the air-pump. The latter is worked from the cross-head by link-work. The pump-diameter is $9^{3}/_{4}$" (250 mm.) and its stroke, corresponding to about $^{1}/_{10}$ of the cylinder-capacity is $9^{3}/_{8}$" (240 mm.). The pump-piston cross-head works similarly in a cylindrical slide bolted to the front of the pump-cylinder. The centre of the vertical rocking-lever used for driving the pump, is somewhat peculiarly attached to two curved cast iron-beams, which are fastened at one of their ends to the foundation, and at the other to the condenser.

Working at 60 lbs. above atmospheric pressure and running at 60 revolutions per minute, with a cylinder-diameter of $15^{3}/_{8}$" (395 mm.) and a stroke of 3' 1" (950 mm.), these engines are said to equal 30 IP.

The valve-gear scarcely differs from the original Corliss pattern. The main difference lies in the high position of the valve-mechanism towards the cylinder-centre; for whereas the centre of the gear-disc is generally kept in line with the cylinder-centre, it is placed some $7^{3}/_{4}$" (200 mm.) above it, and the high position of the motion-rods, necessitates the valve-spindle levers to be turned upwards.

The length of the inlet- and outlet-passages is $12^{1}/_{4}$' (315 mm.) their width is resp. $^{3}/_{4}$" (20 mm.) and $1^{1}/_{8}$" (30 mm.). These dimensions, thus show, the ratio of the inlet- and outlet-passages to the cylinder cross-section to be $^{2}/_{39}$ and $^{1}/_{11}$ in each case. The steam supply and exhaust-pipes, 4" (105 mm.) and $5^{3}/_{8}$" (140 mm.) in diameter, stand in the proportion of $^{1}/_{14}$ and $^{1}/_{8}$ to the cylinder cross-area.

Our fig. 5 (Plate 5) simultaneously illustrates the main positions of the valve-gear. The valves as drawn, correspond approximately to the piston at half-stroke, of course under the supposition that no disengagement has taken place. The gear-disc is drawn in its extreme position towards the cylinder, and is just on the point of reversing its motion. The travel of the gear-disc is $7^3/_4$" (200 mm.), the throw of the eccentric being made to correspond with it.

The travel of the inlet- and outlet-valves, or the travel of the working edges *b* and *d* of the inlet- and outlet-valves, may be seen in our fig. 7 and 7a (Plate 5); they are drawn half-size, in relation to the piston-stroke. These curves were drawn under the following conditions: the lead of the eccentric was given at 13°, the lineal lead (ab) of the inlet-valve was quoted at $^1/_{16}$" (1,5 mm.), and with the valve-gear placed in its central position the working edges of the exhaust-valves were presumed to be closed against the ports, inasmuch as the two exhaust-valves must be shut in this position, in order that only one may open, on the arrival of the crank on its dead centre.

In representing the diagrams by a closed curve, we have somewhat departed from the method, we have previously adopted; but in order to obtain an accurate diagram, the curve has been fixed by a succession of points, corresponding to the crank travelling through successive spaces of 10°.

The very favorable distribution of steam in this engine, becomes at once apparent from the diagrams. For, according to fig. 7, the inlet-port is already fully open at $^1/_6$ of the stroke, and its extreme declination is attained at (g) corresponding to $^9/_{20}$ the stroke, though the limit of the admissible cut-off only corresponds to $^2/_5$ of the stroke. In our fig. 7a, we obtain a lineal lead ($a_1 b_1$) of the outlet-valve equal to $^5/_8$" (8 mm.). The port is fully open at f_1, or at about $^1/_5$ the piston-stroke; the closing of this port begins at h_1 and is entirely shut-off at i_1. Thus, complete compression will only take place close to the piston-stroke end.

In fig. 6 (Plate 5), we show a Corliss-engine driving a high-lift pump as exhibited by the forementioned firm at the Vienna International Exhibition. We may here observe, that the trip-gear is not acted upon by a governor, but by hand, which modification is rendered possible, owing to the load not varying, thus enabling the engines to work at a uniform degree of expansion. The valve-gear of the steam-cylinder is quite similar to the gear just described, though in the last named arrangement the steam-cylinder-bore is $19^1/_2$" (500 mm.) whilst the pump-cylinder is $11^3/_4$" (303 mm.) in diameter, with a stroke corresponding to 3' $7^1/_8$" (1106 mm.).

J. Körösi, Andritz near Graz.

On Plate 6, fig. 1 and 2, we illustrate the Corliss engine-type as constructed by Mr. J. Körösi of Andritz near Graz. The section through the cylinder shows a simple arrangement. The steam inlet- and exhaust-passages are kept narrow, and are almost as long as the cylinder-diameter The cast-iron valves are provided with brass spindles, which are carried by the usual bearings.

The piston-slide is V-grooved, and the cross-head is rendered adjustable by screws. The connection between the Corliss-beam and the cylinder, may be seen from our drawings.

With a stroke of 2' $9^3/_4$" (863 mm.) and a cylinder-diameter of $16^1/_4$" (418 mm.) these engines are run at 60 revolutions per minute.

We refer the reader for additional details to our illustrations, as the chief dimensions are there inscribed.

The 'König Friedrich August Hütte' Potschappel near Dresden.

At the Dresden Industrial Exhibition of 1875, the 'König Friedrich August Hütte' exhibited a very fair specimen of a 20 nominal horse-power Corliss-engine, to which we likewise refer on Plate 6 fig. 3. The latter shows the arrangement of the valves and the valve-gear, and it forms, without doubt, one of the best interpretations of the fifth Corliss valve-gear. We desire especially to direct attention to the arrangement of the valve-gear, as being highly recommendable and worthy of further imitation.

The engine has a cylinder of $12^1/_2$" (320 mm.) diameter and a stroke of 2' 1" (640 mm.); we are unfortunately unable to mention its working speed. The greater portion of the main dimensions are inserted on our fig. 3.

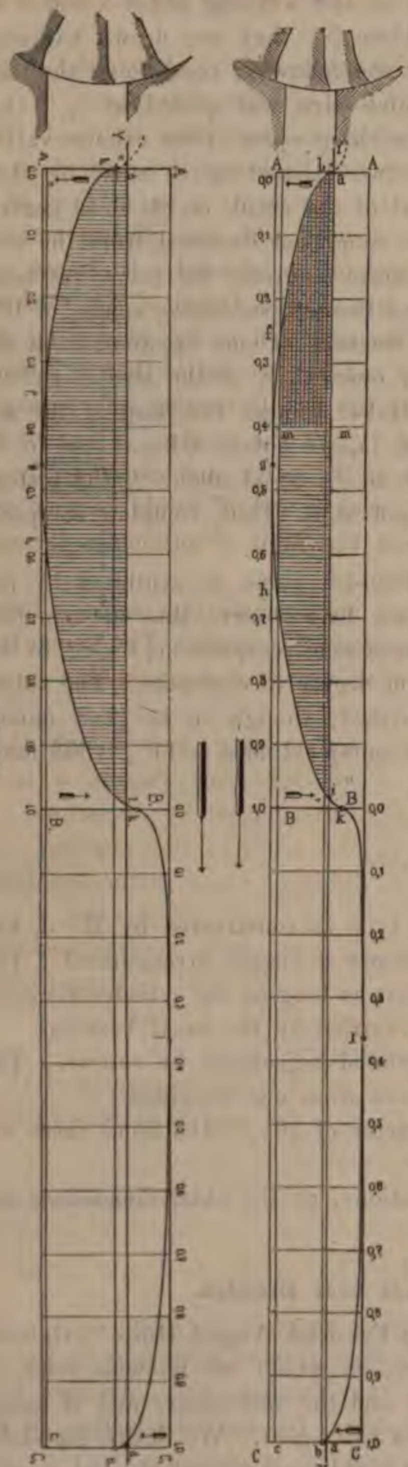


Fig. 48. Fig. 49.

Weise & Monski, of Halle a. S.

Messrs. Weise & Monski of Halle a. S. have of late designed and constructed small Corliss-engines, an example of which we illustrate on Plate 6.

The general arrangement of these engines is represented in fig. 1 and 2 and barring certain subordinate details, which slightly prejudice the sound appearance of these engines, the design may be pronounced good. Amongst such secondary defects, we allude in particular to the very weak cylinder-carriers, and the unproportioned deep spring-blades.

A steam-engine more than any other machine, should possess elements of great stability and it is no doubt owing to this fact, that the old massive engine-bed has even at the present time, many admirers. Though we do not view the Corliss-trunk with the displeasure of many engineers, still we consider one of the first essentials of a good engine-design to consist in a firm- and stable-looking frame, and if the ordinary box-pattern-bed is superseded, the cylinder should at least be supported on strong broad-carriers, much in the same style as we saw adopted by the 'Erste Brünner Actien-Gesellschaft' (vide Plate 5).

If, in this respect we cannot but find fault with the Corliss-engine of Messrs. Weise & Monski, we are all the more ready to award them praise for the remaining constructive arrangement of their Corliss-engines; the valve-gear especially, both by its outward appearance, and in matters of detail, may be classed as one of the best arrangements of its kind.

The cylinder is neatly proportioned, and its connection with the Corliss-beam appears well adapted and pleasing. This may be best seen from the horizontal section of the cylinder — vide fig. 1, Plate 7 —, where the trunk is shewn bolted direct to the front cylinder-end. It will be noticed, that the front cylinder-cover is dispensed with, a modification which is certainly advantageous.

The Corliss-valves are arranged in the usual manner; to ensure greater working accuracy, additional bearing surface is given to the inlet-valves by an extra metal strip on their left side (fig. 1, Plate 7). The bracket-supports of the valve-spindles, which are cast in one piece with the valve-box covers, are commendable; they are not made in the ordinary bottle-shape, but they are shell-formed open at the top-side, thus not merely affording greater accessibility to the valve-spindle stuffing box, but also serving as a catch-oil receptacle.

The diameter of the cylinder is $13^1/_4$" (340 mm.), the stroke is 2′ $3^1/_4$″ (700 mm.) and the working speed is quoted at 65 revolutions; the engine is supposed to work at 25—30 horsepower, with 90 lbs. steam in the boiler.

The steam-inlet- and outlet-passages are respectively $^3/_4$″ (20 mm.) and $1^1/_8$″ (30 mm.) wide and $9^3/_4$″ (250 mm.) long, which thus give a proportion, in the first named, of $^1/_{18}$, and in the second, of $^1/_{12}$, in relation to the cylinder cross-area.

The steam-inlet- and outlet-pipes are respectively $3^1/_8$″ (80 mm.) and 4″ (105 mm.) inside diameter, thus shewing in each case a ratio of $^1/_{18}$ and of $^5/_{52}$ with the cylinder cross-area.

The main positions of the valves are drawn in fig. 8, Plate 7. The lines shewn in full correspond to the position of the crank on its left dead centre, *ab* and *cd* being the connection to the inlet- and exhaust-valves. Our fig. 8a shows the position of the eccentric to be at *f*, or at a lead angle equal to 10°; the corresponding position of the gear-disc is at *e*, with the different motion-rods somewhat removed from their central position. The lineal lead of the inlet-valve is almost $^1/_{16}$″ (2 mm.) and the lineal lead of the outlet valve equals $^1/_8$″ (4 mm.). The travel of the working edge of the inlet- and exhaust-valves in relation to the piston-stroke is drawn in fig. 48 and fig. 49. If we compare these diagrams with those given on Plate 5 (fig. 7 and 7a), we notice that in Messrs. Weise & Monski's engine, the eccentricity or the valve-travel is too small, causing the passages to open too slowly. The limit of automatic disengagement lies at $^{15}/_{32}$ of the stroke. It cannot be carried out so far in practice, as on account of the movement of the valve, and consequently of the disengagement tackle being so slight towards the stroke-end, such a cut-off would become uncertain in its working; for this reason, it is advisable to restrict the limit of automatic disengagement to $^2/_5$ of the piston-stroke.

The throw of the eccentric is $6^1/_4$″ (160 mm.), and as no intermediate link work is introduced between it and the gear-disc, the rocking-motion of the latter is as great. The connection between eccentric rod and gear-disc is direct, and not by the intervention of a crank such as we have seen used in figure 24 (page 16).

The spring-blades, as we have already observed, are exceedingly long, and though their length may contribute to their greater durability and certainty of working, they require a small race to clear their bottom ends when rocking. These spring-blades are adjusted by set-screws.

Pröll's governor fitted with oil-brake is used for regulating the speed of this engine.

The Corliss-trunk is cast in one piece with the crank-shaft bearing, which, with such small engines appears quite in order. Characteristic is the construction of the connecting rod-end.

The crank-shaft 6″ diam. (155 mm.) at its bearings is furnished with several necks to facilitate the mounting of the eccentric, and the fly-wheel, etc. The crank-shaft bearing surface is $9^3/_4$″ (250 mm.) wide, and the pedestal bearing on the other side of the fly-wheel, is $11^1/_4$″ (290 mm.) wide.

The flywheel which is arranged for belt-driving is 11′ $4^1/_2$″ (3500 mm.) in diam. and $11^3/_4$″ (300 mm.) on the face. The additional dimensions of these engines may be read from our working drawings.

3. Spencer and Inglis' automatic, variable expansion-gear.

In 1863, Messrs. Spencer & Inglis introduced an automatic variable expansion-gear. The latter, though retaining the Corliss principle, and resembling the third Corliss valve-gear in the arrangement of the motion-rods, and in the rocking gear-disc on the cylinder-centre, deviates from the original design in the disposition of the disengagement tackle. By the introduction of air-cushions and springs, a far more complete arrangement of the valve-gear is obtained.

This valve-gear, made its first public appearance at the Paris Exhibition of 1867. The engine, to which it was fitted, was exhibited and built by Messrs. Hick Hargreaves & Co. of Bolton, who adopted the Spencer & Inglis valve-gear and who are still turning out a large number of engines fitted with this gear, with some later improvements in the valve arrangement.

The arrangement shewn in 1867 differs however, in no material respect from the construction adopted at the present time, and this fact appears to prove, that the experience gained during these years warrants the soundness of the original design, as requiring little need of improvement.

In fact, we find in the Spencer & Inglis valve-gear an arrangement which answers all the conditions required of a good automatic variable expansion-gear. For it is certain in its action, and of a durable character, offering easy accessibility. No similar valve-gear has been so readily and favorably received, and it may be affirmed, that until recently, the Spencer & Inglis valve-gear was the one most generally introduced.

Fig. 50 shows part of a Corliss-cylinder in elevation, fitted with Spencer & Inglis valve-gearing. The central wrist-plates give motion to the steam-valve-rod E and to the exhaust valve-rod E_1. In this example the steam- and exhaust-valves are worked separately by separate eccentric rods B and B_1. The steam-valve is opened against the resistance of a spring contained in the dash-pot o, and the steam-valve double clip liberating rod E is made in two parts, connected together by the spring-clips. When the clips are raised by the double toe-lever P, the part connected to the valve-lever L is instantly drawn back by the springs and the steam cut-off from the cylinder; R is the rod which fixes the position of the toe-lever, the position of which is varied by the governor acting on the rod M. Fig. 51 is a drawing of the same parts of the valve-gearing but it shows the liberating valve-rod with the clips raised, the valve-lever pulled back and steam cut-off. Fig. 52 is a detail of Spencer & Inglis' double clip liberating valve-rod, partly in section. It shows the rod in two parts one within the other connected by the clips and free when the clips are raised, to separate. Fig. 53 is a plan of the liberating valve-rod.

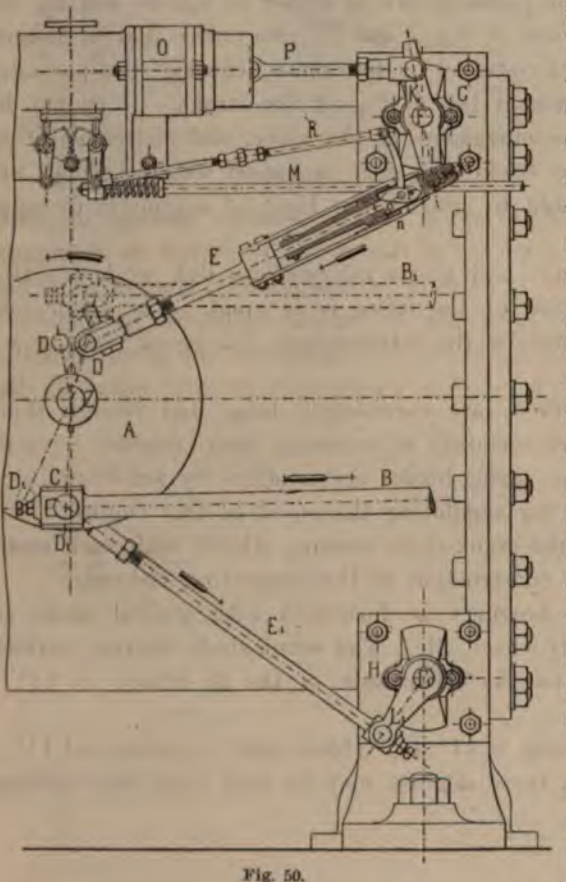


Fig. 50.

As has already been observed, the arrangement of the valves, motion-rods, and of the gear- or wrist-plate, in the Spencer & Inglis expansion-gear is identical with the third Corliss valve-gear. Consequently we here obtain a similar distribution of steam, etc. On the other hand, the clip- or disengagement-gear, appears of more rational design than the original Corliss-type, because the clip of the catches is not merely one-sided as the motion-rod is clipped simultaneously on both sides, so giving it greater certainty of action. No complaint on this score has yet become public, although the trip or clip arrangement of other valve-gears — especially of the fifth Corliss valve-gear — is often found deficient in this respect, so naturally damaging the chief advantage to be gained by the adoption of self-acting variable expansion-gears.

A close inspection of the Spencer & Inglis valve-gear, displays at once the completeness of its design, and shows that, if it is constructed with good workmanship, the mechanism will work for years without needing stoppage or repairs.

As shewn in fig. 50 and 51, and more especially in fig. 52 and 53, the motion-rod of the inlet-valve is made in two parts, telescoping into each other, one end of which is connected with the wrist-plate, whilst the other extremity is rigidly connected with the inlet-valve. The first of these (*E*) termed the double-clip liberator-rod, rocks on the pin *D* of the wrist-plate *A*, and ends in a cylindrical formed rod *e* which in its turn, is made to fit exact in a sleeve *T* of the upper part of the motion-rod. To the square boss of the lower portion of the rod *E*, two spring-clips are bolted, which are furnished with catches or clips (*nn*) towards their extremities. The upper sleeve-formed part of the motion-bar, has catch-plates (*oo*) into which the clips (*nn*) gear, when the two parts of the motion-bar have sufficiently approached each other. When thus in gear, the motion-bar may be considered as one rigid piece, the spiral spring *O* to which we shall again refer, constantly tending to keep the part *T* of the motion-bar in tension. This spring is thus constantly tending to close the inlet-valve, so that it will only be necessary when cut-off of the steam is desired to disengage the double spring-clips from the catch-plates *oo*. This is done by a cam-piece *r* (marked *R* in fig. 52) which swivels on a pin placed inside the sleeve-portion of the motion-bar. The cam is connected with the governor by link connection *r*, and thus according to the declination of the governor-balls, the cam will assume various positions. It is self-evident, that disengagement will ensue all the

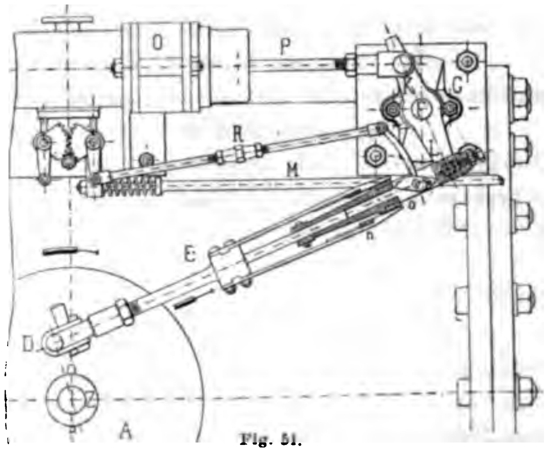


Fig. 51.

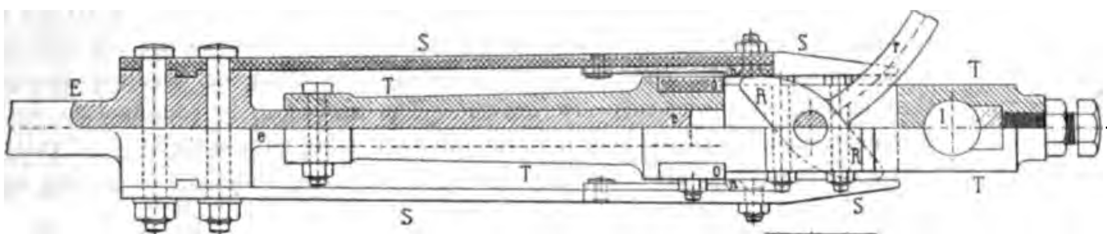


Fig. 52.

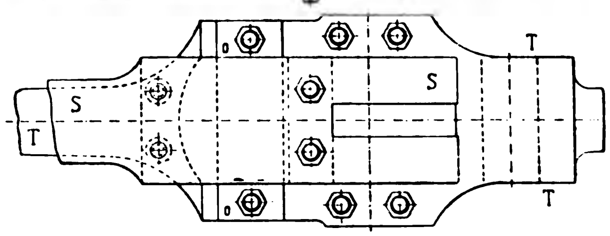
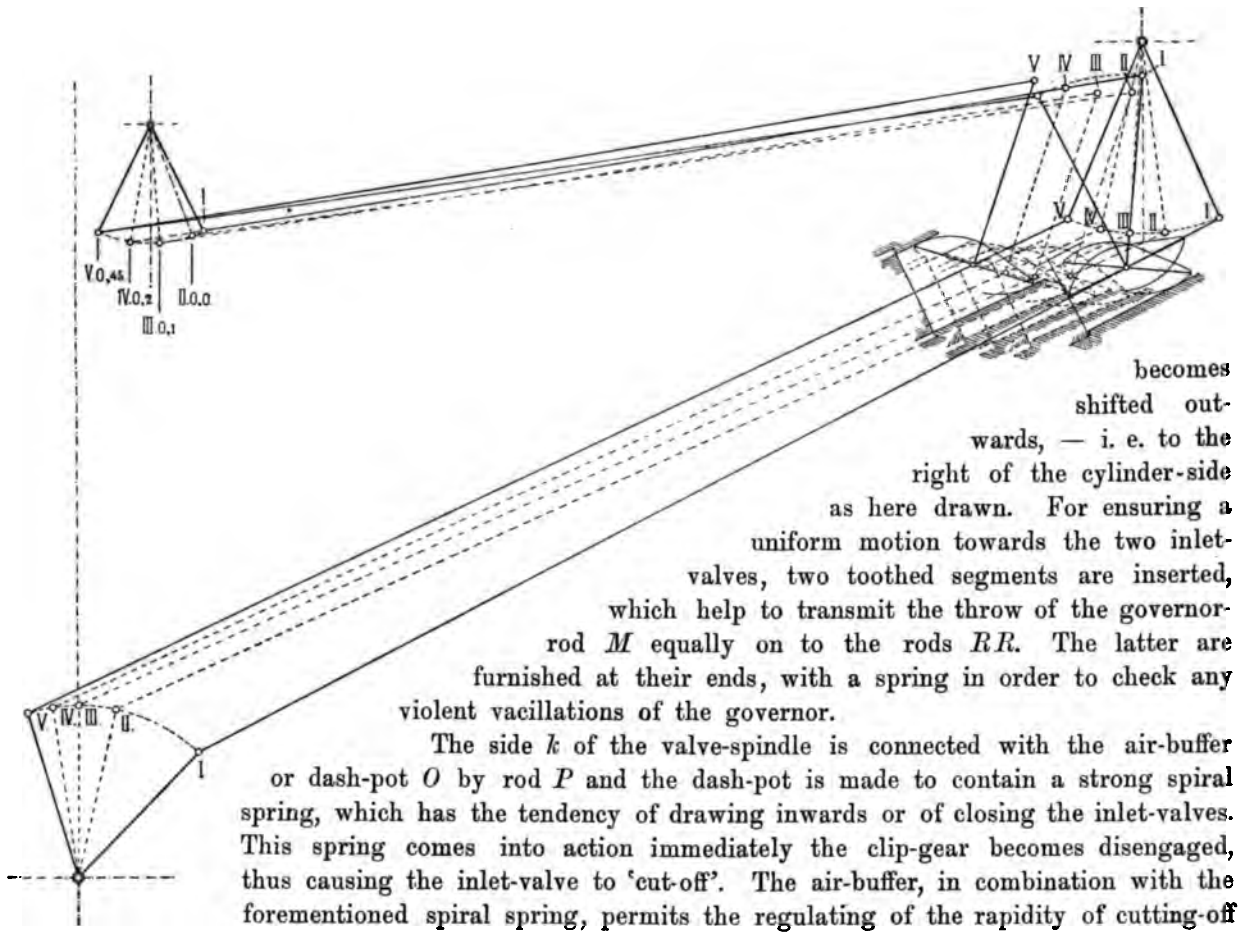


Fig. 53.

sooner, the more the cam *R* is placed cross-wise on the motion-bar axis. The swinging action of the motion-bar, in which the cam-pin takes part, brings about this cross-wise position; consequently the later the cut-off is desired to take place, the more must the longitudinal axis of cam and motion-bar coincide with each other at the beginning of the stroke, and vice versa. The working of this mechanism will be best understood on referring to fig. 54, which diagram indicates all the different relative positions of the wrist-plate centre, of the steam-valve-rod and of the valve-lever and the toe lever, which trips out the catches. The double motion of the cam-piece certainly complicates the diagram, alone if the various inscribed figures are followed, it will not be difficult to trace the different relative positions.

The figure shows, that disengagement will sooner ensue the more the governor-rod *R*



becomes shifted outwards, — i. e. to the right of the cylinder-side as here drawn. For ensuring a uniform motion towards the two inlet-valves, two toothed segments are inserted, which help to transmit the throw of the governor-rod *M* equally on to the rods *RR*. The latter are furnished at their ends, with a spring in order to check any violent vacillations of the governor.

The side *k* of the valve-spindle is connected with the air-buffer or dash-pot *O* by rod *P* and the dash-pot is made to contain a strong spiral spring, which has the tendency of drawing inwards or of closing the inlet-valves. This spring comes into action immediately the clip-gear becomes disengaged, thus causing the inlet-valve to 'cut-off'. The air-buffer, in combination with the forementioned spiral spring, permits the regulating of the rapidity of cutting-off and simultaneously prevents the moving parts from knocking or jarring against each other.

Fig. 54.

Fig. 55 and 56 show the construction of the dash-pots. The arrangement of the steel-spring for closing the valve and effecting the cut-off is especially shown in fig. 55. The piston which

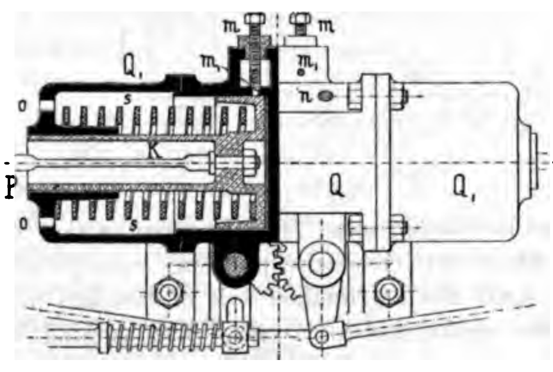
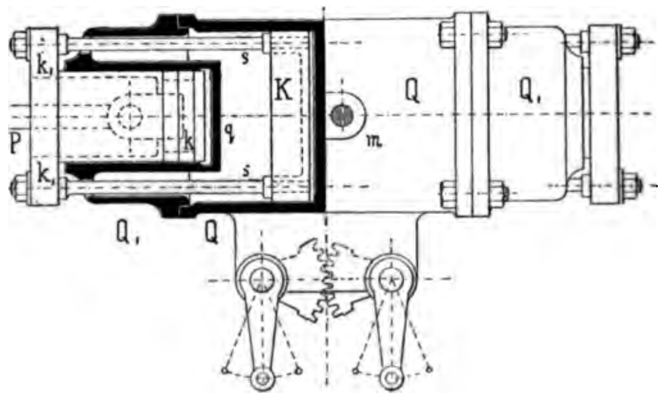


Fig. 55.

Fig. 56.



works in the dash-pot serves to prevent concussion by pressing against a small quantity of air, shut in as the piston approaches the bottom. Our drawing — fig. 55 — shows half the air-buffer in section and the other half in side-elevation, and illustrates the dash-pot most generally used. Its main body Q, consists of two open cylinders with one partition common to both. The trunk piston K works in these cylinders as shewn. These cylinders each contain the spiral spring S, which becomes compressed on the piston being drawn outwards. This piston is air-cushioned by the opening m_1 and the set-screw m, but especially by the larger opening n, which takes in air as the piston moves outwards. This opening n is so placed, that the piston K closes it, at about half its stroke; the remaining air behind the piston is then forced to escape by the smaller adjustable opening m_1, by means of which the flying back of the piston may be retarded at pleasure.

The dash-pot represented in fig. 56 is one introduced by Messrs. Hick Hargreaves & Co. and combines the dash-pot with an air-spring. As the bottom or inside of the small trunk-piston is in communication with the condenser whilst its outside surface leads to the atmosphere, the air presses it inwards, and thus forms the spring for closing the steam-valve, when the latter is liberated by the action of the toe-lever. The piston works in the same manner as described in fig. 55, the air-passages and set-screw being similarly retained.

In our opinion, the communication between the cylinder q and the condenser is superfluous, since the outward travel of the piston K creates of itself a vacuum, much in the same manner as we noticed in the original Corliss-type. The piston K is of course connected with the valve-spindle-lever.

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4. Engines working with the Spencer and Inglis valve-gear.

Messrs. Hick Hargreaves & Co., Engineers, Bolton.

The engine shown on Plates 9 and 10 is one constructed by Messrs. Hick Hargreaves & Co. of Bolton, for driving a Rail-mill, for rolling steel-rails, at the London and North-Western Railway-works, Crewe. It is coupled direct to the rolling mill without the intervention of any gearing. The mill is on the 'three high roll' plan and when steam is turned on, the engine drives the rolling machinery at 50 revolutions per minute, the speed being controlled directly by the governor acting on the expansion-gear, so that whether the mill is running empty, or rolling rails, the turning speed is practically uniform. This is perhaps the most severe test for an automatic expansion-valve-gear. The result of the working of this Engine during some years has been most satisfactory and affords an example of the suitability of this Corliss-valve-gearing for engines having great variation in load or resistance.

Fig. 1 is an elevation of the engine complete, showing the cylinder, framing, crank and connection, fly-wheel, condensing apparatus, etc. The cylinder is 40 inches in diameter, and the stroke 5 feet, the piston-rod, cross-head and main-shaft are of steel, this material being largely used in all engines made by Hick Hargreaves & Co. Preparation is made for working the engine with or without condensation. Fig. 2 is a plan of the engine complete, showing all the parts in plan. Fig. 3 is a section through the cylinder and part of the framing. This drawing shows Hick Hargreaves & Co. improved method of constructing the cylinders of Corliss-engines, with separate internal liner, separate steam-jacket-casing, and separate end-valve-chests, a construction which ensures a thoroughly sound and substantial cylinder, and admits of very close and hard metal being used for the internal cylinder or liner. Fig. 4, is an end-view of the cylinder showing the back guide, the valve-levers, wrist-plates, etc.

The power of the engine when non-condensing is given at 476 IP., increasing to 670 indicated horse-power, when condensing. The throttle-valve is placed over a cast-iron pipe of rectangular section placed over the cylinder. The outlet-valve chests, which also form supports for the cylinder, give off the spent steam into the exhaust-pipe, either communicating with the condenser and the air-pump, or with the atmosphere. The steam-inlet- and exhaust-pipes are respectively, $8^3/_4$" (224 mm.) and 14" (360 mm.) in diameter, and their area in respect to the steam-piston-area, is in the first named, $^1/_{20}$ and in the second $^1/_8$.

The hollow Corliss engine-frame of rectangular section is bolted to the front valve-boxes and to the crank-shaft-bearing. The connecting-rod, six times the crank-length, is made in the marine-engine style. The crank-shaft diameter is 1' $7^1/_4$" (494 mm.) in diameter, which is reduced across its bearing-surface to 1' 5" (436 mm.); the width of bearing is 1' $8^1/_2$" (524 mm.).

On account of the great varying loads to which rolling-mill-engines are subjected, the fly-wheel had to be made both large and heavy, in order to maintain a uniform speed. Its diameter is 22' and it is $16^3/_4$" (416 mm.) on the face; the wheel-arms, 12 in number, are wedged in the boss and bolted to the rim.

The arrangement of the other engine-parts, — viz. fixing of the cold water- and air-pump-lever, crank-shaft-pedestal, Porter's governor running at about 300 revolutions per min. etc. — is graphically explained on Plate 9.

Fig. 1, on Plate 10, shows a side-elevation of the cylinder of the Crewe-engine, representing also the valve-gearing in detail, and fig. 2 is a diagram of the valve-motions showing the relative positions of the valves for all positions of the piston.

Messrs. Hick Hargreaves & Co. apply separate eccentrics for working the inlet- and exhaust-valves on engines running under largely varying loads, for the purpose of rendering the action of the one set independent of the other. This arrangement allows a free choice in the amount of lineal lead given to the exhaust-valves, and also yields greater limits in working expansively: that is to say, the extreme position at which the governor may automatically effect the disengagement of the inlet-valve motion-rods can be lengthened out or deferred close on to the stroke-end. It is usual with the forementioned engineers when using two eccentrics, to arrange the valve-gear in such a manner as to render an automatic cut-off up to $^3/_4$ stroke possible. With the London and North-Western Rolling-Mill-engine, the range of the corresponding automatic adjustable cut-off, is limited to $^2/_5$ stroke. The lineal lead of the valve is $1^3/_4$" (45 mm.) with a steam-passage width of $3^1/_8$" (80 mm.); consequently the exhaust is already half open, with the crank on the dead centre.

The crank is in this position in both figures of Plate 10; the inlet-valve a has opened to the extent of $^9/_{16}$" (15 mm.) and attains its extreme position in a_1, whilst the inlet-valve b, travels the smaller corresponding distance bb_1. The main driven centre of the wrist-plate describes the arc ee_1. The eccentric is set at an angle of 85° behind the crank.

The port of the outlet-valve (d) as already mentioned is opened half-way, the outlet-valve reaching its greatest declination at d_2. The arc cc_2 explains the very small distance travelled during this period by the outlet-valve. Both valves are worked from one wrist-plate placed at the back of the one, gearing the inlet-valves. The dotted line of fig. 1, marked with e' in fig. 2, indicating the travel of the head of the eccentric describes the arc $e'e'_2$ up to its return-motion. The corresponding eccentric is set to an angle of 117° in advance of the crank. On the crank reaching the dead-centre, the valve b assumes the 'rôle' of the valve a which we have just described, and similarly the valve d takes the working action of the valve c.

The construction of Messrs Hick Hargreaves & Co.'s valves differs materially from those we have hitherto described. Their sectional form will be seen from fig. 2, Plate 10. The valve-spindle of the inlet-valves is only made flat at their end-discs. The outlet-valve with straight through passage, is cast hollow for reducing as much as possible the clearance-space, care being taken however to prevent the steam passage from becoming thereby reduced in size.

In fig. 57 we have drawn a diagram relating to the inlet-valve travel; the distance ac denotes the $1^3/_8$" (36 mm.) inlet-passage width, *ab* representing the lineal lead. The port is fully opened at *f*, or at about 0.15 stroke. According to the diagram, the limit of automatic variable expansion would therefore be limited to $^2/_5$ stroke, where the line *mm* closes the double shaded portion of our diagram. Our fig. 58 similarly relates to the outlet-valve. On account of the considerable lead v_1, the working edge of the valve has already reached the limit *g* of its declination at 0.24 stroke. The closing of the port ensues very late according to the diagram, or at about 0.99 stroke; in spite of this, the diagram proves that a certain amount of compression takes place. The steam exhaust begins already at 0.87 stroke, the curve beginning to rise rapidly in order to have opened the port from a_1 to $b_1 = v_1$ on reaching the dead-centre $C_1 C_1$.

The cylinders of the large Corliss-valve Beam engines which drive the machinery at the great Mills of Sir Titus Salt, Bart. Sons & Co., Saltaire are drawn on our Plate 11. There are two pairs of Beam-engines with 4 Corliss-valve cylinders, each 50" dia. and 7' stroke. The engines work at 30 revolutions per minute — and transmit over 2000 horse-power. These engines were originally by Fairbairn, and were for many years considered models of engineering skill. About 10 years since, the original cylinders which had stamper-valves, were taken out and replaced by the Corliss-valve

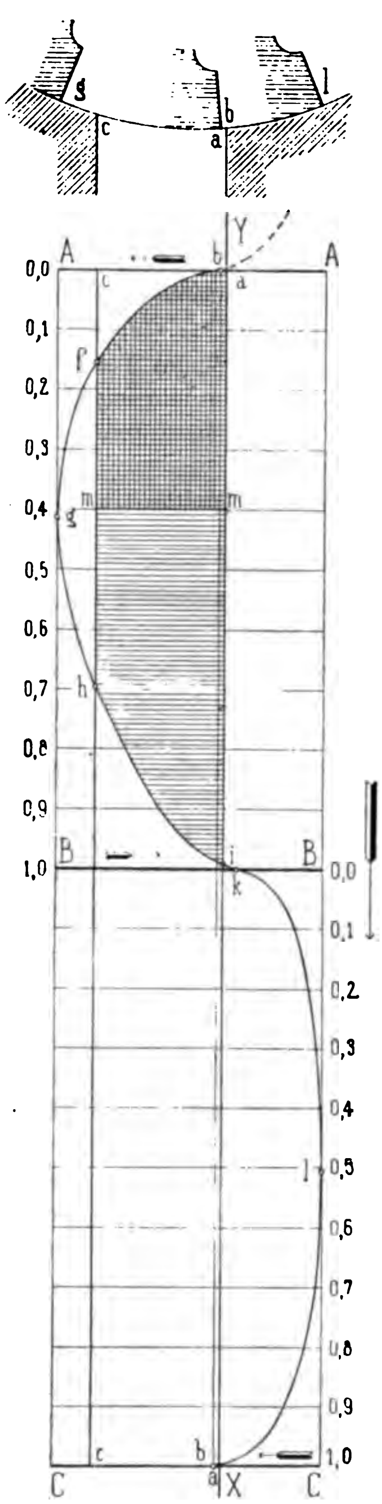

Fig. 57.

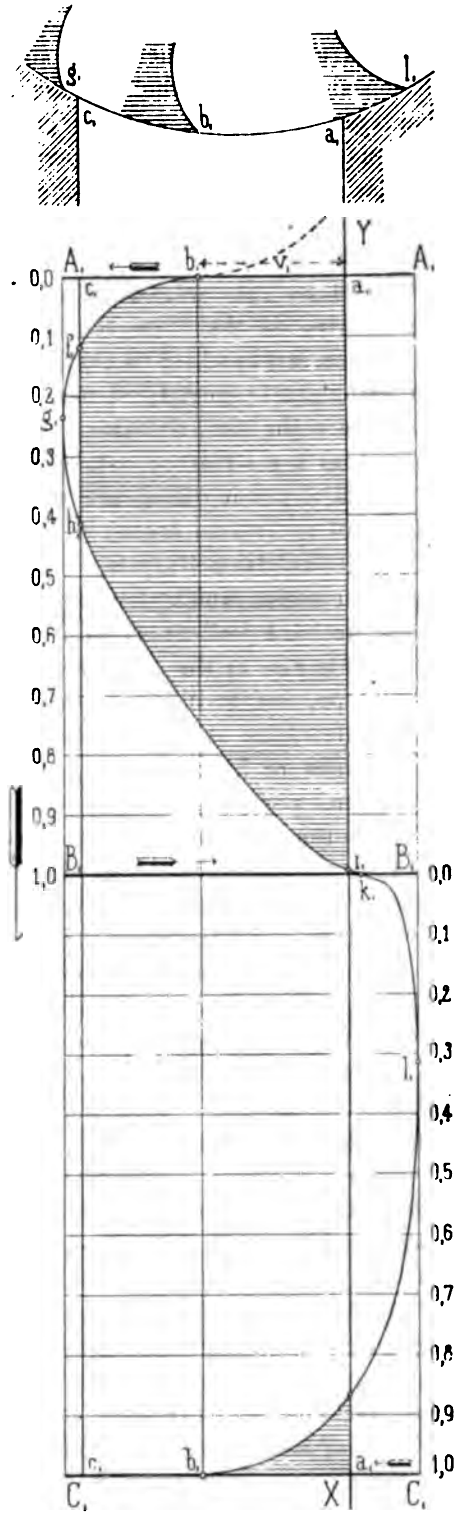

Fig. 58.

cylinders shewn in the drawings; the result was a marked saving in fuel-consumption and increased steadiness in the turning. The engines as now arranged are amongst the largest examples of Corliss engine-types, hitherto made. The new cylinders are constructed by Hick Hargreaves & Co. from the designs of Mr. Wm. Inglis. Fig. 1 is an elevation in section, shewing the steam and exhaust valves and chests, and the steam starting stop-valve. Fig. 2 is a side elevation, and fig. 3 an end elevation shewing the whole of the valve gearing. Fig. 4 is a plan in section, shewing the steam jacket space round the cylinder proper, and shewing also the valve levers. Fig. 5, is also a plan in section — but taken through the valves, and shewing the valve spindle-levers and other gearing. Fig. 6 is an elevation on a smaller scale, giving an outline diagram of the various rods and levers for transmitting motion to the valves. The valve gearing is Inglis & Spencer's double-clip type.

The cylinder is 4′ 2″ (1270 mm.) diam. and 7′ (2140 mm.) stroke; so giving off a piston speed of 7′ (2,14 m.) per sec. when running at 30 revolutions per min. The steam-supply pipe has a valve inserted of the same construction as the inlet-valves, for regulating the steam-supply; it is worked by a worm-wheel (fig. 2), though it may be quickly worked by a hand-lever attached. A small ball-valve is introduced near the valve, which on starting the engine opens by a spindle-screw, and balances the throttle-valve. The supply and exhaust steam-pipes are cast at the side of the cylinder and are furnished with expansion-joints.

All the four valves are worked from one eccentric.

L. Poillon of Lille.

An engine which shows great similarity, in its general arrangement and matters of detail, to the one we have just described is constructed by L. Poillon of Lille, (France). Our Plates 12 and 13, illustrate this engine, which may be pronounced to be an exceedingly true reproduction of the original type, and to display a very careful and well devised arrangement.

The engine is of 80 indicated horse-power; its cylinder is $15^3/_4$″ (405 mm.) in diameter, and with a stroke of 3′ (915 mm.), working at 82 revolutions per minute we get a piston-speed of 8′ $2^1/_2$″ (2,5 m.) per second.

If this engine is compared with Messrs. Hick, Hargreaves & Co.'s speciality, we notice at once that the arrangement of the jacketed cylinder is very nearly the same in each case. This similarity also extends to the rectangular steam-supply pipe with its lubricators, and the Corliss valve used as a throttle-valve.

The Corliss engine-frame cast hollow and rectangular in section, is made to carry a Porter's governor driven by belting at about 170 revolutions per min. For the purpose of counter-balancing the weight of the moving parts of the governor, an air-cylinder is introduced and constructed as shewn in fig. 11 and 12 (Plate 12). The crank-end of the engine-frame rests on two legs on the floor, but as the screw bolts holding it down, are only $10^1/_2$″ (270 mm.) apart, the corresponding width of bearing surface, for the crank-shaft, appears very small.

In fig. 4 and 5, (Plate 12) we show sections of the piston slide-block, which runs in straight slides in the engine-frame. The connecting rod is five and a half times the length of the crank or 8′ 2″ (2515 mm.) long. The flywheel which is cast in one, has a diameter of 10′ 5″ (3200 mm).

The air-pump with its condenser is placed horizontally below the cylinder; with a diameter of 8″ (203 mm.) and a stroke of 15″ (380 mm.) the air-pump stands in the proportion of 1 : 9.8 to the steam-cylinder. The construction of the condenser and of its valves is shewn in various sections, in fig. 6—10. The air-pump piston is driven by a rocking-lever attached to a cast-iron support below the floor-line; the upper end of this lever is connected by two rods, with the steam piston cross-head, whilst two short connecting rods similarly unite its lower end with the pump-piston cross-head. To ensure the horizontal travel of the pump-piston, it is lengthened out beyond its cross-head, and supported in a slide fixed to the forementioned cast-iron support.

Fig. 6, (Plate 13) explains the simple construction of the disengagement forks, which in one respect, will be seen to differ from Messrs. Hick Hargreaves and Co.'s method of construction.

To afford ample bearing surface to the inlet valves, shewn in fig. 9, the latter are provided with ribs both at their ends and at their centre. The exhaust valves, represented in fig. 10, scarcely differ from the original type.

The working of the valve-gear may be inferred from our fig. 5 and 5a. The piston is here supposed to be beginning its forward stroke with the crank on its dead-centre. The valve-gear is presumed to have been moved to the right to the extent of the lead-angle of 20°, in which position the inlet-valve would be sufficiently opened to allow the passing of the steam, without throttling it. The passage of the exhaust-valve *d* is similary opened up to $^2/_5$ of its width, this allowing the vacuum formed in the condenser to re-act on the steam in the fore-part of the cylinder. If the valve-gear was turned in the direction of the inscribed arrows, the valves *b* and *c* would work quite in a similar manner.

G. Sigl, of Vienna.

The engineering works of G. Sigl of Vienna, have for a number of years, adopted the Spencer & Inglis valve-gear in their Corliss-engines. The general design of these engines, and the care bestowed on matters of detail, fully warrant these machines to be held as exemplary models to the engineering profession at large. The pair of coupled engines which are represented on our Plates 14 and 15, were constructed by the last mentioned firm, for the town water-works of Florence.

The general arrangement of these engines, may be best seen from the plan drawn in fig. 2 (Plate 14). Both engines are of exact design and finish, and though the crank-shaft, flywheel, and the governor etc. are common to both, each cylinder has its separate condenser and its own air-pump driven from the back-end of the piston-rod.

The cylinder-diameter is 1′ $7^1/_2$″ (500 mm.) the stroke = 3′ $10^3/_4$″ (1200 mm.) and the average piston speed calculated at $41^1/_2$ revolutions per minute, amounts to 5′ 5″ (1,66 m.) per second.

The annexed indicator diagrams — fig. 59 being taken from the cross-head side and fig. 60 being taken from the front side of the cylinder — indicate under the forementioned conditions 137 horse-power. The diagram drawn in fig. 61 was taken with the machine running idle, and as this indicates 10 horse-power due to frictional resistance, the effective power of these engines amounts to 127 horse-powers.

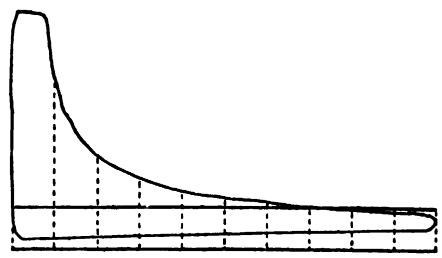

Fig. 59.

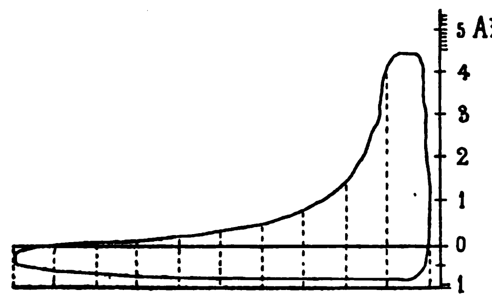

Fig. 60.

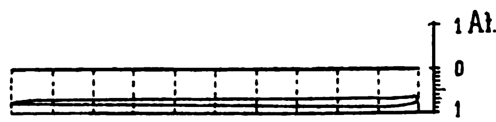

Fig. 61.

The under side of the steam cylinder — vide fig. 2 and 4, Plate 14 — is made to receive the steam which is then passed upwards round the cylinder through a passage $9^1/_4$″ (240 mm.) wide; in this circuit the steam is made to pass a throttle-valve and enters the valve-box from its side. The exhaust is taken up by the cylinder-supports whence it passes into a pipe leading either to the condenser or into the atmosphere. The steam inlet and exhaust pipes are respectively 5″ (127 mm.) and

$5^1/_2''$ (140 mm.) diameter and therefore their proportion to the piston-area is $^1/_{15}$, and $^1/_{12}$, in each case.

The piston-rod, of one uniform thickness, is made to pass through both cylinder covers, and the piston itself is mounted in two parts, being fastened by cone and nut. The cylinder casing is cast in one piece and bolted to the valve-boxes. The front cylinder cover is cast in one piece with the corresponding valve-box, though its centre is formed by a separate stuffing-box bolted to it. This arrangement facilitates the attachment of the Corliss engine-frame to the cylinder. This frame is cast in one piece with the crank-shaft bearings, $7^1/_2''$ (190 mm.) diameter and 1′ (310 mm.) width. The connecting rod-end is forged in one piece, and is attached to a crank-disc, the diameter of which is $^1/_5$ the length of the connecting rod. The crank-pin is simultaneously made to form a counter-crank working the cold water-pump of $9^3/_4''$ (250 mm.) diameter and $9^3/_4''$ (250 mm.) stroke.

The double acting air-pump, of equal stroke to that of the steam-piston, is $8^1/_8''$ (210 mm.) in diam. and its piston-rod is $1^1/_2''$ (40 mm.) diam. The capacity of the air-pump is $^5/_{28}$ that of the cylinder.

Proell's governor, is placed between the two engines, and is driven both by belting $3^1/_2''$ (90 mm.) wide and by a set of bevel-wheels giving off a speed of 144 revolutions per minute.

The flywheel, common to both engines, is 15′ (4590 mm.) in diameter, and $10^1/_4''$ (264 mm.) on its face. A toothed wheel is mounted at its side for driving the pump-work.

As the details drawn on Plate 15, will no doubt be found self-explanatory, we will merely refer to fig. 7 and 7 a, shewing the main positions of the valve-gear. The lineal lead of the inlet-valve is $^1/_{16}''$ (1,5 mm.), that of the exhaust-valve $^3/_{16}''$ (5 mm.); the lead angle of the eccentric is 26°, its eccentricity or throw amounting to 5″ (130 mm.). Owing to this large angle, the alternate motion — i. e. return-stroke of the gear-disc, and of the inlet-valves already takes place at a third, or to be more exact at 0.32 the piston-stroke. The lead-angle of the wrist-plate or gear-disc is 17°.

We may further observe with reference to these details, that the cross section of the spring used for both inlet-valves, as shewed in fig. 9, is $^3/_4''$ (20 mm.) by $^3/_{16}''$ (5,5 mm.) whereas its length when unstrained is 1′ $9^1/_2''$ (550 mm). The front of this spring cylinder is fitted up with an indicator — vide fig. 11 — for the purpose of shewing with every stroke, the degree of expansion, at which the engine is working.

Escher, Wyss & Co. of Zürich.

A Corliss-engine of high class finish was shewn by Messrs. Escher, Wyss & Co. of Zürich at the Vienna International Exhibition, working with the Spencer & Ingliss valve-gear. As this engine is already known in many engineering centres, we shall confine our remarks to the peculiar construction of its cylinder which Plate II, fig. 4 illustrates.

The cylinder casing is cast in one piece, and carries the inlet-valve steam passages, on its top-side. The pair of front-valves, to which the casing is bolted through suitable flanges, and the front-cylinder cover are cast in one. The piston is lubricated by two passages provided for in the casting of the casing; a copper-pipe is inserted into each, and as the pipe penetrates through the casing, the two are rendered steam-tight in the boring of the cylinder-core. The piston stuffing-box is let into the hollow cylinder-cover.

The piston-rod stuffing-box is 1′ $11^5/_8''$ (600 mm.) in diameter, and has a stroke of 4′ $4^5/_8''$ (1350 mm.), so that with the crank running at 42 revolutions per minute, the piston-speed equals 6′ 2″ (1,9 m.) per second; the lead angle of the single eccentric is 25°, consequently the limit of expansion is attained at $^3/_{10}$ the stroke.

The air-pump piston, with hemp-packing is 1′ $5^1/_2''$ (450 mm.) diameter and 1′ $11^5/_8''$ (600 mm.) stroke, hence the capacities of the air and steam cylinders are in the ratio $^1/_4$.

With a cut-off at $^1/_7$ the stroke, and with a boiler-pressure of 5 atmospheres, the engine indicates about 170 horse-powers.

Socin & Wick, of Bâle.

The Corliss-engine, shewn at the Vienna Exhibition by Messrs. Socin & Wick, Engineers of Bâle, was working at 6 atmospheres with condenser attached and was running at 65 revolutions (1,6 m. piston-speed); it indicated 25—30 horse-powers. The piston stroke was 2′ $5^1/_4$″ (750 mm.), the cylinder-diameter $12^7/_8$″ (330 mm.); the cylinder was steam-jacketted.

The Bessemer-steel crank, shewed equal thickness throughout its length, thus much simplifying labour. The toothed mortice-wheel, $5^7/_8$″ (150 mm.) on its face, $2^1/_4$″ (58 mm.) pitch and of 10′ $4^1/_4$″ (3200 mm.) diameter, geared into an iron pinion. The air-pump, attached to the engine, was driven direct from the piston cross-head.

The firm guarantees, a coal consumption of $2^3/_4$ lbs. (1,25 kg.) per hour per indicated horse-power for the larger types of these engines.

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5. J. Frederick Spencer's variable automatic Expansion-gear.

In 1868 Frederick Spencer of London patented a cut-off mechanism, entirely deviating from the preceding trip-gears. We represent it, attached as before, to a horizontal Corliss-engine in fig. 62, 63 and 64; the first named figure shows this gear in its central position, with the valve in gear, whereas fig. 63 represents the gear disc *A* in its extreme position with the inlet-valve disengaged. It will be noticed, that the arrangement of the gear-disc or wrist-plate *A* and of the inlet-valves is quite analogous to the III Corliss valve-gear, whilst the transmission of the governor-movement, by means of toothed segments, has been borrowed from the Spencer & Inglis valve-gear.

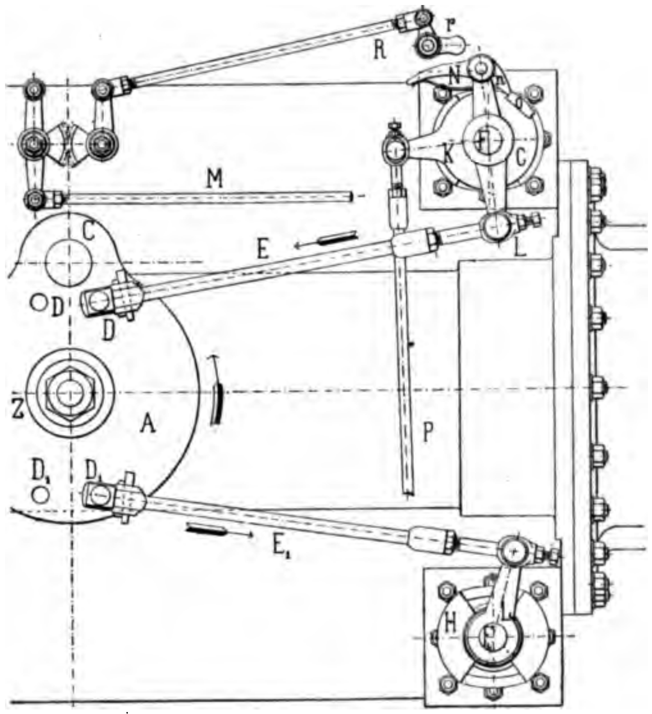

Fig. 62.

As the rocking motion of the gear disc and of the valve spindles, has been retained — the trip-gear alone being differently constructed, without however, exercising any varying influence on the former —, it follows, that the distribution of steam in the Spencer Corliss-engine type, must take place in precisely the same manner, as fore-explained.

The valve spindle *F* of the inlet-valve *G* carries two loose cranked-levers *L*, the lower end of which are attached to the adjustable motion-bar *E*, driven in the usual manner from the wrist-plate *A*. The upper ends of the lever *L*, carry a movable catch *Nn* between them; a spring has the tendency of pressing upwards the longer arm of this catch, so that its end is continually forced downwards on to the circumference of a disc *K* firmly keyed on to the valve-spindle *F*. The circumference of this disc is furnished with a protruding catch-plate *o*, as shewn in fig. 62 into which the catch *n* gears, and in this manner the movement of the gear-disc or wrist-plate A is transferred to the valve-spindle F when the motion rod E — fig. 62 — is moving in the direction of the arrow. This rotary movement of the valve-spindle opens the inlet-valve and allows steam to enter the cylinder behind the piston.

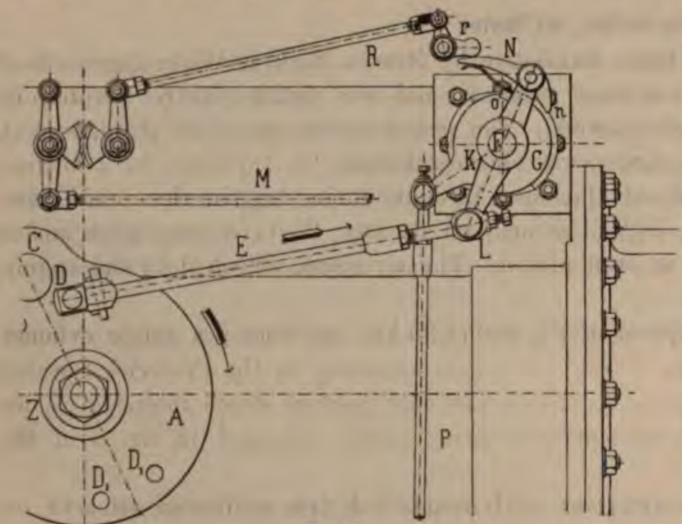

Fig. 63.

Prior to the wrist-plate entering on its return stroke, the crank-lever r, which is set in a certain position and is controlled from the governor by the intermediate rods RM, catches against the catch N whilst the continued movement of the lever L forces the catch-end n, away from the catch-plate o. As will be seen, the disc K is connected to a vertical dash-pot rod P, to which a weight is suspended so that by this arrangement, the disc K will have a constant tendency of following the downward pull of the rod P; consequently as soon as the catch n becomes disengaged from the catch-plate o, the disc K will instantaneously follow this tendency, and close simultaneously the inlet-valve.

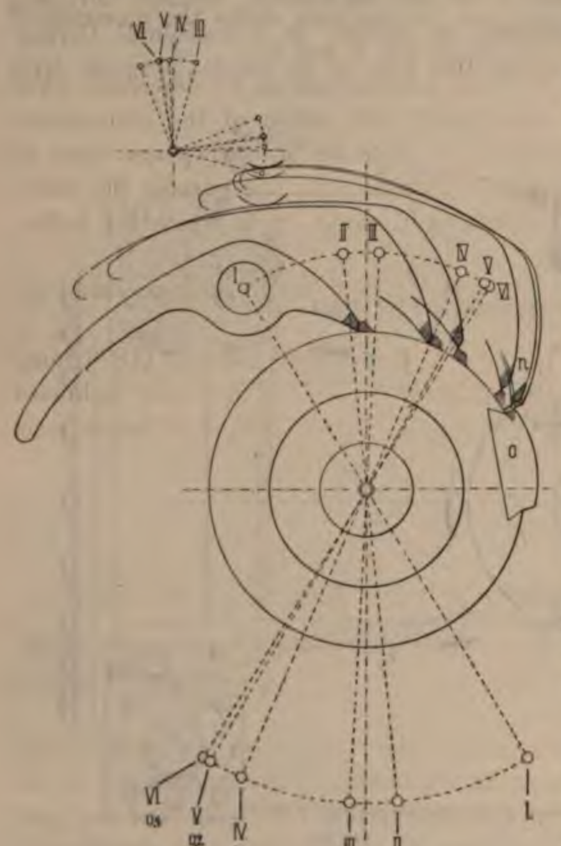

Fig. 64.

If, as represented in fig. 63, the wrist plate has entered on its return-stroke, the disengagement of the catch Nn, must have taken place. The motion-rod E moves in the direction of the inscribed arrow, until it has again landed the catch-end n — with the assistance of the forementioned spring — into gear with the catch-plate o; when this is accomplished it resumes its stroke as shewn in fig. 62.

Our fig. 64 represents the working relations of catch and catch-plate. Thus, in the position marked I, the catch has just dropped into gear, whilst its central position is indicated by II. In order to reduce the friction caused by the circular travel of the valve, the distance between I and II should be relatively kept smaller than the distance from II to VI. The other inscribed positions of this gear, are self-explanatory, as they are brought in relation to the piston-travel, corresponding to the automatic cut-off.

The Spencer valve-gear, as our description and drawings amply prove, enjoys simplicity as its chief merit. It has therefore been largely applied of late years, especially in combination with the air-buffer of Messrs. Spencer & Inglis.

6. Marine-engine working with the Fr. Spencer Valve-gear.

R. W. Peek & Co. of New-York.

The Corliss valve-gear has hitherto been comparatively little used in marine-engines. This may probably be accounted for, owing to a fixed rate of expansion being mostly adopted in marine-engines, in place of a variable cut-off controlled by a governor, which, where introduced is made to act on a throttle or shut-off valve. If the Corliss valve-gear is appended to a Marine Engine, the duty of the governor either devolves on the Engineer, taking up much of his time especially on high seas, or the trip-gear is arranged to cut-off at a fixed rate of expansion, under the supposition of a uniform load, just in the same manner as we saw introduced, on the Steam pump described on pg. 37.

The engineering firm of R. W. Peek & Co. of New-York have constructed a single cylinder marine-engine, fitted with a modification of the Corliss valve-gear according to the Frederick Spencer type. Of this engine, or rather of its cylinder, as this is the only portion which interests us, we give different views on Plate 8, the disengagement gear being shown enlarged in fig. 5 of the same Plate.

The preceding description of this valve-gear, will render but few additional remarks on our part necessary; we therefore confine ourselves to the following. The disengagement of the catch from its catch-plate, is not effected by the governor, but the engineer shifts the moments of contact, by means of a lever fastened in a segment, as shewn in fig. 1 and 2.

The air-cylinders or dash-pots, are of precisely the same construction as we described, when treating the sixth and seventh Corliss valve-gears; consequently the action of the atmospheric pressure is used in place of a spring. These two air-cylinders — vide fig. 3 — are placed close together on the engine-frame, though they are arranged behind the cylinder; for this purpose the valve-spindles are extended, in order to carry at their lower ends, small cranks on to which the buffer-pistons are fixed.

The engine is fitted with a straight reversing-link, merely used for reversing, since the variable expansion is obtained by the Spencer mechanism.

The cylinder-bore is 3′ 11$^1/_2$″ (1220 mm.), the two piston rods having 5′ 11$^1/_4$″ (1828 mm.) stroke. The engine frame is formed by four inclined columns let into the bed-plate and tightened up at the under-side; the cylinder is supported on four uprights, the upper portion of which form the slides.

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7. Variable automatic Expansion-gear of Douglas & Grant of Kirkcaldy.

Messrs. Douglas & Grant', Engineers of Kirkcaldy, patented a variable automatic expansion-gear in 1870, which has been largely adopted by them, of late years, on engines of almost all sizes.*)

The Douglas & Grant valve-gear, bears similarity to the Spencer type, and belongs with the latter, to the third Corliss-valve arrangement, as fig. 65 shews. The arrangement of the wrist-plate A with the eccentric-rod B, the four motion-rod attachments DDD_1D_1, and the position of the exhaust-valve H in regard to its spindle F and lever L, have already been described in the original construction. As in the Spencer valve-gear, so also with the present cut-off arrangement,

*) Vide: 'Engineering' d. 11. November 1870 pg. 345 and Dingler's Polyt. Journal Part. 3, vol. CXCIX, anno 1871.

the disengagement mechanism is mounted on the spindle F of the inlet-valve G. To render the disengagement mechanism plainer we have shewn it enlarged in fig. 66 to 69, and we may further observe that in fig. 65 it is drawn in gear whilst fig. 66 and 67 presume it to be disengaged. The valve-spindle F has two levers KK keyed on to it, apart from each other in order to take up the buffer rod P between them. The lower circumference of the boss of these levers is furnished with protruding catch-plates or hardened steel nibs oo into which the catches or points nn of the links NN gear, when the motion-rod E is moved in the direction indicated by the arrows inscribed in fig. 65. Another bent lever r is mounted eccentric fashion, on the valve-spindle F, and is kept in a certain position, by being connected with the governor, through the intermediate rods MR. The intermediate piece L is carried loose on the boss of the lever r, — vide fig. 68 and 69 — and the links NN are hinged on to the small eye of the intermediate piece L. To the inner sides of these links NN, additional catches are attached, which work with ample play-room in the bottom recessed portion of the intermediate piece L. The last-mentioned catches, consequently force the intermediate piece to follow the rotary motion of the links NN, though, on account of the eccentric setting of the lever r, and the direction in which the motion-rod E is travelling, the swing-

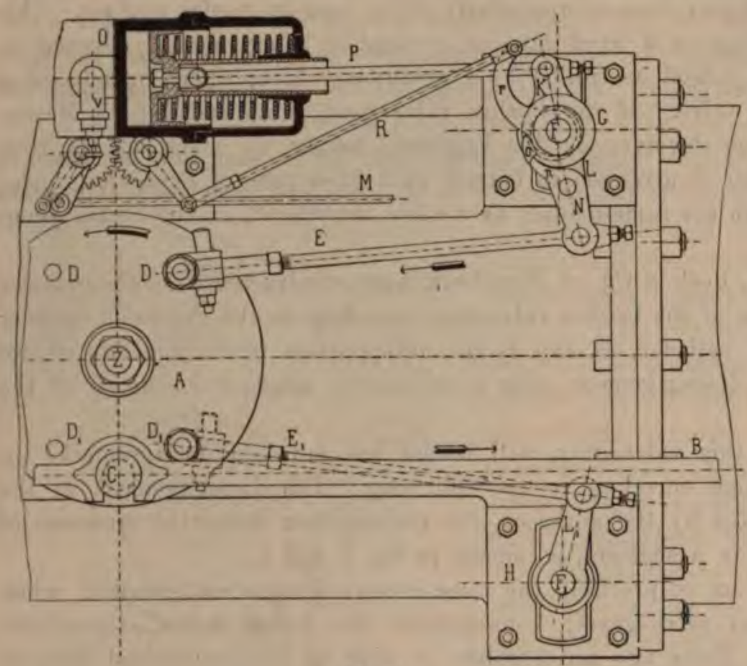

Fig. 65.

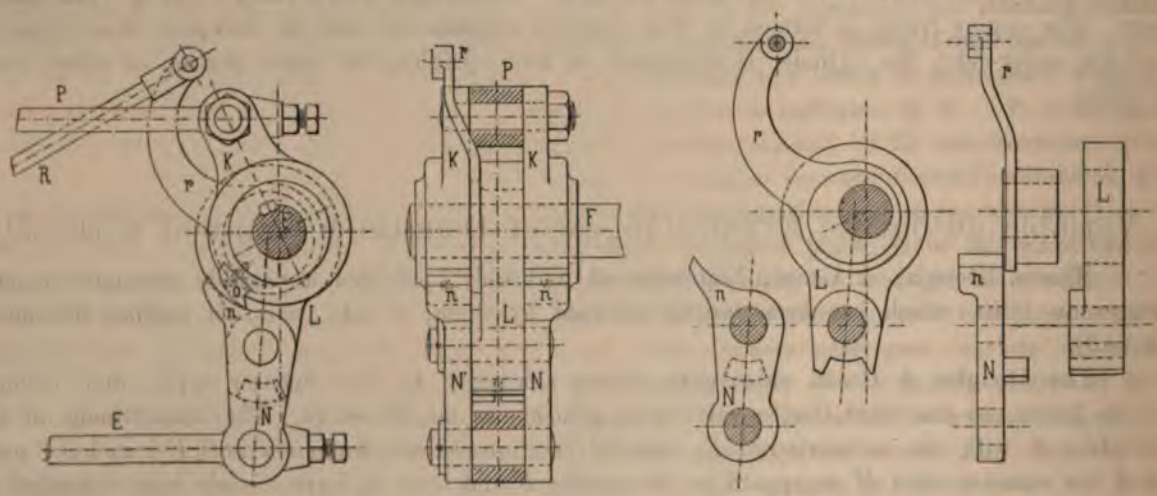

Fig. 66. Fig. 67. Fig. 68. Fig. 69.

centre of the links NN will be pushed further or nearer to the fixed valve-spindle centre. It is this receding and approaching movement of the links NN, which disengage or set in gear the points or catches nn and the steel nibs oo. When disengagement ensues, the inlet-valve is closed by the action of the buffer-spring which is connected with the valve-spindle by the rod *P* and the lever *K*.

'When the valve is about to open 'as Engineering has it', the link-points are in gear, and are gradually moved outwards by the motion of the lever *r* towards the full side of the eccentric, at which point they are disengaged, and the valves closed by a spring. The position of the eccentric *r* which is connected with and moved by the governor, determines the point at which the valve will cut-off the steam; and the nearer, the full side of the eccentric is to the starting point, the earlier will the cut-off be.'

The points *nn* fully catch the nibs *oo* when the governor balls are running low, as shewn in positions I and II fig. 70. If steam is already cut-off at 0.0 stroke, the lever very soon approaches the full side of the eccentric, as shewn in position III. If only one eccentric were used, the extreme limit of automatic cut-off, would be reached at about $^2/_5$ stroke, which in our fig. 70, corresponds with the position marked V.

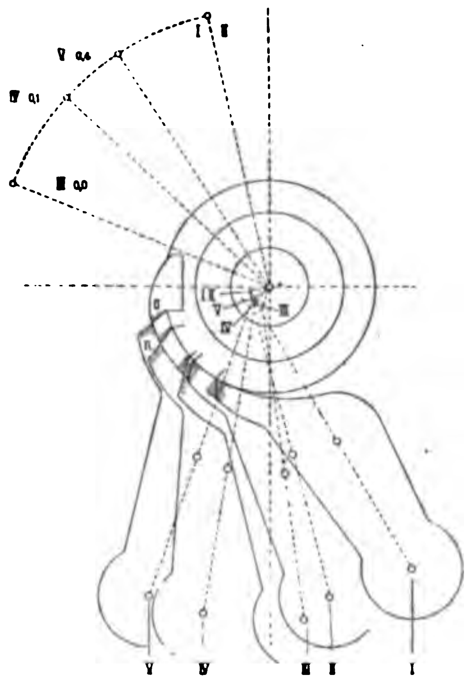

Fig. 70.

Messrs. Douglas & Grant constructed, under the superintendence of Mr. G. Allan, a Horizontal Compound Corliss-engine indicating no less than 1000 horse-power, for the Fleming Spinning and Weaving Mills, of Bombay, being the most powerful out of a large number which they have constructed. This engine is drawn in plan in fig. 2 (Plate 16), fig. 1 gives a side-view of the external valve-gear applied to the high-pressure cylinder, whilst fig. 3 represents a longitudinal section, simultaneously showing the main positions of the valves, and in fig. 4 we have a cross-section of the same low-pressure cylinder.

The bore of the high-pressure cylinder is 3' 4" (1016 mm.), that of the low 5' 6" (1676 mm.) whilst the stroke of both is 6' (1828 mm.). The cranks are set at right angles to each other, the receiver being placed under the high-pressure cylinder.

At the time these engines indicated 1000 horse-power, they were working with a boiler pressure of 80 lbs., and an expansion of 0.25 in the high-pressure cylinder, yielding approximately a tenfold total expansion. The piston-speed was 7' 2" (2,23 m.) per sec. and the engines were consequently running at about $36^1/_2$" revolutions per minute.

Both the cylinders and covers are steam-jacketted — vide fig. 3 and 4 — and the piston as well as the Corliss-valves, work in cast-iron bushes, made from a composition of tough and hard iron.

The piston rod, of the uniform thickness of $6^1/_2$" (165 mm.). is carried through the hind cylinder-covers and there supported by a flat slide. The heavy engine-frame, is supported at the end of the slide on two feet, on account of this frame being hereabouts joined to its other part, which is cast in one piece with the stool carrying the crank-shaft bearing.

The crank-shaft diameter, where the fly-wheel is mounted is 1' $8^3/_4$" (508 mm.) being reduced to 1' 4" (406 mm.) at its bearings which are 1' $11^3/_4$" (610 mm.) wide; the bushes may be adjusted during the running of the engine. The connecting rod is $5^1/_2$ times the crank-length, whilst the crank-pin in 10" (254 mm.) in diameter and of equal length. The shaft and crank-pin, piston-rods etc. are of steel.

The diameter of the toothed fly-wheel is 19' 10" (6096 mm.) and with a width of 24" (610 mm.) on the face, its cast-iron teeth are set out to a pitch of $5^3/_{16}$" (133 mm.). The teeth are strengthened in the manner shewn in our Plan, up to the pitch-line; 16 segments bolted together form the wheel-rim. The 10 arms of the fly-wheel, are fastened to the inner rim, by wedge and bolts, their other conical ends being let in to the wheel boss and secured with wedges. The weight of the fly-wheel and of the crank-shaft is over 53 tons (52162 kg.).

The rim of the fly-wheel pinion, 6′ 3¾″ (1942 mm.) in diam. is similarly secured to its arms and boss. The condenser is placed close behind the low-pressure cylinder, and is furnished with Allan's improved diaphragm, for dividing the water and offering the greatest cooling surface to the steam; the steam condensing-surface, thus obtained is about 180 sq. ft.

The air-pump, 4′ 3½″ (1168 mm.) in diam. and 2′ 11⁹⁄₁₆″ (914 mm.) stroke, is driven by a wrought-iron lever, from the extension of the low-pressure piston-rod. The large-cylinder has a four-fold capacity, of that of the air-pump.

Each cylinder may be worked independently of the other, and without condensing. The low-pressure cylinder, is in fact so strong, that if supplied with steam direct from the boilers, it can be used to drive the whole mill.

The travels of the working edges of the inlet-and exhaust-valves of the high-pressure cylinder are shewn in fig. 71 and 72; those of the low-pressure cylinder are represented in fig. 73 and 74.

If we notice fig. 5 and 6 of Plate 16, referring to the crank-circles of the high and low pressure cylinders, we shall perceive, that the travels of the inlet-and exhaust-valves of both cylinders, are rendered independent of each other, by the application of two eccentrics. This arrangement allows automatic variable expansion to take place within distant limits, as in the high pressure cylinder, the automatic cut-off can ensue up to $^7/_{10}$ stroke, whilst with the low pressure cylinder the steam may be cut-off by the expansion-gear itself, up to $^6/_{10}$ stroke; the shaded portion of our diagrams confirms this, by shewing shaded the limits of automatic cut-off.

Working non-expansively is out of the question with this valve-gear, since if the clip-gear had not been disengaged, the inlet-port would still have to be open on the return of the piston-stroke. The travel which would result herefrom, but which in reality never takes place, has therefore merely been shewn in dotted lines in our fig. 71 and 73. For this reason the working valve-edge may only travel the curve $abfg$, after which it must pass on to the line AB, to continue its travel later on at l. Our fig. 74, shows a certain difference with our previous diagrams, inasmuch, as this valve does not travel on a gradual return-motion, but forms a kind of loop $l_1 l_1$ which though not affecting the steam-supply is nevertheless detrimental, on account of the repeated changes in the direction of motion.

The diagrams, moreover confirm, the advantageous distribution of steam, as well as the slight overlapping of the inlet-valves.

Equal cut-offs on both cylinder sides, are obtained by different lineal leads. Thus:

in the inward-side of the high-pressure cylinder:	Inlet ¼″	(6.5 mm.);	Outlet 1¹³⁄₁₆″	(47 mm.)
„ „ outward-side „ „ „ „ „	„ ⅜″	(10 mm.)	„ 2″	(52 mm.)
„ „ inward-side of the low-pressure „	„ ¼″	(6.5 mm.);	„ 2½″	(63 mm.)
„ „ outward-side „ „ „ „ „	„ ⅜″	(10 mm.)	„ 3″	(75 mm.).

The diameters of the valves vary largely, for whereas the inlet- and exhaust-valves of the high-pressure cylinder are respectively 7⅜″ (190 mm.) and 8⅜″ (215 mm.) the corresponding valves of the low-pressure cylinder are 9¾″ (252 mm.) and 11⅞″ (304 mm.) in diameter.

The throw of all the four eccentrics amounts to 4½″ (114 mm.); this eccentricity is augmented by an intervening lever in the proportion of 3 : 4 on to the gear-disc. In fig. 3, 5 and 6 of Plate 16, the inscribed points of the inlet-valve eccentric are marked with ee_1e_2 whilst those of the exhaust-valve excentric, correspond to $e'e'_1e'_2$. It is needless to refer specially to the working positions of the valves drawn in fig. 3, as their action will be readily understood with the aid of our diagrams.

On Plate VII we illustrate a Compound Beam-engine, similarly constructed by Messrs. Douglas & Grant.

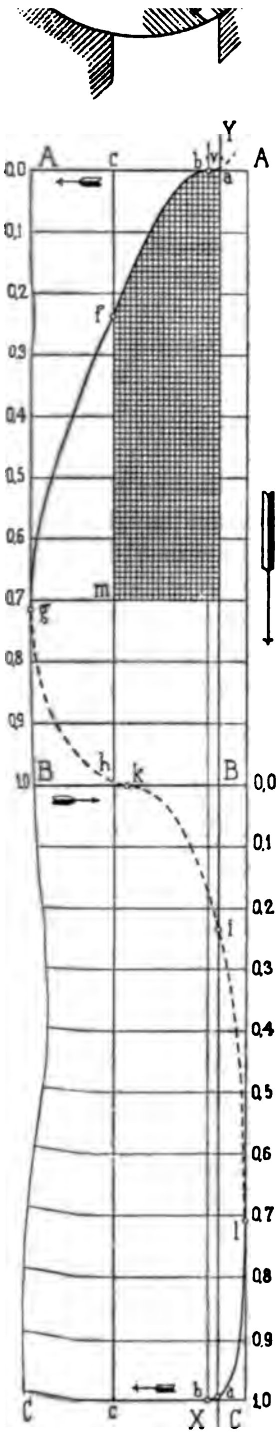

Fig. 71.

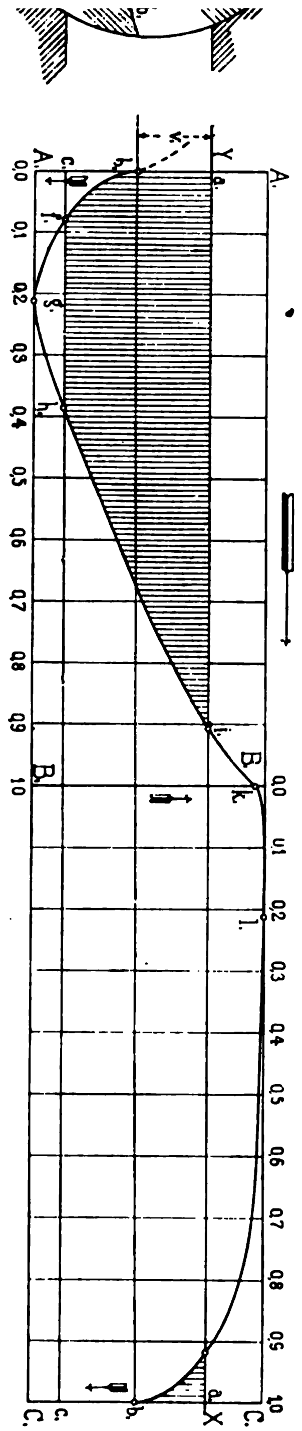

Fig. 72.

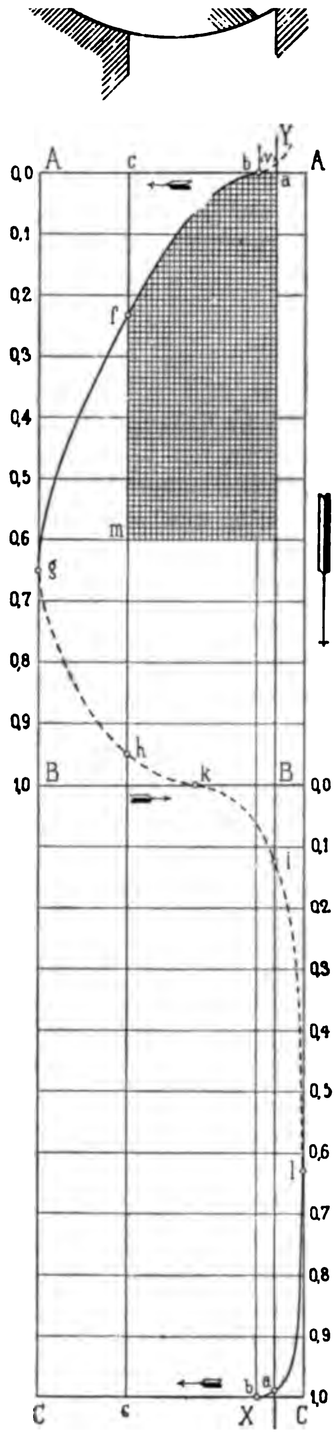

Fig. 73.

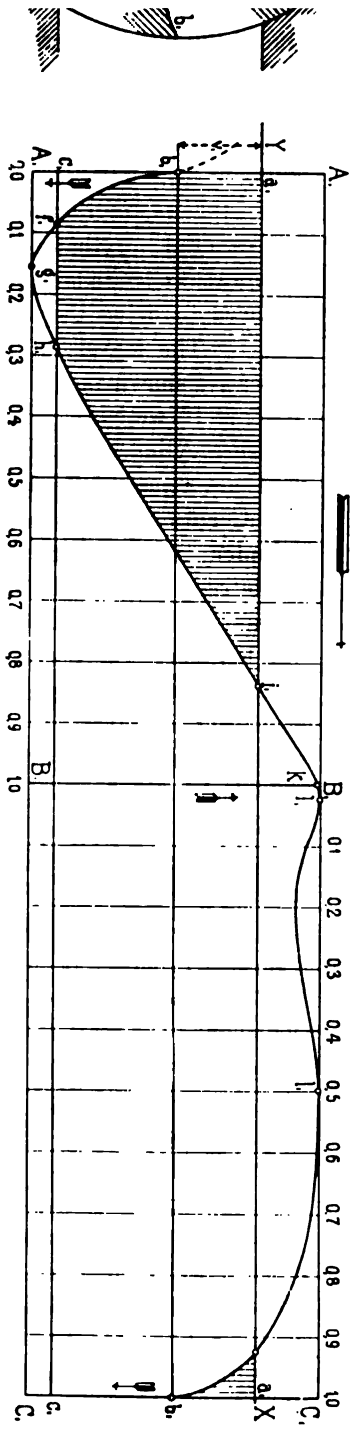

Fig. 74.

The high-pressure cylinder, 2′ 1¾″ (661 mm.) diam. and 2′ 5¾″ (762 mm.) stroke, works with Corliss-valves and the Douglas & Grant gear. Separate eccentrics work the inlet-and exhaust-valves; these eccentrics, are set on a separate horizontal shaft, which is geared by bevels from the crank-shaft. The low-pressure cylinder 2′ 8⅝″ (838 mm.) diam. and 4′ 11¼″ (1524 mm.) stroke, has two equilibrium-valves worked off the horizontal shaft, by rod and lever. The crank-shaft, 15⅜″ (394 mm.) diam. at the fly-wheel, is reduced to 11⅞″ (305 mm.) diameter at its bearings, which are 1′ 5¾″ (457 mm.) wide. The connecting-rods 3¾″ (95 mm.) diam. as well as the crank-pin 5¾″ (146 mm.) diam. are made of steel.

The air-pump 1′ 8″ (508 mm.) diam. and 2′ 5¾″ (762 mm.) stroke, stands in the capacity-ratio of 1 : 5.7 to the low-pressure cylinder.

The transmission of power is effected by rope driving, the face of the fly-wheel receiving 12 grooves for this purpose. The fly-wheel diameter is 15′ 10″ (4876 mm.) and its weight is put down at 11.15 tons (11810 kg.)

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8. Automatic variable Expansion-gear, designed by Emil Borzini.

An exceedingly original and compendious expansion-gear designed, by Emil Borzini of Milan for Corliss-engines, originates from the works of B. Pisani at Milan. This mechanism has been adopted, of late years by the last named firm with considerable success, and has met with a favorable reception amongst engineers. Its main advantage, consists in its simple construction; all the parts being of circular form, can be worked up accurately, and at little cost, on the ordinary lathe.

The entire disengagement-tackle is enclosed in a case keeping it from dust etc. without rendering its fitting up, or taking to pieces more difficult. We illustrate this automatic variable expansion gear in our fig. 75, as attached to one side of a horizontal cylinder. It will not be necessary, to refer here to the general arrangement, which as our reference letters prove, is similar to some of the preceding types, and we may therefore pass on, to describe the disengagement gear with the aid of fig. 76 to 83.

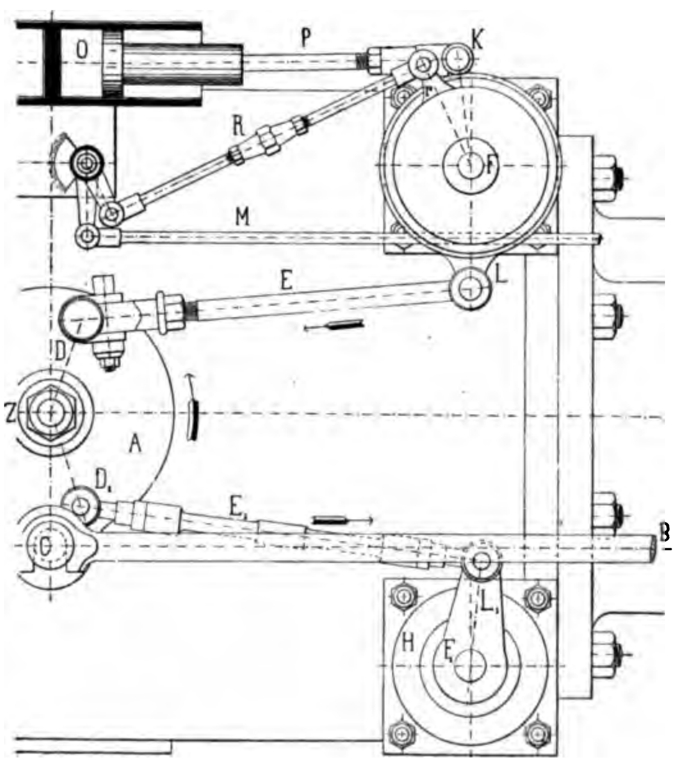

Fig. 75.

On the valve-spindle *F*, a disc *K* is keyed, to which the buffer rod *P* is attached. A circular casing, inside of which, the remaining mechanism is placed, carries a lever *L*, whose eye forms the connection with the motion-rod *E*. The end of the valve-spindle carries, a loose disc *R* furnished with a small lever *r*. A box *f* also placed loose on the valve-spindle inside of the plate *R*, forms, as it were, two rings of different diameters, the largest of which, fits accurately in the ring *L*; the two are connected together by groove and key *b*, so that the box *f* is obliged to participate in the rotary movement of the ring and of the lever *L*, whilst its loose fitting on the valve spindle permits it to slide on the latter.

This box *f*, contains a plate *g*, similarly fastened and revolving with it.

In order to transmit the rotary motion of *L*, *f* and *g*, on to the disc *K* or intermittingly on to the valve-spindle *F*, the two discs *K* and *g* work on to a clutch-box. These two discs will be seen to have two concentric grooves opposite each other. In the groove belonging to the disc *K*, two ring-sectors each furnished with a catch-tooth *o*, are fastened in by three countersunk screws — vide fig. 76 —; the opposite groove of the plate *g* is similary made to receive two short steel-sectors *n n* leaving sufficient space between them to allow the teeth *o* to grip in this space (fig. 78). To deaden the shock of the plate *g* against the disc *K* when the clutch-box comes into gear, the edge of the plate *f* is provided with a leather-cushion. The spiral *S* tends to press the plate *g* against the disc *K*, or to bring the clutch-box into gear. The knocking out of gear of the clutch-box, requires the plate *g* to be pressed back against the action of the spring. This is accomplished by a separate mechanism drawn over the smaller ring-portion of the box and applied to the box *f*; it consists of a steel ring with two diametrically opposed grooves *e e*. A side view of this ring and of its groove is shewn in fig. 81. It is in these grooves *e e* that two pins screwed through the boss of the lever *r*, gear.

Fig. 76. Fig. 77.

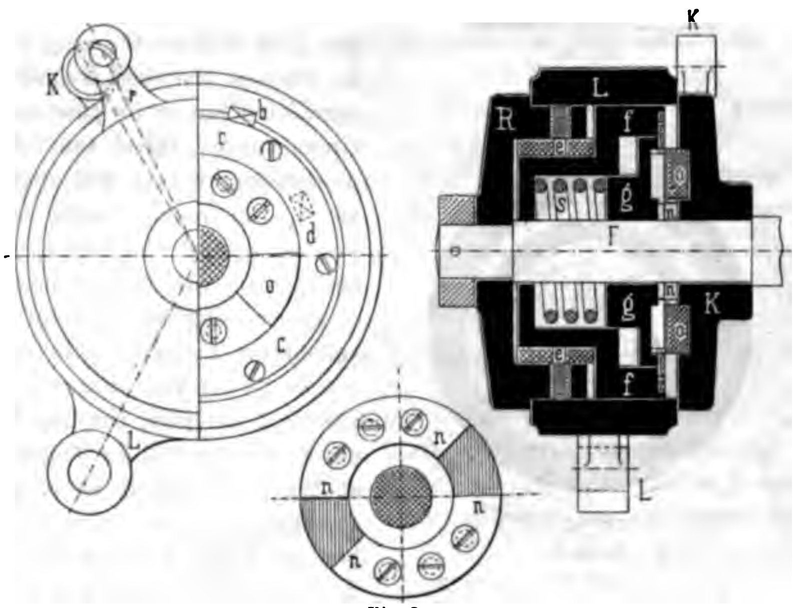

Fig. 78.

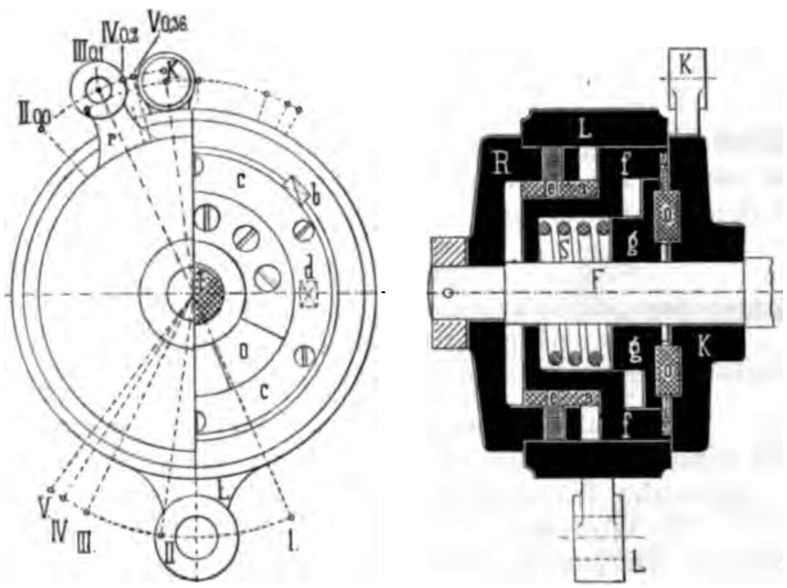

Fig. 79. Fig. 80.

Our fig. 80 shows the clutch-box in gear. If the lever *L* is therefore moved in the direction of the arrow (fig. 75), the disc *K* and spindle *F* are similarly turned, and the inlet valve is opened. This motion however merely continues so long as the pins are sliding in the straight portions of the grooves *e e*, for as soon as the pins get into the slanting portions of these grooves, the lever *r* being held firm in a given position from the governor, the box *f* and plate *g* are drawn back. The teeth *o o* become disengaged from the sectors *n n*, so relieving the clutch-box and allowing the buffer *O* to come into action and close the valve.

In order to afford as correct an idea of the different working positions of the pins pertaining to various expansion grades, we have shewn the ring in section and in plan (partially unrolled) in figs. 82 and 83. Fig. 82 enables us to read off the corresponding positions of the levers *KL* and *r*, and of the pins. As already explained, the box *f* as well as the ring *a* revolve with the boss of the lever *L*, whereas the disc *R* under control of the governor may be considered fast in its positions. The first named, will under all circumstances travel the full travel assigned to them by the motion-bar, but it will depend on the positions of the pins, as to, the travel, during which the ring *a* and the box *f* is pressed against the disc *K*. Now as this travel corresponds exactly to the inletting of the steam, we thus obtain a ready means of ascertaining the limits of expansion. The entire travel of the valve-lever *L*, brought in relation to the ring *a*, gives us the length zz_1 or yy_1. Fig. 83 explains that according to the position of the pins, the travel of the latter in the upper portion of the groove will be longer or shorter. If, for instance the pin at the beginning is at *z*, it will finally arrive at z_1, and no disengagement will have taken place, on account of the clutch-box not being knocked out of gear. Only when the pin starts in a position between *x* and x_1, will the box *f* recede from the disc *K* over and above the depth of the clutch-grip, thus involving disengagement. The extreme limit of automatic variable expansion, corresponds to the nearest position of the pin to *z*. It allows a cut-off at over one third (0.36) the stroke with a lead-angle of about 16°; the end-position of the pin in this case is at *x* where the disengagement of the clutch-box ensues. The travel beyond *x*, equal to *x* x_1 in an extreme case, always takes place with the clutch-box out of gear.

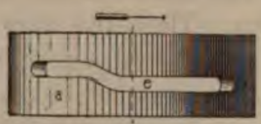

Fig. 81.

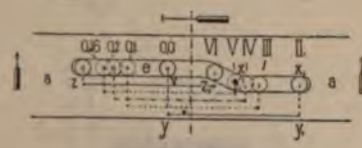

Fig. 83.

9. Variable Automatic Expansion-gear of Jerome Wheelock of Worcester U. S.

The variable automatic expansion-gear of Mr. Jerome Wheelock of Worcester, one of the most important Machinists of North America, became known to English engineers, partly through the Philadelphia Exhibition, and still more so, by the Paris International Exhibition of 1878.

This valve-gear excited the greatest interest, at Philadelphia, as well as at Paris. The economical arrangement of the inlet-valves, the simplicity of the external mechanism, as well as the apparent durability of the moving parts — were the chief meritorious points displayed by a Horizontal Engine, exhibited in motion by the last named Engineering firm.

The main characteristic of this valve-gear, is the transfer of the inlet-valves to the under side of the cylinder, in close proximity to the exhaust valve; thus only one opening at each cylinder end is rendered necessary. It is not to be denied, that the conception of this arrangement is a happy modification of the Corliss-engine.

It will be seen, from the side-elevation of this valve-gear given in fig. 1 Plate 17, that the top part of the cylinder is kept perfectly plain. The gear-disc or wrist-plate with the mechanism of the III. Corliss valve-gear as well as the springs of the V. Corliss valve-gear, have been dispensed with, and we find substituted a far more concise gear working on two main centres; altogether this arrangement is of more pleasing effect.

The disengagement-gear is derived from the Harris or the IV. Corliss-valve gear, with this difference that the fork is reversed with its prong downwards, owing to the governor link-mechanism working accordingly. Our text fig. 84 represents this relieving-motion as attached to the left cylinder side, whereas in fig. 85 the position of the respective valves to each other is drawn in section. We have retained our former alphabetical reference, so that with the aid of our Plate 17, the working of the whole arrangement will be easily understood.

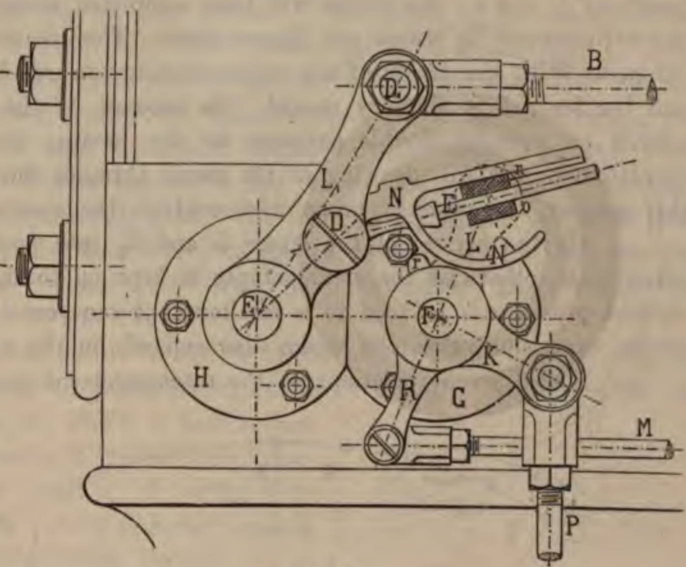

Fig. 84.

A lever L_1 is keyed fast on to the steel exhaust-valve spindle H, the former receiving its rocking motion from the link B and the eccentric rod. A pin D is screwed eccentric fashion into the lever L_1, and this pin forms the swing-centre of the disengagement-rod NN, and of the guide-rod E. The end of the last-mentioned rod is kept square next to the pin, on account of its working in the narrow slot of the crescent-formed part of the rod N, but this rod is otherwise of circular section, sliding in the steel sleeve o. As aforesaid, the disengagement-rod is fork-formed with its curved prong facing downwards, whereas its other prong is kept straight, and furnished with a steel catch-plate at its under side, which according to the position of the rod NN falls in or out of gear with the steel-sleeve. A pin is welded on to the sleeve o and fits into an eye of the lever L. The latter with its arm K forms a crank-lever, connected with the buffer rod N to a falling dash-pot weight; thus, this lever is continually being pulled in the direction of the fingers of a watch, and as a consequence there is a constant tendency of the sleeve tripping up against the catch-plate, or as we have already explained, of a rapid shutting-off of the valve.

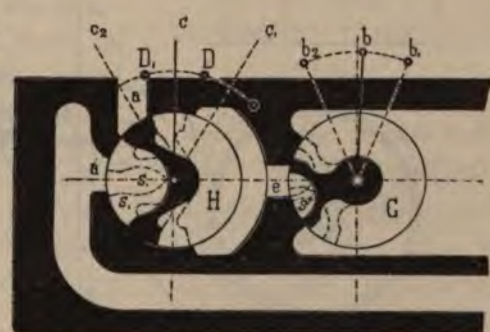

Fig. 85.

In order to effect disengagement at the proper time, another lever R is mounted loose on the valve-spindle, behind the crank-lever LK. The boss of this lever carries a projecting catch r, which when moving in the direction of the fingers of a watch, presses against the crescent-formed prong of the disengagement-fork and forcing up the latter, relieves the catch-plate n from the sleeve o. It may perhaps appear superfluous to observe, that the lever R is connected with the governor by the rod M, and is adjusted to a certain position, corresponding to the degree of expansion, with which it is desired to work the engines.

The form of valve used, is shewn in our fig. 85. The valve H works similar to the slides of engines running with two separate slide-valves; that is to say, its duty is to place the ports aa_1 alternately in communication with each other whilst exhausting, and with the return of the piston-stroke, to open the passage a to the extent of the lineal lead. It is therefore not quite correct, to term this valve the exhaust-valve, though we have retained this nomenclature in order not to complicate the description, by using another term. The valve G is, therefore, merely the expansion-valve, and it differs in form from the ordinary Corliss-valve only through being concave on its working surface s so as to lessen the frictional-travel and to increase the size of the steam-passage. The distribution of the steam is effected in the following manner: Assuming the valves to be in positions b_1 and c_1, the piston will have completed about half its stroke, and be moving in towards the cylinder-end to which our figures refer. The steam-passages aa_1 are quite open, allowing free exhaust. With the travel of the valves tending towards b and c, steam-passage a_1 becomes contracted and the lever L is similary moved. On account of the formentioned valve-concavity, the valve G affords on opening double-passages to the steam; the advantage thus obtained is evident, for throttling or the wire-drawing of the steam through the valve is thereby completely prevented. In this manner, the valve G in no wise controls the opening and shutting of the admission-port.

On the arrival of the levers L and L_1 into positions b_2 and c_2, disengagement must have taken place, otherwise the steam-supply is kept up to the stroke-end. Considering that the duration of back-pressure is reduced to a minimum, it can scarcely be considered a fault, that on the closing of the expansion-valve, the steam also expands in the valve-box H.

The different positions of the disengagement gear are represented in outline in our fig. 86.

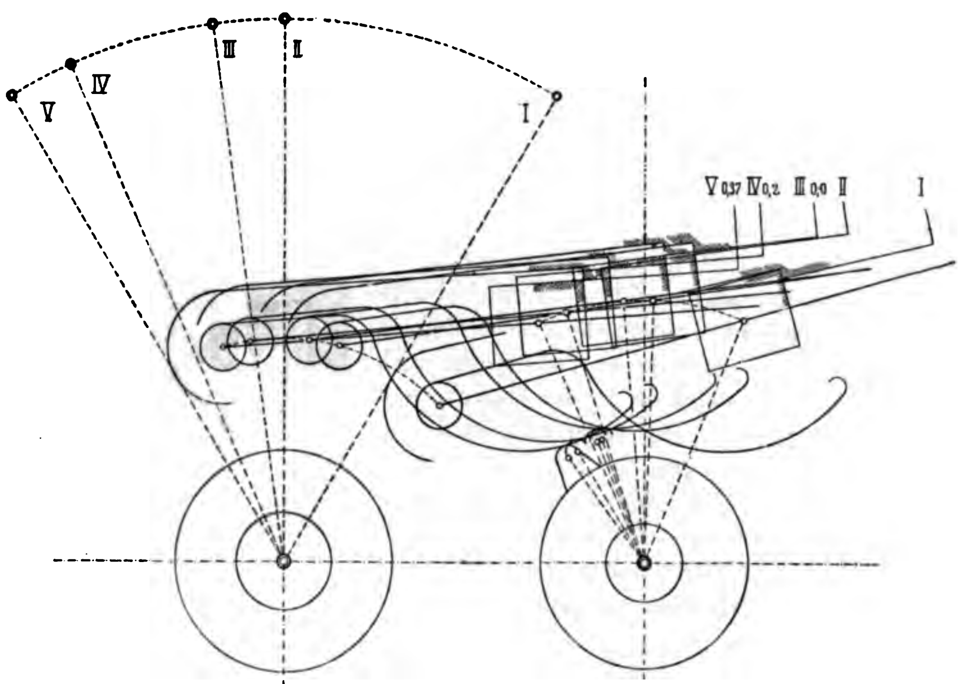

Fig. 86.

As this drawing explains, the automatic cut-off, lies within narrow limits in this arrangement, worked as it is by one eccentric. Our outline was drawn under a presumed lead-angle of 15°.

The engine represented by our Plate 17 was exhibited by Mr. Wheelock at the Paris Exhibition. The eccentric-rod is made to slip on or off the first valve-lever — vide fig. 1 — its end forming a handle for the purpose of gearing the engine by hand. The connecting rod joining the two exhaust-valves is placed behind, and it is rendered adjustable — similar to the other rods —

by a screw-joint, in order to obtain as exact a distribution of steam as possible. An intermediate link attached to the governor-stand, increases the throw of the eccentric on to the valve-gear, and thus brings the eccentric rod closer up to the cylinder — vide fig. 2 Plate 17.

On account of the symmetrical arrangement of the disengagement-gear, the collar-movement of the governor is transmitted to the valve-gear by an intermediate toothed segment and pinion placed in front of the cylinder; the prolongation of the lower screw-bolt of the valve-box forms the centre of this segment.

Referring to the valve-spindles, our fig. 3 (Plate 17) shews us a constructive arrangement which requires the greatest accuracy of workmanship and finish. — We allude to the valve-spindles being made to fit without any packing, a long metal-bush rendering them steam-tight. These spindles are made of hardened steel, and as the hind part of the valve, possesses a greater effectual surface for the action of the steam, the latter presses the spindle-boss against the bush-lining, and a steam-tight joint is thus obtained. The easy movement of the valve is largely praised, since actual practice proves that the wear and tear of the valve-face takes place in exactly the same degree as the spindle itself, so preventing any leakage-gaps. The adjustability of the valves on their seats, is effected by a steel set-screw let in the back cover of the valve-box; in this manner, the spindle-boss may be brought closer to or further away from the metal-bush. These details are shown drawn to a larger scale in fig. 6 — 8 (Plate 17).

The construction of Wheelock's patent piston is shewn in section in fig. 5, and in order to facilitate the description of this highly approved piston-construction the annexed figs. 87 to 90 are here inserted. The circumferenc of this piston, which is cast hollow has two grooves, into which four ring-segments *k* are inserted, overlapping each other in the manner shewn at *f* and *n*. A spring *S* is attached to the inner side of these segments, which pressing against the piston, forces the segments against the cylinder surface and so forms a very efficient steam-tight contact.

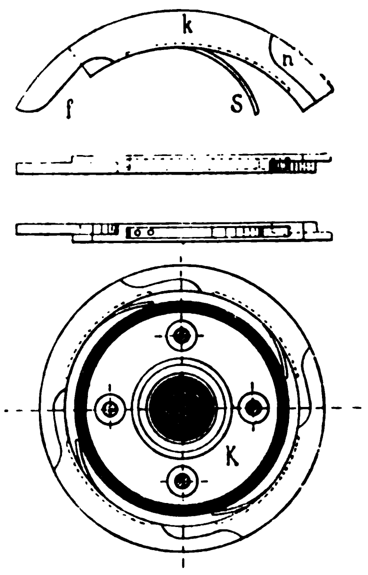

Fig. 87—90.

The arrangement of the steam-pipes may be also seen from fig. 4 (Plate 17). The main steam-pipe from the boiler is made to discharge direct into the space containing the two expansion-valves shewn immediately under the cylinder. It is claimed that if by any means water should be carried along by the steam, that it would do the cylinder no harm, on account of this last mentioned space being sufficiently large, to take up the water prior to its entering the cylinder. The exhaust-pipe leading into the atmosphere, takes the exhaust steam from the bottom cylinder-space. The cylinder with its flat bottom, is carried on cast-iron legs, to which it is firmly bolted.

A cylinder-diameter of 1′ 5″ (432 mm.) is made to correspond to a piston-stroke of 3′ 10″ (1200 mm.), with a piston-speed of 7′ 10″ (2.4 m.) per second. The engines, working at 5 atmosphere pressure, develop 150 HP.

The two steam-pipes are 5″ (127 mm.) and 6″ (152 mm.) in diameter, and their respective areas are therefore in the proportion of $^1/_{11.5}$ and $^1/_8$ to the cylinder-area. The curved slide-bars are not turned to the radius from the piston-centre, but to a far smaller radius, as the bore-holes in fig. 2 show.

The cross-head of the ordinary Corliss-type, is finished with its pin — of $3^1/_8$″ (80 mm.) diameter and $3^1/_4$″ (85 mm.) length — in one piece.

The crank-pedestal resting on two legs is bolted to the engine frame, and is made 1′ 4″ (410 mm.) long and $8^1/_4$″ (210 mm.) in bore.

The fly-wheel, 16′ (4880 mm.) and 2′ $1^3/_8$″ (650 mm.) on the face, is simultaneously used for belt-driving and works a belt 1′ $9^1/_2$″ (550 mm.) wide.

In proof of the superiority of the Wheelock Automatic American Engine, it may be added that it took the highest prize awarded to any engine at the late Paris International Exhibition, and that no less an important engineering firm, than that of Messrs. Daniel Adamson & Co. of Dukinfield, have become the sole makers of this engine for Great Britain.

10. The Automatic Variable Expansion-gear of Messrs. J. & E. Wood, Victoria Foundry, Bolton.

About the same time, as the Vienna International Exhibition afforded a more general insight into many of the approved and successful Corliss-engine constructious, 'Engineering'*) published an account of an automatic variable expansion-gear, founded on the V Corliss valve-gear arrangement. It was attached to a horizontal Compound-engine, in such a manner that the low pressure cylinder was fitted with an ordinary slide-valve. This arrangement was designed and constructed by Messrs. J. & E. Wood, Engineers of Bolton, and on Plate VIII, the reader will find the corresponding automatic variable expansion-gear illustrated.

We confine ourselves to this part of the engine, as it offers in other respects no special novelty and we also utilise the forementioned source in the following description.

A general side view of this gear is shewn by fig. 1 (Plate VIII), fig. 2 giving plan and fig. 3 end-view (partly in section) of the same valve-gear. It will be noticed in the first place, on referring to these several views, that the valve-gear is all mounted on a cast-iron frame, which is complete in itself, and which has only to be bolted down to the engine bedplate. This arrangement not only facilitates erection, by enabling the valve-gear to be all put together in the workshop, and then transported in its complete state to the place where the engine is to be fixed, but it also tends to insure general truth and accuracy in the working of the gear.

It will be seen from the general views that a shaft, driven from the crankshaft by bevel gear, gives motion by another pair of bevel wheels to a short shaft mounted in bearings on the valve-gear frame, this latter shaft carrying three eccentrics. Of these eccentrics, that in the centre A_1 gives motion to the exhaust-valves, these being of the Corliss pattern, and situated on the underside of the cylinder. These valves have, as in all Corliss-engines, a constant motion. The two other eccentrics AA drive each a steam admission valve, and, as will be seen from the detail views, each is connected by a short rod with a rocking lever TT_1, of which the lower end works on a fulcrum on the valve-gear frame. At the upper end each rocking lever is attached to a driving bar e, this bar having its other end carried by a couple of rollers NN, as shown. At the roller end there is also fixed to the underside of the driving bar a catchplate with three teeth nn, these teeth engaging, when the driving bar is drawn back, with corresponding teeth oo on a catchplate fixed at the end of the buffer-spindle P from which motion is given to the corresponding steam-valve. The use of the multiple 'saw teeth' on the catches is a special point in Messrs. Wood's gear, and a very good one, as by means of it they are enabled to get a large amount of bearing surface. Thus, for the valve-gear of an engine working up to 250 HP. indicated, they employed three teeth, each 4 in. in width, and they thus obtained a length of 'bite' of 12 in.

The action of the gear, which will be readily understood, is as follows: As each driving bar

*) d. 21. Nov. 1873, p. 421—422.

is pushed towards the cylinder by the action of the eccentric, its catches, which during that portion of the movement are in gear with those *oo* on the buffer-rod *P*, give motion to the latter, and the corresponding steam valve is thus opened. At a certain point in the stroke — determined, as we shall explain presently, by the action of the governor — the rollers *NN*, which we have mentioned as carrying one end of the driving bar, mount two short inclined planes *rr*, and by so doing raise the driving bar *e*, and bring its catches *nn*, out of gear with those on the buffer-rod *P*. As soon as this disengagement takes place, the spring *S* draws back the buffer-spindle *P*, and thus closes the steam-valve, and cuts off the steam, the 'cut-off stroke' of the valves, as we may term it, being checked by the compression of the air in the air-cylinders or dashpots *oo*, as in the ordinary Corliss-gear. On the driving bar *e* making its return stroke under the action of the eccentrics, the rollers descend the inclines, the teeth re-engage those on the buffer-spindle, and the whole operation is repeated. The action of the gear driving the other steam-valve is of course precisely similar. The springs *S* by which the return stroke of the buffer-spindles is effected are, we may mention, made of shear steel untempered, so that if necessary they might be renewed by any village blacksmith, and they are bent to such a form that their top-point moves as nearly as possible in a straight line.

It is obvious that in the arrangement we have described the point of disengagement of the teeth of the driving bar, and consequently the point of cut-off, is determined by the position of the short inclined planes which the rollers supporting the bar are caused to mount, and this position of the incline is adjusted by the governor in the following manner. Referring to the detail views, it will be seen that the inclined planes are fixed upon small brass carriages, which move in suitable guides, and which are connected by short links to the lower end of levers *R*. This lever is fixed on a spindle also carrying another lever, the latter being coupled to the rod *M* leading to the governor. It will readily be understood that, as the governor balls rise, the carriages, with the inclined planes, is advanced towards the driving bar *e*, and thus an earlier disengagement of the teeth, and consequently an earlier cut-off, is obtained.

We have already pointed out the advantage gained by employing a separate eccentric to drive the steam-valves of Corliss-engines, and explained how it enabled the range of expansion to be increased. Another advantage attendant upon this mode of driving the steam-valves, is that the valves may be opened as gradually as may be desired, thus avoiding the sudden shock which occurs with many engines fitted with Corliss-gear. Messrs. Wood's arrangement possesses these advantages equally and in the arrangement we are now describing the eccentrics for the steam-valves are set so that they almost coincide with the main crank, their lead being only sufficient to work off the slight cover lap given to the steam-valves, thus causing the latter to be just opening when the main crank is passing the centre. The eccentrics thus give, comparatively speaking, a moderately slow opening to the steam-valves; but even with this arrangement it is found desirable, in order to avoid shocks when using steam of high pressure, to slightly hollow the edges of the steam-valves, and thus obtain a more gradual admission. As the eccentrics, as set by Messrs. Wood, have a slight lead on the crank, they of course cause the area of opening of the steam-port, due to the movement of the valve, to increase more rapidly than the speed of the piston, and thus there is practically no throttling.

We have now to describe the provision made by Messrs. Wood for stopping the engine in the event of anything going wrong with the driving gear of the governor. Referring to fig. 1, it will be seen that each disengaging plate, besides having the two short inclines — which are mounted by the rollers of the corresponding driving bar each time the cut-off of the steam is effected —, is also provided with a supplementary incline facing in the opposite direction. When the engine is working in its normal condition the action of the governor keeps the supplementary incline clear of the rollers; but if the driving gear of the governor fails, the balls fall to their lowest position, and the lever, being then pushed to the extremity of its range towards the cylinder, the auxiliary incline just mentioned is brought under the rollers of the driving bar and the teeth *nn* on the latter are thus prevented from falling into gear with those on the buffer-spindle *P*. Under these circumstances, the steam-valves are of course not opened, and the engine stops. The same action also takes place in the event of the rod *M*, which forms the connexion with the governor, being broken. In this case the lever *R* is pushed to the extremity of its range towards the cylinder by the action of a weight attached by a rod to a lever.

It is evident, however, that the arrangement we have just described would not only stop the engine in the event of the governor gear breaking down; but would also, if no provision were made to the contrary, come into play each time the engine was stopped, and would thus interfere with the readiness of starting it again. To avoid this inconvenience there is fixed on the spindle actuated by the governor a square-ended lever (not shewn in fig. 1), and there is also provided a catch I, which is shown out of gear in the engraving. When it is desired to stop the engine this catch is thrown forward before steam is shut off, and thus, as the engine slackens speed, the square ended lever takes a bearing against the end of this catch, and the governor balls being thus prevented from falling to their lowest position, the auxiliary incline on the disengaging plates, to which we have referred, is prevented from being brought under the rollers of the driving bars. The various parts of the gear, we may add, are so arranged as to prevent the teeth of the driving bar catch-plate from falling into gear with the wrong teeth of the catch-plates on the buffer-spindles under any possible circumstances. Altogether, the whole of the details of the gear are capitally worked out.

According to 'Engineering' a set of indicator diagrams were taken from an engine exactly similar to that we have been describing, and which was constructed by Messrs. J. & E. Wood for Messrs. F. W. Booth & Co., of Leigh, near Manchester. When the diagrams were taken this engine had been running for twenty-six weeks, giving an average of 405 indicated horse power, with an average consumption of 29 tons of coal per week, this corresponding to 2.67 lb. per horse-power per hour. The 29 tons, we should state, included all coal used for raising steam for heating the mill and offices. The diagrams were taken with the engine running at 42 revolutions per minute, corresponding to a piston speed of 420 ft. per minute. The boiler pressure was 77 lb. per square inch, and the action of the valve-gear, was excellent.

The diagrams, were taken from the back and front of the high-pressure cylinder respectively, and the former showed a mean effective pressure of 32.18 lb., and the latter of 33.75 lb. per square inch. The mean effective pressure exerted in the high-pressure cylinder was thus 32.87 lb., this corresponding to an indicated power of 239.4 HP. developed in that cylinder. Of the other pair of diagrams, also taken from the back and front of the low-pressure cylinder, the average effective pressures was in the two cases 9.77 lb. and 9.85 lb. respectively, or a mean in that cylinder of 9.81 lb. per square inch. The power developed in that cylinder is thus 172.9 horse-power, making the total power 412.1 horse-power indicated. In the diagram, taken from the back of the high pressure cylinder, the initial pressure shown was 71 lb., and in the diagram, taken from the front 74 lbs. per square inch; it will be noticed, that the loss of pressure between the two cylinders was exceedingly small. The vacuum was also well maintained, since the diagram from the front end of the low pressure cylinder shewed an almost constant vacuum of 12 lbs. per square inch during the exhaust stroke, while in the back-end diagram the result was nearly, but not quite, so good.

The working positions of the valves is shown in fig. 4 (Plate VIII) the points *a d* and *b*, corresponding to the crank, being on the left dead-centre. The positions in which the inclined planes *rr* must be under the control of the governor, in order to effect disengagement at certain stroke-periods, is graphically explained by our fig. 5 (Plate VIII).

An improvement on the valve-gear which we have just illustrated has been lately made by Messrs. J. & E. Wood, displaying great originality, and which up to the time of writing has not been previonsly published. We are indebted to the makers for the working-drawings of the improved arrangement represented on our Plate 18.

As in the Wheelock engine, which may possibly have served as a model, so also in this arrangement, the underside of the cylinder is only furnished with one steam-passage for the cylinder supply and discharge. The steam is conducted through the middle pipe under the cylinder, whilst the exhaust takes place through the feet of the cylinder. In order to facilitate the method of disengagement, the latter is shown enlarged in fig. 4 of the Plate.

The steam or inlet valves at GG are of the ordinary Corliss-type, the spindles of which pass through stuffing boxes in the brackets or bearings shewn in our illustrations. To each of the spindles is attached a lever LL which is connected at the opposite ends to the buffer cylinder OO (containing the spiral spring S for closing the valve) and to the sliding catch block N which contains the steel tooth plates oo and the trigger block rr. The driving rod E which receives its back and forward motion from the eccentric acts alternately on each of the catch blocks NN. The drawing shows the driving rod E at the end of its stroke in gear with the block N in connection with the valve at the back end of the cylinder. On the rod E being pulled forward the valve begins to open at the same time compressing the spiral spring in the buffer cylinder O. When the catch block N is pulled so far forward that the trigger block r comes in contact at the bottom, with the wedge piece K, the trigger block begins to rise, lifting with it the driving rod E which rests upon it, thus freeing the tooth plates oo in the sliding catch block, and nn in the driving rod E and allowing the spring in the buffer cylinder to close the valve and cut off the steam.

The same action takes place for the front valves of the cylinder at the return stroke of the rod E. The wedge piece K is held in position upon the swivel cranks kk which are connected to the governor through the levers RR and rods MM.

When the governor rises the same motion is transmitted to the wedge piece K thus causing the steam to be cut off earlier. On the governor falling the steam is cut off later. The variation of the cut-off thus given being from O to $^3/_4{}^{\text{ths}}$ of the stroke.

The exhaust or outlet valves at HH have on the spindles, levers $L_1 L_1$ which are connected direct through the rods, $E_1 E_1$ to an eccentric which gives them positive forward and backward motion.

Only one port is used at each end of the cylinder to admit and discharge the steam.

The constructive arrangement of the cylinder and of the valve-gear as well as the position of the governor are fully shewn in figs. 1—3 (Plate 18). JH is the handle of the injection valve, DV is that of the steam-valve, and the handle of the blow-off valve is shewn at BV.

In fig. 5, the positions of the valve-gear are graphically represented on an enlarged scale. According to the tracing supplied to us by the makers, the governor is represented in middle position, whereas the wedge piece K along with the swivel cranks kk are shewn in their highest position. If this high position of the wedge piece K is assumed as its middle position, we should obtain the unsymmetrical declination shewn in fig. 6 *a*, which may well be expected, not to take place. For this reason, we hold the symmetrical declination represented in our fig. 6 *b*, to be more correct.

The travel of the disengagement mechanism, in relation to the piston-travel, is graphically explained by our fig. 7.

Objection may perhaps be taken at the application of oscillating dash-pots, on account of the wear and tear on their centre, eventually causing a noisy motion; if care and good judgment be however excercised in the constructive portion, we may presume that no such detriment will present itself for years. In other respects, the present arrangement with its original combinations of various ideas may be deemed one of the most perfect solutions of the problem, how to construct a rational automatic variable expansion-gear! This the more so since the more compendious arrangement of the whole valve-gear to the underside of the cylinder, as compared with the decidedly more complicated Corliss-type, has many more points in its favor.

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11. The Automatic Variable Expansion-gear of Messrs. Märky & Schulz.

Great interest was manifested, at the Vienna Exhibition, in a then newly patented Corliss valve-gear by Märky & Schulz, which was attached to a Corliss-engine, exhibited by the Carolinenthaler Maschinenbau-Actiengesellschaft.

The general arrangement shewed similarity to the V Corliss-valve-gear, though its method of disengagement was as original, as it was ingenious. In our fig. 1 Plate IX we give a view partly in section, whilst fig. 2 gives us this valve-gear in plan.

The wrist-plate A is placed at the side of the cylinder, and motion is transmitted in the usual manner on to the exhaust-valves by the motion-rod E_1E_1. The rods EE work the inlet-valves, and in this construction they are made longer, than we saw adopted in the V Corliss-valve-gear; they work against the arms of two hollow dash-pots O_1 in which the buffer-rods p are placed. A strong spiral spring is attached to the outer end of the latter, which so causes the rod p and buffer-piston O to be constantly pulled to the left. The middle portion of the rod p is made square and furnished with a steel plate o behind which, as fig. 1 shows, a vertical sliding bolt n assisted by a spring is inserted in the dash-pot O_1. If therefore the rod E moves towards the cylinder, this motion becomes imparted to the dash-pot O_1, as well as to the piston-rod p and buffer-piston O. The forementioned bolt n holds the rod in fork-fashion, and it carries a pin outside the dash-pot O_1 working loose in a long groove of a small link e. The latter is suspended from a slide-block r, moving horizontally under the control of the governor.

The action of this mechanism is as follows: As soon as with the horizontal position of the rod, the bolt n has geared into the catch o and the dash-pot O_1 begins to move towards the cylinder, the inclined position of the link e will cause the pin to ascend in the groove of this link; this will continue till the link has almost become perpendicular and the groove-end prevents the pin from rising any further. At this moment, the pin is pressed downwards, whereas the dash-pot O_1 continues its travel, and consequently the bolt-edge n becomes liberated from the catch o, thus allowing the spring of the dash-pot to come into action and close the inlet-valve in the usual manner. It is evident, that the more the link e approaches perpendicularity at the beginning of the link-travel e, or the more the slide-block r is placed to the left, the earlier will the 'cut-off' take place. The spring S becomes compressed with the return-stroke of the dash-pot O_1. Our sketch shows the front dash-pot O_1 and the buffer-piston in their extreme position, towards the steam-cylinder, though as the governor balls are in their lowest position, automatic cut-off has not taken place, or in other words, steam is being admitted up to nearly full stroke.

An advantage in the present disengagement method, is that the shocks, which always ensue at disengaging periods, are not transferred to the governor, but that they are confined to the slide block r.

We are given to understand, that the practical working of this mechanism is excellent, and it has also been much praised in several engineering circles. Noteworthy is the great accessibility to all the working parts, demanding no great mechanical skill to attend to. The working in and out of gear of the disengagement mechanism is always sure and certain to take place at the proper time.

According to the size of the lead-angle and the use of only one eccentric the range of expansion is small, automatic cut-off not exceeding $^2/_5$ stroke.

In the engine exhibited, the cylinder was 1′ 4½″ (421 mm.) bore, and running at 102 strokes of 3′ 2″ (948 mm.) per min. the piston-speed was 6′ 3″ (1.6 m.) per second. The engine worked non-condensing at 75 lbs. The cylinder with its valve-boxes and legs was cast in one piece, and was not steam-jacketed. The piston worked through both cylinder-covers, and its end was carried on a table. The crank-pedestal was cast with the engine-frame, but without means of adjustment, and the fly-wheel $47^1/_{10}$ tons (4800 kg.) in weight served as strap-pulley.

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12. The automatic variable Expansion-gear of the Maschinenfabrik Crimmitschau.

a. Fitted with the Steiner Valve-gear.

The Steiner valve-gear, has probably been largely introduced into Germany, by the Steam-engine-works Crimmitschau (Saxony). According to information received from this engineering firm, they have fitted the Steiner gear since 1872 to 150 Steam-engines varying in sizes from 15 up to 300 horse-powers. Of these machines; 29 were Condensing-engines of a minimum power of 25 HP.

Following Messrs. Märky & Schulz' example, Steiner has similarly discarded the rocking-levers and disengagement-tackle of the fifth Corliss-gear. In its place, he has adopted a parallel horizontal arrangement of the dash-pots, which in Corliss' gear were placed at right angles to each other. By way of further contrast, the springs effecting the shutting-off of the valves were arranged vertically by Corliss, whereas Steiner places them horizontally.

This valve-gear may be explained from the annexed woodcut fig. 91. The exhaust valves *HH* are worked as usual from the rods E_1E_1 attached to the front and back sides of an oscillating wrist-plate *A* placed sideways in front of the steam-cylinder. The rods e_1e_1 each give motion to a slide *T* furnished with a vertical movable bolt nn_1 on its side nearest the cylinder. As our figure shows, the upper edge of this bolt *n*, fits behind the steel catch-plate *o* of the buffer-rod *P*, and consequently compels the latter to move with the slide *T* in the direction indicated by the arrow

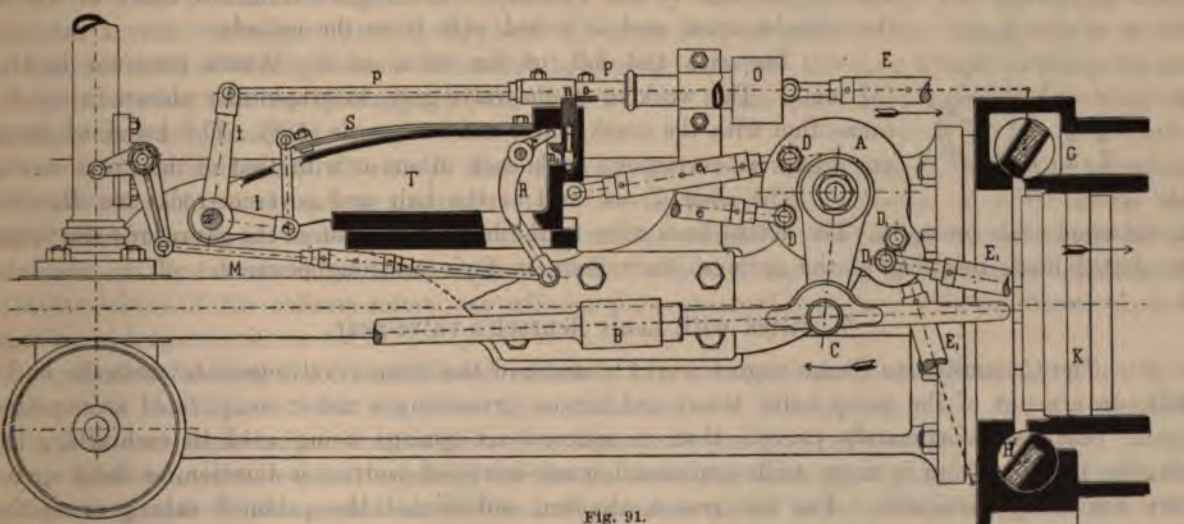

Fig. 91.

The inlet valve *G* is opened by this motion, the swing-centre of the lever *R* similarly taking part in the movement of the slide, whilst its lower eye is kept fast under governor-control. The lever-arm *R* thus approaches perpendicularity, and a moment occurs when its shorter arm *r* forces the bolt nn_1 down, and disengages the same from the steel catch-plate *o*. The springs *S* fastened on the back of the slide *T*, compressed by the previous stroke, now come into action and shut off the inlet-valve, by the somewhat complicated intermediate link-mechanism *tt*, *p* and *P*.

The lever *Rr* receives two motions: one from the slide *T*, the other from the rise or fall of the governor-balls. This action is explained by our figure 92, demonstrating as it does the position of the eye of the lever *R* in order to effect automatic cut-off at the inscribed degrees of expansion or stroke-portions.

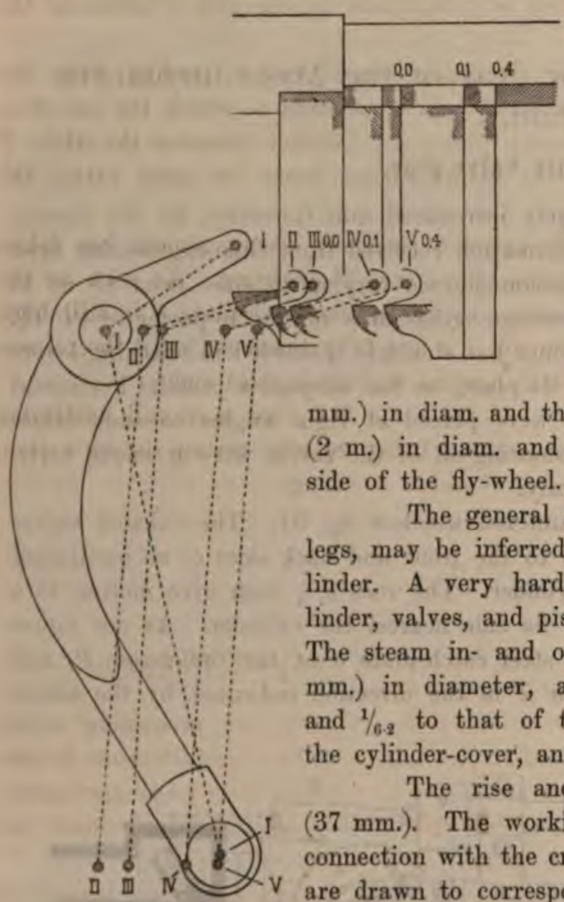

Fig. 92.

The reader will find, the Steiner-valve gear fitted to an engine of 1′ $2^5/_8$″ (375 mm.) cylinder-diameter and of 2′ $5^1/_4$″ (750 mm.) stroke on Plate 19 of the Atlas.

The piston working with 75 lbs. steam-pressure at an average speed of 4′ 6″ (1.37 m.) per sec. runs the crank at 55 revolutions per min. The flywheel 11′ $4^1/_2$″ (3500 mm.) diam. and 9″ (230 mm.) on the face, is mounted on a crank-shaft $6^7/_8$″ (175 mm.) in diam. and the engine power is transmitted from a belt-pulley $6^1/_2$′ (2 m.) in diam. and $11^5/_8$″ (300 mm.) wide on the face, mounted at the side of the fly-wheel.

The general arrangement of the valves, steam-pipes and cylinder-legs, may be inferred from fig. 3 giving a longitudinal-section of the cylinder. A very hard iron-composition, is used in the casting of the cylinder, valves, and piston-rings, with a view of diminishing wear and tear. The steam in- and outlet pipes are each $4^1/_4$″ (110 mm.) and $5^7/_8$″ (150 mm.) in diameter, and their cross-areas are thus in the ratios of $^1/_{11.4}$ and $^1/_{6.2}$ to that of the cylinder. The engine frame is made to overlap the cylinder-cover, and is bolted with it to the cylinder.

The rise and fall of the collar of the Watt's governor is $1^7/_{16}$″ (37 mm.). The working of the valve-gear, is graphically shown in fig. 5 in connection with the crank-travel and lead-angle (10°). The inscribed arrows are drawn to correspond with each other or with that of the crank-motion.

The slide *T*, as well as the bolt and governor-rods, are drawn to an enlarged scale on fig. 6. The dotted lines refer to the highest position of the governor-rods, though the dotted lines, referring to the springs, show them in their unstrung position.

b. Fitted with Louis Renzsch's valve-gear.

The Crimmitschau Steam-engine works abandoned the Steiner valve-gear towards the end o[f] 1877, on account of the many bolts, levers and hinges, presenting a rather complicated arrangement. Again, practice unfortunately proved, that in spite of six springs being used to each slide, they often broke, so causing in many mills unpleasant break-downs of protracted duration, as these springs were not easily obtainable. For this reason, the firm substituted the patented valve-gear of their Manager (M. Louis Renzsch) as an improvement on the Steiner gear.

A sketch of Renzsch's valve-gear, as fitted to an engine, is drawn on our Plate X, fig. 2—4 referring to different positions of the valve-gear.

The wrist-plate A with its four motion-rods, and the dash-pot frame have not been deranged, though the slides TT_1 are somewhat modified. Each of the latter, is made to carry a cylinder receiving a spiral spring S and a buffer-piston P, which spring exercises a constant tendency to pull the piston P away from the cylinder. The connection of this piston, with the inlet-valves is effected in the usual manner.

Similar to the Steiner and Märky & Schulz valve-gears, the buffer-piston P is furnished with a steel catch-plate o, behind which a vertical sliding bolt n grips — vide fig. 2 — owing to the action of the small spring s. The oscillation of the wrist-plate A in the direction of the inscribed arrow, imparts motion to the slide T, which movement is transferred to the rod P effecting the opening of the inlet-valve.

The bolt n has a slot through it, into which the wedge-shaped rod r (leading from the governor) enters. This rod r presses the bolt n down, at the given position at which the cut-off is to take place, by overcoming the pressure of the small spring s. Contact between the slide T and the piston P being thus broken, the action of the spiral spring closes the inlet valve, the resulting shock being air-cushioned.

The second slide T_1 is shewn in fig. 3 in its extreme position; disengagement has taken place, the catch-plate o has passed over the bolt n leaving the spring S unstrung. As soon as the wrist-plate has attained its central position, as represented in fig. 4, the catch-plate o is still high over the bolt n, and the spring S is partly strung, though it is not fully tensioned until the return-stroke of the wrist-plate, after the bolt has again caught against the catch-plate end.

In comparing these two last named valve-gears, of the same firm, we may call particular attention to the greater simplicity of the second type, which being equally certain in its action, dispenses with the noise of external springs, by enclosing these in a casing.

13. The automatic variable Expansion-gear of Karl Kliebisch.

A very peculiar valve-gear arrangement, totally differing from all the preceeding arrangements, is the valve-gear patented by Karl Kliebisch and adopted by the Sangerhauser Actien-Maschinenfabrik und Eisengiesserei — formerly belonging to Messrs. Hornung & Rabe of Sangerhausen.

According to the lead-angle of the inlet-valves, steam may be advantageously used expansively up to $^3/_4$ stroke.

The annexed figure 93 shows, that the valve-gear is worked from a horizontal transverse shaft, placed in front of, and in centre-line with, the cylinder. An eccentric A_1 is keyed on this shaft, which by rods E_1 and lever F_1 works the exhaust-valve H. Owing to this arrangement, the movement of the exhaust-valve, is consequently symmetrical on each side of its middle position; — a similar travel of the exhaust-valves, as will be here observed was met with in Messrs. J. & E. Wood's engines.

To the back of the forementioned eccentric, two other eccentrics of smaller throw are fitted on the same shaft; these work the inlet-valves by means of a suitable trip-gear. Our fig. 93 shows only the one of these eccentrics A which gives motion to the front inlet-valve-G.

The whole valve-gear including the motion-shaft, the dash-pot O, and the swing-centre of the levers R and K are carried on a frame of peculiar form, bolted to the engine-frame. The lever K is symmetrically worked from the eccentric A. A bracket NN, sits on the boss of the lever K, with sufficient play for its small vertical motion, on its centre-slot. At its lower end, this bracket is fitted with a trigger n which by the action of a spring S let into the bracket, is

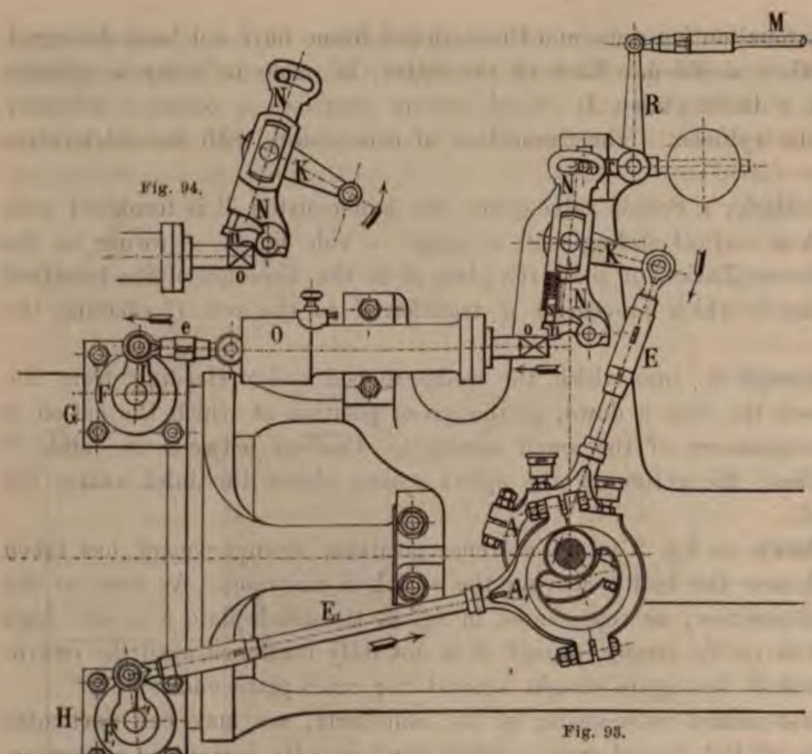

Fig. 94.

Fig. 93.

constantly pressed down behind the square portion of the buffer-rod *o*; provision is made to prevent the trigger *n* from ever falling too low, by a knuckle joint round the end of the bracket

In our fig. 93, we represent the eccentric as having already performed a portion of its stroke, and consequently the buffer-rod has been pushed in the direction shewn by the arrow. A spring placed inside the dash-pot *o* has a contrary tendency, always seeking to close the valve.

A small link *e* connects the valve spindle lever *L* with the dash-pot piston, and the problem now resolves itself in effecting the disengagement of the trip gear, by the automatic action of the governor. For this purpose, the bracket *NN* has a circular slot at its top end, into which a steel pin works. This pin fits on a lever *r* worked direct from the governor through the rod *M* and the lever *R*. The weight of the moving parts is counterbalanced by a weight suspended from the lever *R*. Automatic disengagement of the trip-gear must in all cases take place towards the end of the stroke of the eccentric, as we will prove later on.

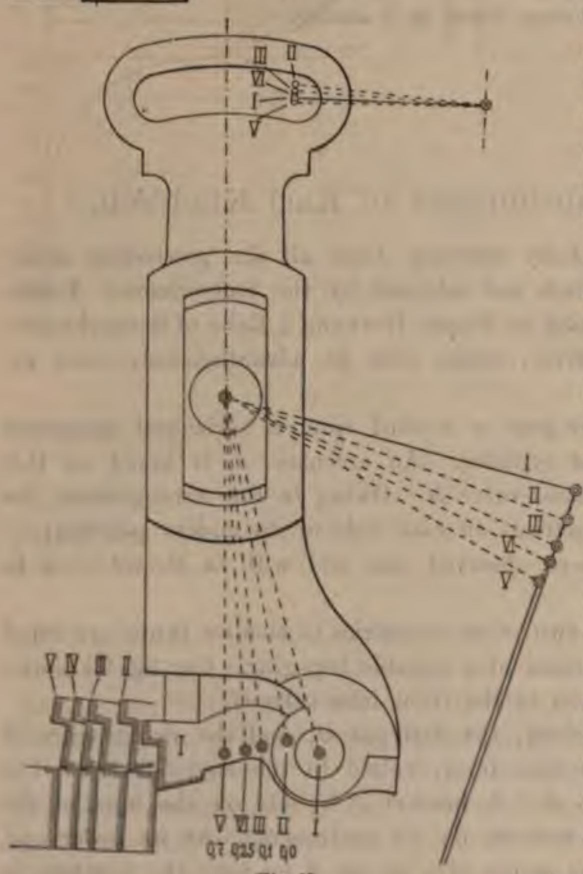

Fig. 95.

On disengagement ensuing, the dash-pot piston is thrust back by the action of the spiral spring, and while the dash-pot, deadens the shock, the inlet valve becomes closed. The position of the trip-gear towards each other after disengagement, is represented by fig. 94.

According to the position of the governor-collar, the bracket *N* is raised more or less by the lever *r*, thus simultaneously shortening or lengthening the oscillation of the lower part of the bracket. It is therefore obvious, that the trigger *n* will be the sooner relieved from the dash-pot piston *o*, the smaller the radius of its oscillation becomes. This fact is moreover confirmed by our fig. 95, representing as it does the position of the trip-gear, for certain piston-stroke portions. We perceive, that the travel of the trigger *n* becomes gradually smaller, on account of the crank-motion of the eccentric. This is clearly confirmed by our fig. 95, and we may therefore conclude that automatic disengagement is far more exact, with early, than with late cut-offs.

We have already observed, that steam must never be admitted up to full stroke with this valve-gear; the diagram of the inlet-valve, as represented by fig. 96, will readily explain the reason why. According as the lead-angle is chosen, the point g may fall on any point of the line AB — that is to say the limit of automatic variable expansion may lie between 0.0 and full stroke when one separate eccentric is used for the inlet-valves. If only one eccentric is used for all the valves, then the point g must lie before the completion of half the stroke, in order that the condition attending a uniform working of the two exhaust-valves may be fulfilled. But if the motion of the inlet and exhaust-valves is effected by different gear-tackle, then the position of the point g on the line AB becomes optional. If, however, as in the example before us, the lead has been fixed in order that the valve may receive an accelerated motion at the stroke-commencement, then the limit of expansion or the position of the point g is thereby also determined. The nearer the point g approaches B, the later is steam shut-off, in case disengagement does not take place. In the engine before us, this will only happen at i (vide fig. 96) when the piston has travelled $\frac{1}{5}$ of its return stroke. Consequently, fresh steam would be supplied up till then, and in order to prevent this, care must be taken to effect automatic disengagement at the latest at g, if not before. For this reason, the line referring to the travel of the valve-edges is shewn dotted in our diagram from g to l, since, such a travel may never take place.

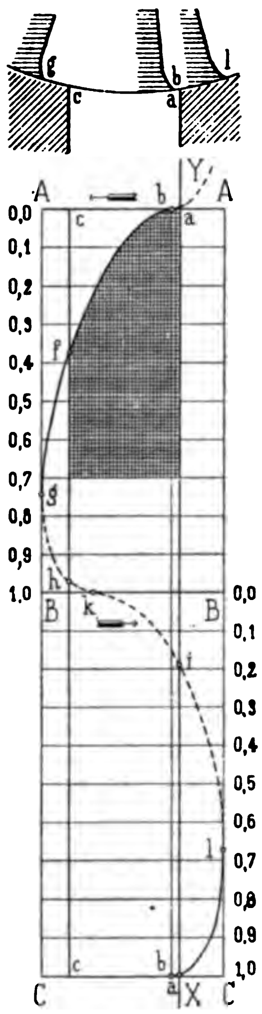

Fig. 96.

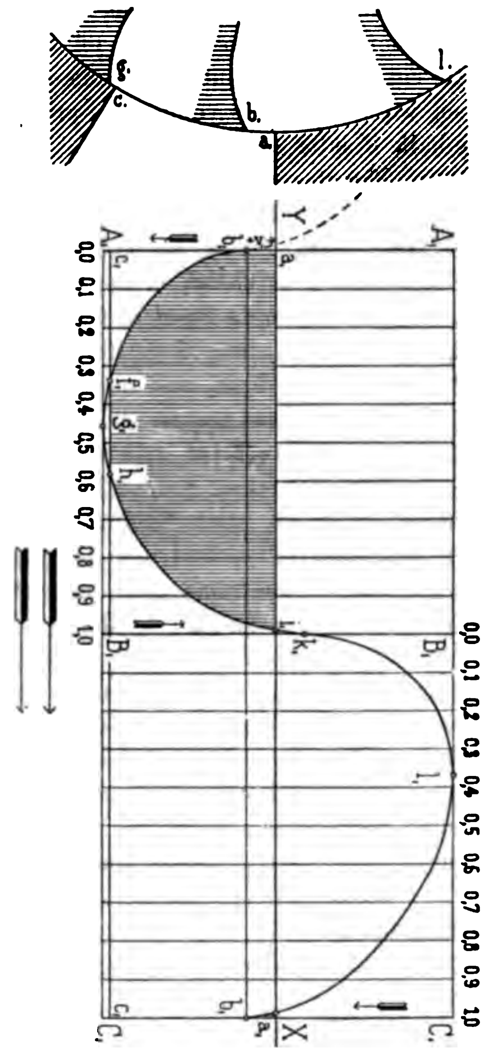

Fig. 97.

It is of course evident, that it would be improper to speak here of the lead-angle of the inlet-eccentric, in the sense put forward by Zeuner, in his valve-diagrams. The inlet-eccentric receives an oscillation of 65° from its stroke-direction when the piston is on the dead-centre; consequently the eccentric must still oscillate to 115° in order to bring the respective moving-parts into their extreme position.

The diagrams illustrated in our figs. 96 and 97 refer to the engine represented in our Plate 20. The steam-passages are $\frac{11}{16}$" (18 mm.) and $\frac{7}{8}$" (23 mm.) wide, and $12\frac{1}{2}$" (320 mm.) long. The lineal lead of the inlet-valve is $\frac{1}{16}$" (1.5 mm.) and that of the exhaust-valve is $\frac{3}{16}$" (5 mm.).

The eccentric working the inlet-valve, is set with an eccentricity of $2^1/_2$" (65 mm.) 65° in front of the crank, and the eccentric, working the exhaust-valve has $1^1/_2$" (40.5 mm.) eccentricity with a lead-angle of 11°.

The engine illustrated on Plate 20 is termed a „30 horse-power engine" by the Sangerhauser Maschinenfabrik. Its cylinder is $14^1/_2$" (380 mm.) in bore and of 2' $5^1/_4$" (750 mm.) stroke; the crank running at 60 revolutions per min. gives a mean piston speed of close on 6' (1,5 m.) per sec. As 30 horse-power are thrown off the engine with a cylinder steam-pressure of 6 atmospheres and with cut-offs at one-fifth and one-quarter stroke when non-condensing and at 0.1 and 0.13 stroke when working on the condensing-principle, it follows that the engine power may be increased fully one-half, if later cut-offs are used.

The steam-cylinder, is constructed in the ordinary way without steam-jacket. The steam-pipe is 4" (100 mm.) in diam., or $^1/_{14}$ the cylinder cross-area, and the copper exhaust-pipe $5^1/_2$" (140 mm.) diam. (or $^1/_8$ the cylinder-cross-area) either passes the steam into the condenser, or into the atmosphere, as shewn in our drawing.

The piston, is fitted in two parts, which are held by a closed screw-bolt; it is made steam-tight by two cast-iron rings furnished with one common spring. The piston-rod is of cast-steel $2^1/_4$" (59 mm.) in diam., and on account of the centre-line of the crank-rod running $5^3/_4$" (145 mm.) out of the cross-head-centre, the latter receives an eccentric pressure in its slides, and consequently the slide-blocks are fitted with double adjustable-wedges.

The connecting rod, 5.26 as long as the crank, is $3^3/_4$" (95 mm.) diam. at its centre; it is furnished with an open head at its butt-end (4" = 100 mm. long and 3" = 75 mm. diam) its other extremity (4" = 100 mm. long and $3^1/_8$" = 80 mm. diam.) being closed.

The engine-frame piece is cast in one piece, and somewhat overlapping the cylinder-cover is bolted to the latter and to the crank-pedestal.

The crank is mounted close to the bearing of the crank-axle, and is made of cast iron. The crank-pin only $4^7/_8$" (125 mm.) long is of cast steel. The diameter of the crank-shaft is uniform between its bearings namely $6^3/_4$" (175 mm.) in diam.; the crank-shaft pedestals are each $9^3/_8$" (240 mm.) long and 6" (155 mm.) in bore.

The fly-wheel is fastened to its boss by four screw-bolts, whereas the connection between the rim portions is effected by plate and wedges. Its face is $7^3/_4$" (200 mm.) wide, and the flywheel diameter is 11' $10^5/_8$" (3400 mm.).

We meet here with the Buss Cosinus-governor applied for the first time; it is driven by bevel-gearing of $^5/_8$" (16.5 mm.) pitch, from a strong shaft $1^1/_2$" (39 mm.) diam. at a speed of 298 revolutions per min. The bevel wheels on the crank-shaft, as well as the others are set to a pitch of $^3/_4$" (20.5 mm.).

All the motion-rods are rendered adjustable by screw-joints, and to increase the durability of the rocking pieces, these are made of steel.

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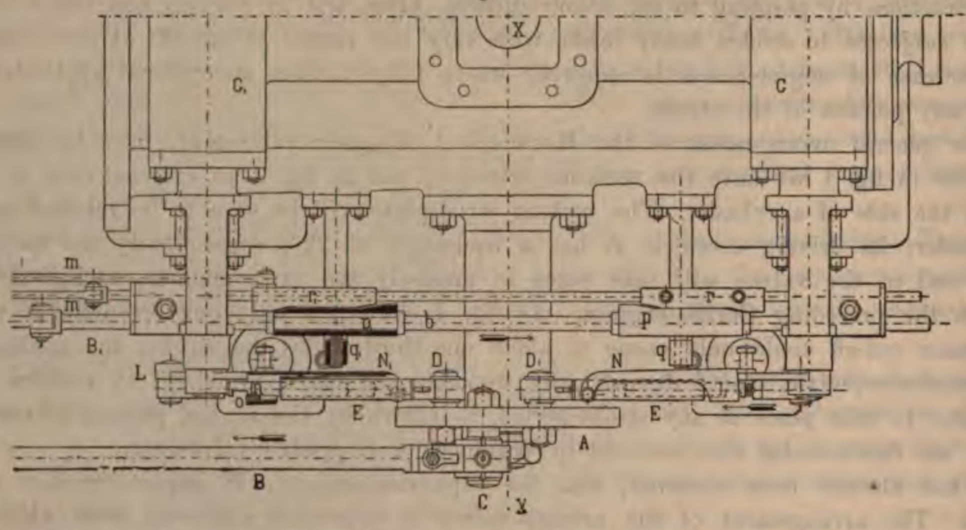
14. Wannieck & Köppner's Automatic Variable Expansion-gear.

The engines constructed at the works of Friedrich Wannieck of Brunn, and fitted with the Wannieck & Köppner automatic variable expansion gear, unquestionably belong to a class of Corliss engines, in which automatic cut-off can almost take place at any piston stroke-portion.

This cut-off arrangement possesses the advantages of the ordinary Corliss valve-gears; thus we notice the rapid opening of the inlet and exhaust valves at the commencement of the stroke and also perceive that the steam-passages are kept well open during the stroke, or whilst steam is running in the direction of the inscribed arrows. As soon as the wedge-piece p comes into solid contact with the opposite piece r, the toothed link N is knocked out of gear, and the inlet valve closes.

Fig. 98.



According to the high or to the low position of the governor balls, the wedge-pieces rr_1 are brought closer to, or further off, the cylinder-centre XX; the knocking of the wedge-pieces pp_1 driven from the expansion-eccentric, implying disengagement, thus ensues sooner or later during the forward, as well as during the return strokes of the motion-rod E. The symmetrical movement of the wedge-pieces rr_1 is ensured by the application of two toothed-segments (see fig. 1 Plate XI). In order that the time of contact between the governor wedges rr_1 and the pieces pp_1 may not be excessive, the former (rr_1) are so fixed, that when the expansion-eccentric E_1 is placed diametrically opposite the crank, automatic cut-off can only ensue between half-stroke and full-stroke. On the other hand, if disengagement is desired to take place between 0.0 and 0.5 stroke, then all that has to be done, is to move the expansion-eccentric round its circular slot, to the extent of 90^0, so that it then follows the crank at an angle of 90^0 as shewn in fig. 1, without in any way necessitating any alteration of the governor. It is not necessary to place the eccentric in any of the intermediary positions, on account of the governor controlling the 'cut-off' within the range of half the stroke.

We should also observe, that with later cut-offs than $^1/_{20}$ stroke, the wedge-pieces pp_1 do not leave the pieces rr_1 at the moment the links N get into gear with the catches o. Consequently these links could not become engaged, if their reciprocating motion in front of the bolts qq_1 was in a straight horizontal line. As the rods E and links NN have, however, a rocking motion in front of the bolts qq_1 dropping in fact below them, their working into gear is even in that case certain, and as soon as the links NN again approach the bolts qq_1, the wedge-pieces pp_1 have once more left the governor-pieces rr_1; the bolts are easily pushed back by the links NN, when these motions are ready to repeat themselves.

On Plate 21, we illustrate an engine of the Corliss-type fitted with the Wannieck & Köppner Valve-gear, as constructed at the works of Mr. Frederic Wannieck of Brunn; fig. 1 gives a side elevation of the engine, with its condenser and air-pump arranged under the engine-room floor, whilst plan and end-view of the same arrangement are shewn in fig. 3 and 4. This engine is of 35 H.P. (nominal) and its cylinder is of the ordinary Corliss-type with 17" (435 mm.) bore; the average piston-speed is 5' 6" (1.7 m.) per sec. running at 108 strokes per min. The steam-pipe is $4^1/_2$" (115 mm.) in diam. and as the exhaust pipe is $5^7/_8$" (150 mm.) in diam. the proportion of the two to the cylinder cross-area is respectively $^1/_{14.4}$ and $^1/_{8.4}$.

The piston-rod $2^5/_8$" (67 mm.) in diam. is prolonged through both cylinder-covers, being supported by the stuffing-box of the hind cylinder-cover. The narrow hollow engine-frame, is bolted by six screw-bolts to the cylinder; the crank-pedestal, is cast in one piece, with the engine-frame, which is furnished with V, in place of circular-slides. The Porter-governor is carried by the frame, and is driven by belting, at 170 revolutions per minute. Two vertical-rods are attached to its collar, one of which is fastened to the piston of a brake, whilst the other is connected with a lever of a short shaft, which imparts a rocking-motion to a second shaft fitted on the same frame, by means of the forementioned toothed segments. To the other end of this shaft, two levers of equal length are fitted, which move the rods mm_1 along with the wedge-pieces rr_1.

The connecting-rod is made $3^7/_8$" (100 mm.) in diameter at its centre, and is $4^1/_2$ times the length of the crank; the cross-head is $2^3/_4$" (70 mm.) in diam. and $3^7/_8$" (100 mm) long. The connecting-rod is placed as close as possible to the crank, the brasses of the former being merely allowed to protrude on the outer side, in order the prevent a dangerous thrust on the crank-pin. For the same reason, the boss of the crank, is made as short as possible.

The crank-shaft diameter is $6^3/_4$" (171 mm.), and has a bearing surface $13^1/_4$" (342 mm.) long.

The fly-wheel, $8^3/_{16}$" (210 mm.) on its face, is toothed to $3^1/_8$" (80 mm.) pitch, and with a tooth-flange diameter of 13' 4" (4100 mm.) weighs nearly 4 tons (4000 kg.).

The condenser is fixed immediately under the cylinder — vide fig. 1 and 3 — and forms a long pipe $10^1/_2$" (270 mm.) diam.; the exhaust-steam from the cylinder enters the condenser from the top, whilst the injection-water is introduced from the bottom, after it has passed the injector-valve. The water almost circulates to the top of the condenser, through a pipe inserted in the latter (fig. 4). The top of this injection water-pipe carries a rose, the opening of which, is regulated from the bottom, by a wrought-iron rod. A very good vacuum, is said to be obtained, by this arrangement.

The double acting air-pump is carried on a separate foundation, and driven in the manner shown from the engine crank-pin. The pump piston-stroke is $12^3/_8$" (317 mm.), and with a diameter of 1' (310 mm.) its capacity, is in the ratio of 1 to 6 to that of the steam-cylinder.

The feed-pump, bolted to the side of the air-pump, is driven from the cross-head of the latter; it takes the feed-water by a copper-pipe, from the hot-well, placed over the air-pump. A cock, fitted between this pipe and the suction-valve, serves for the purpose of stopping the feed-pump, in which case, it delivers the suction-water, into the forementioned pipe.

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15. Bède and Farcot's Automatic variable Expansion-gear.

Amongst other new and interesting Corliss-engines, the Vienna International Exhibition brought to public notice, the Bède & Farcot automatic variable expansion-gear, fitted to a 50 HP. Condensing-engine, which was constructed by Messrs. Houget, Teston, Bède & Co. of Verviers. This valve-gear, similarly belongs to a type permitting automatic cut-offs to take place at later stroke-periods, than the original Corliss valve-gears allow.

In the annexed fig. 99, representing the Valve-gear of Messrs. Bède & Farcot, we note that a shaft B proceeding from the crank-shaft, is placed parallel to and at the side of the cylinder-axis; this shaft is made to drive a vertical spindle, by means of a set of bevel-wheels. The last named spindle, is driven at the same number of revolutions as the crank-shaft, and the governor is mounted on it; our fig. 99 does not show the governor. The exhaust-valves H, are driven from a shaft in the frame A_1 carrying a cam T, which is shewn in detail, in fig. 6 and 7 of Plate 22. Eyes laterally placed in this frame connect the motion-rods E_1E_1 with the levers L_1L_1 of the exhaust-valves HH. If the crank-positions K (fig. 6 and 7) are followed in the direction of the in-

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scribed arrows, it will be seen that the travel of the exhaust-valves, is quite depending on the form of this cam; in the construction before us, the form of this cam is so chosen, that the valves open quickly, and remain stationary in their extreme open position, but again shut rapidly, stopping closed, almost during the entire subsequent stroke.

By far the greatest interest attaches to the disengaging or trip-gear. Comparing the annexed fig. 99 and fig. 6 and 7 (Plate 22) it will be seen that an eccentric *U*, keyed fast on the vertical spindle, revolves in the frame *A* following the crank at an angle of 126°, whence it follows that

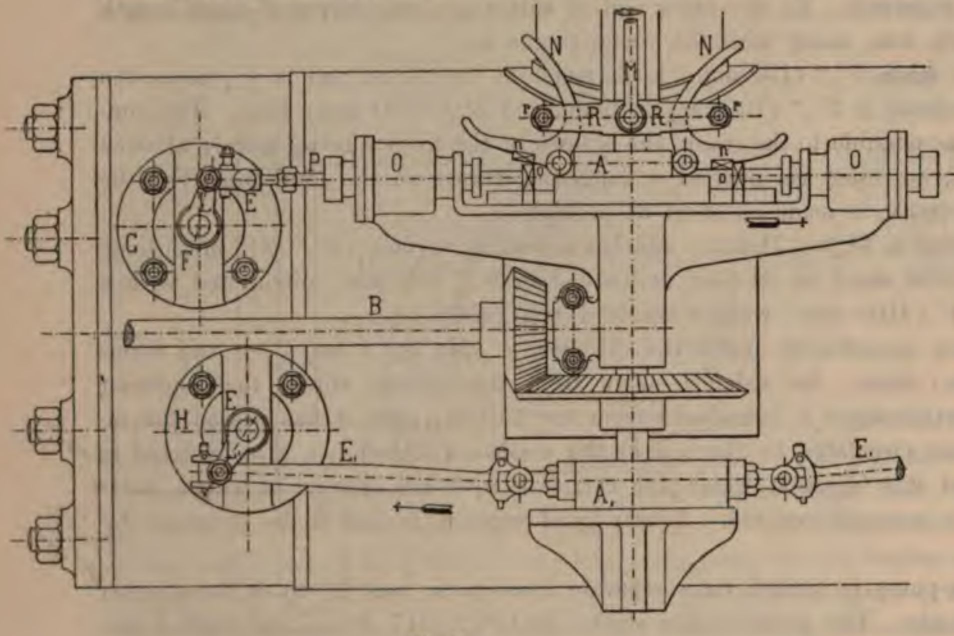


Fig. 99.

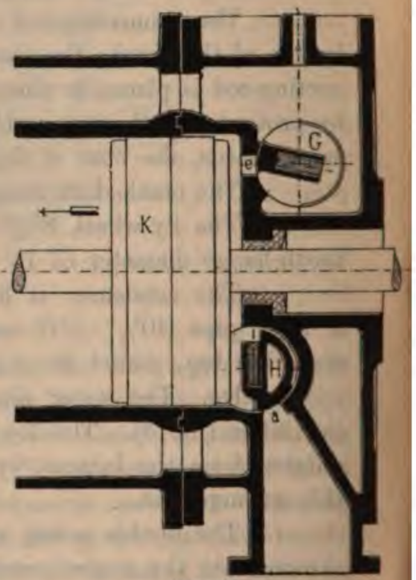


Fig. 100.

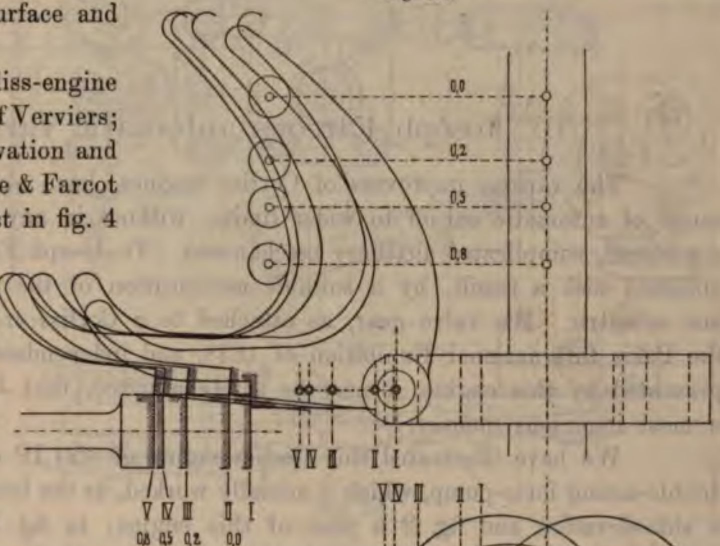
the eccentric, only then assumes its change of stroke, when the piston has travelled $^4/_5$ of its stroke, so that the 'cut-off' is only up to that time, under governor control. With this object, two triggers *NN* swivel on pins, fitted to each side of the frame *A*. The lower portion of each trigger, is furnished with a steel catch *n*, gearing at the proper time into the square end *o* of the dash-pot piston *P*. The other extremity of this piston, has an eye for the purpose of connecting the inlet-valve spindle lever *L* (by means of a short link *E*) with this piston.

The action of this valve-gear, is as follows: Confining ourselves to the mechanism at the right of the cylinder, which corresponds to the position of the valves shewn in section by fig. 100, we observe that the crank is on its right dead centre. The catch *n* of the trigger *N*, is in gear with the square-end *o* of the dash-pot piston, and consequently the frame *A* and also the buffer-rod *P* have been so far drawn to the right, that the inlet-valve *G*, has opened to the extent of the lineal lead. With the continued horizontal movement of the trigger *N*, the upper arm of the latter, impinges against the fixed-roller *r* of the rail *R* which has a vertical traverse, equal to that of the sliding collar of the governor. As the swing-centre of the trigger is still moving onwards, a moment occurs, when the catch *n* is knocked out of gear, through the roller *r* forcing the trigger *N* to swivel round its centre, in a circular-direction from right to left. It is at this period, that the action of the spring in the dash-pot comes into play, by rapidly drawing back the piston *P*; this closes the inlet-valve, whilst the left exhaust-valve *H*, moves in the direction of the inscribed arrow. We must here correct our wood-cut fig. 99, which erroneously shows the frame *A*, moved too much to the right. The two dash-pots *O*, as well as the sliding-surface of the frame *A*, are cast in one piece, bolted to the cylinder.

Automatic disengagement, through the action of the governor, is shewn in our fig. 101. This valve-gear possesses the great advantage, that as near as the positions of the catch-edges of *n* and *o* may be to each other, the governor-roller *r* is nevertheless obliged to lift comparatively high, in order to effect disengagement at the proper moment. The various positions of the eccentric in the frame *A* are represented in fig. 102, corresponding to the positions of the trigger *N* in fig. 101.

An additional advantage of this valve-gear, is that the shock reacting on the governor, at the moment of disengagement, is much lessened in intensity. This is owing, to the peculiar form of the trigger, which includes a very acute angle, between the tangent of the contact surface and the direction of motion.

Fig. 101.



Our Plate 22, illustrates a Corliss-engine constructed by the Houguet & Teston Co. of Verviers; fig. 1 and 2 show the engine in side-elevation and plan; fig. 3 gives a front view of the Bède & Farcot valve-gear attached to the cylinder, whilst in fig. 4 we have a cross-section and a part longitudinal section of the cylinder and of the valve-gear; the latter is drawn to an enlarged scale in fig. 5.

The cylinder of 3′ 3″ (1 m.) stroke and 17½″ (450 mm.) bore, has a mean piston-speed of 4′ 10″ (1.5 m.) per sec., obtained by 90 strokes per min. The steam-pipe 4¾″ (120 mm.) in bore, is bolted to the top of the throttle-valve, which is covered with a wood-lining, — an arrangement which offers to the eye a very compact connection with the cylinder; the cross-area of the cylinder is consequently in the proportion of 1 to 14 to that of the steam-pipe. The exhaust-pipe leading to condenser, has an internal diameter of 5½″ (140 mm.), and is furnished with a two-way valve, by which the steam may be exhausted into the atmosphere, when not condensing; the area of the exhaust-pipe is $^1/_{10}$ of the cylinder cross-area.

Fig. 102.

The details of the steam-cylinder are extremely original. The valves are arranged in the cylinder-covers, thus probably completing all the possible combinations relating to the placing of the valves: for, in the first Corliss-engines we found these valves, symmetrically arranged on the top and bottom side of the cylinder, whereas both Wheelock & Wood place all the four valves on the underside of the cylinders, and now we find that Bède & Farcot arrange them in the cylinder-covers.

The cylinder will be seen to be constructed of four main-pieces, namely: the inner-cylinder-surface, the steam-chamber with the steam-pipe abutments and supports, and the two cylinder-covers. The cylinder-proper is carried by the steam-chamber, by legs at its ends — vide fig. 5 —; the joint, between the latter and the cylinder-ends, is rendered steam-tight, by a tongue and groove joint and a caoutchouc-ring.

The piston-rod 3″ (75 mm.) in diam. is prolonged beyond the back cylinder-cover, where it is coupled with the piston of the air-pump; the engine frame is fitted with circular slides and is bolted to the front cylinder-cover and to the crank-pedestal (7½″ = 190 mm. bore and 13″ =

330 mm. length). The connecting-rod is made 5.3 times the length of the crank. The crank-pin is $4^1/_2$" (115 mm.) diam. and is $5^7/_8$" (150 mm.) long.

With a diameter of 14' $7^1/_2$" (4500 mm.), the fly-wheel is $15^1/_2$" (400 mm.) on the face, and weighs nearly 6 tons (6000 kg.). The engine-power is transmitted by belting, from the fly-wheel.

The governor used, is that of Proell without compensating-weight. The double-acting air-pump is placed behind the cylinder; its stroke is the same as that of the cylinder or 3' 3", and its diameter is $6^1/_4$" (160 mm.). The relative capacity of the air-pump to that of the cylinder, is consequently as 1 : 7.9. A vacuum-indicator is attached to the top of the condenser.

16. Joseph Farcot's automatic variable Expansion-gear.

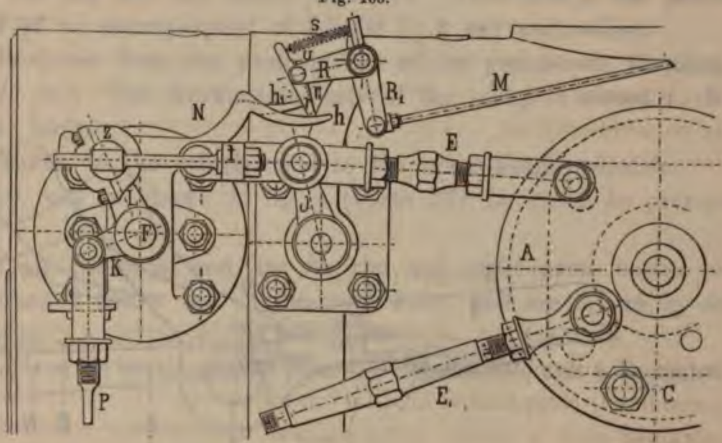
The various improvers of Corliss-engines, have always endeavoured, to extend the narrow range of automatic cut-off to wider limits, without in any way introducing, what must always be considered, complicated auxiliary mechanisms. To Joseph Farcot, the merit is due, of having entirely obtained such a result, by a suitable modification of the trigger-gear and the application of only one eccentric. His valve-gear, as attached to a Corliss-engine, was submitted to public opinion at the Paris International Exhibition of 1878, and independent of the various new constructive-details presented by this engine, it may be safely asserted, that Joseph Farcot has solved the problem in a most ingenious manner.

We have illustrated this Corliss-engine of 350 HP on Plate 23, though we have omitted the double-acting force-pump, which it actually worked, as the latter is beyond our province. Fig. 1 gives us a side-elevation and fig. 2 a plan of this engine; in fig. 3 we have a longitudinal section of the valves, as well as the geometrical relation between the moving parts of the valve-gear: lastly fig. 4 gives us the constructive details of the cylinder, as shewn in half-section. This valve-gear, may be said, to be a combination of the IV Corliss-gear and of that of Messrs. Bède & Farcot; for we find the rocking wrist-plate with its four motion-rods borrowed from the first named, whilst the construction of the cylinder and the arrangement of the valves in the cylinder-covers, are analogous to the last-named gear. The advantages of the two valve-arrangements, are consequently shared by the present expansion gear, whilst the invention of a mechanism permitting automatic cut-offs between 0.0 and 0.8 of the stroke, has brought the Farcot automatic expansion-gear to a state of perfection, which leaves little to improve upon.

The wrist-plate at the side of the cylinder, is placed somewhat above the cylinder-axis, though exactly midways between the cylinder covers. By this arrangement, the driving-pin of the gear-disc is brought close up to the engine centre-line, whilst the movement of the motion-rods of the inlet-valves is almost horizontal. This motion is assisted, by the application of an auxiliary lever *J* shewn in our fig. 103 and 104. The portion of the adjustable motion rod *E*, between the wrist-plate and the auxiliary lever *J*, is constructed in the ordinary way. Its other end, forms however, a guide-rail fitted laterally with eyes *tt*, into which long cylindrical rods *ee* are screwed. The extremity of the motion-rod *E* is fork-formed, to admit the trigger *N* to play freely between the prongs. The crank-lever *LK* is keyed fast on to the valve-spindle *F*. A rod *P* connected with the dash-pot piston, is attached to the lever-arm *K*. In place of the ordinary weights, or spiral springs, or air-pressure, such as we found introduced to the dash-pots of the VI and VII Corliss-valve gears, the buffer-piston is kept down, by the full steam-pressure. The bottom of the dash-pot has an air-passage regulated by a valve, in order to cushion the piston on its descent. The other arm *L* of the crank-lever, is also fork-formed, and its eyes are made into bearings *aa*, for the purpose of carrying a small rod z, fitted with a steel projection in its middle. The ends of this rod, form guides, into which the forementioned rods ee slide, so securing the requisite horizontal movement, for ensuring the exact working in and out of gear, of the trigger N.

Since, in order to effect cut-off up to $^8/_{10}$ of the stroke, automatic disengagement should be able to ensue during both alternate motions of the motion-rod E, one end of the trigger K takes the form of two unsymmetrical prongs h and h_1. The crank-lever RR_1 connected with the governor by the rod M, carries two fingers rr_1 corresponding and vertical to the rocking planes of the prongs h and h_1; one of these fingers r is firmly connected with the arm R, whilst the other r_1 is merely loosely suspended from the other arm R_1 by a knuckle-joint.

Fig. 103.



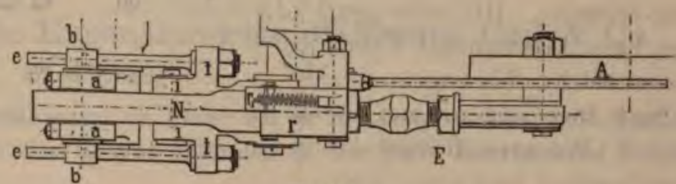


Fig. 104.

This valve-gear works as follows: Supposing the trigger N to be in its extreme position, and to be in gear moving towards the wrist-plate, whilst we will also presume the governor to be in its highest position. It is then evident that the prong h_1 will come in contact with the finger r_1, but as the latter is free to swivel, it will pass over the prong h_1 without pressing it down. In the meantime, the other prong h is always below r_1 and on account of its form, it will press against the rigid finger r_1 and having to give way, it will leave the lever L to the action of the downward pulling dash-pot steam-piston. If however, the lever-arm R is gradually rising (corresponding to a falling of the governor-balls and implying a later cut-off,) then a moment must occur, when the motion-rod E will be at its extreme approach towards the wrist-plate, before the prong h has come in contact with the rigid finger r — i. e. prior to automatic disengagement taking place. With the return-stroke of the motion-rod E, the finger r_1 will follow the pull of the weak spiral spring S, and its upper joint coming against the knuckle U, the latter will prevent it, from turning any further in the same direction round its swing-centre; this finger r_1 then becomes rigid, as it were, and as the prong h_1 catches and presses against it, the continued movement of the trigger N forces the trip-gear out of gear, which naturally implies a shutting-off, of the steam.

The different working positions of the rigid finger r are shewn in outline in fig. 105. When in position I the trigger is in its extreme position; the cut-off, regulated by the rigid finger r lies between 0.0 and 0.28 stroke. In position IV (0.28), the valve-gear is just changing its stroke, when the finger r_1 begins to work in the manner shewn in fig. 106. The stroke of the governor-lever, lies within the range indicated by positions II and VIII, and consequently the automatic variable cut-off, is limited by positions II (0.0 stroke) and VII (0.8 stroke), whereas if the governor-lever corresponds to position VIII, then steam is supplied during full-stroke.

A very ingenious adjusting-mechanism, is attached to the governor. When a Corliss-engine is about to be started, full steam is admitted during the first piston-strokes, on account of the governor-balls, being in their lowest position; for this reason the number of revolutions, is always irregular at the commencement of starting. To remedy this defect, the following adjusting-mechanism is here introduced. A hand-wheel is fitted on the governor-rod, the boss of which is lengthened out and furnished with an external thread, which screws into the governor-frame, while the governor rod *M* is allowed to slide freely in the boss of this hand-wheel, till the boss-end strikes against a shoulder fixed on the governor-rod. In order to stop the engine, the hand-wheel is turned, till the boss is

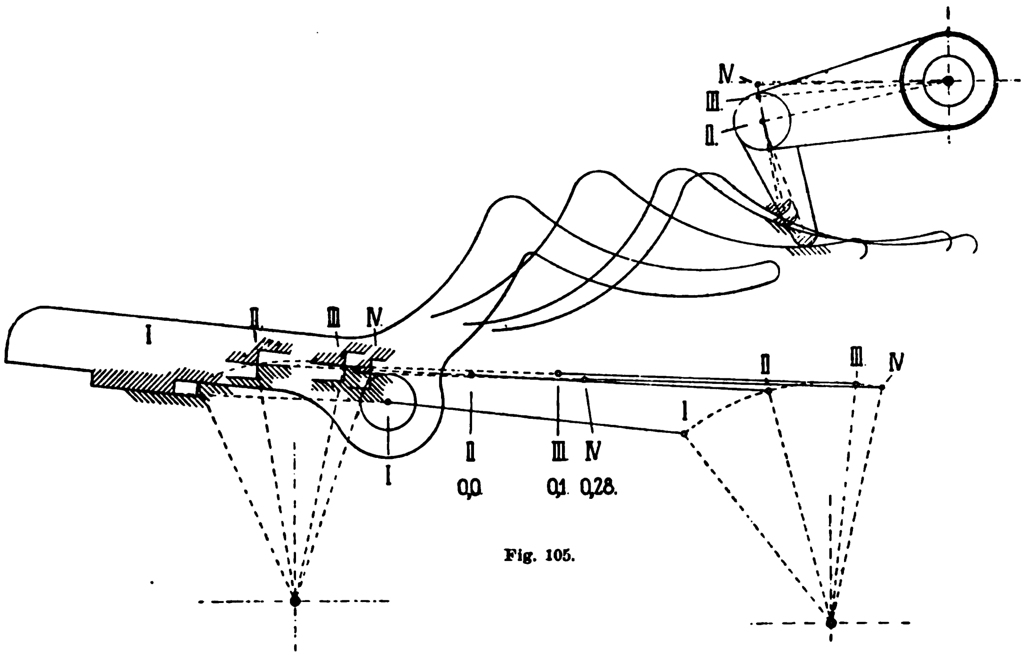


Fig. 105.

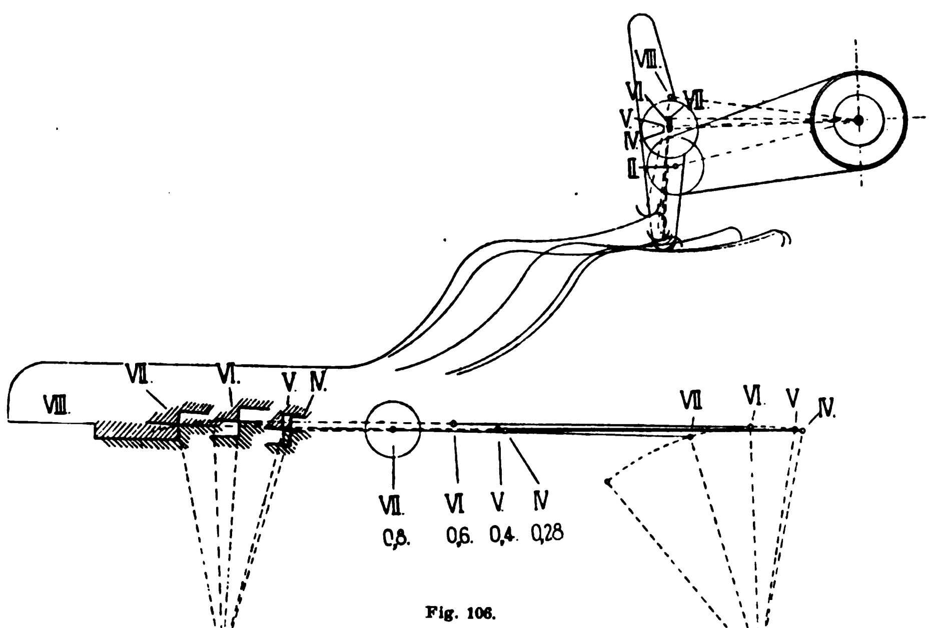


Fig. 106.

so far screwed through the governor-frame, as to press back the shoulder of the governor-rod. The governor-balls are thus brought almost instantaneously and without much trouble, into their highest position; this position of the governor, answers to a cut-off at 0.0 stroke, which naturally implies no steam-supply to the cylinder, consequently the engine, is brought to a standstill.

If it is desired to start the engine, then the hand-wheel is turned in the opposite direction, and consequently the shoulder on the governor-rod, recedes in the same degree as the boss is screwed back, owing to the weight of the governor-balls pressing in this direction. Means are therefore thus provided, of starting the engine as slowly as desired, and of still working expansively.

The cylinder diameter is 3′ 3″ (1 m.), and the stroke is 5′ 10″ (1800 mm.); the piston working at 30 revolutions per min. runs at an average-speed of 5′ 10″ (1.8 m.) per second.

The double acting steam-pump is driven from the prolongation of the piston-rod; its diam. is 14″ (360 mm.) and its stroke 3′ 3″ (1 m.). The working-capacity of the pump is stated to be a little over 8000 gallons (630 cbm.) per hour.

The engine frame is bolted, as before to the cylinder and to the crank-shaft pedestals.

The eccentric is strengthened by rods as shewn in fig. 1 (Plate 23) in order to prevent its bending.

The fly-wheel, is 7″ (180 mm.) on the face, and has its rim and eight arms bolted together. The air- and feed-pumps are arranged below the engine-room floor, and are driven by an oscillating beam from the piston cross-head.

The governor, Farcot's patent, is driven by bevel-gearing from the crank-shaft, and is furnished with counterweight and water-brake.

17. The Automatic Variable Expansion-gear of Messrs. Cail & Co. of Paris.

We have represented this valve-mechanism on Plate 24, as the last, working with Corliss-valves and trip-gear, and may also observe that is was exhibited at the Paris International Exhibition by Messrs. Cail & Co. of Paris.

The principle of the external valve-gear, may be referred to the III and IV Corliss-valve-gear, whereas the Spencer-mechanism, may have been emulated in the trip-gear.

Similar to the Corliss-arrangement, the four valves receive their travel from a peculiarly formed wrist-plate, fitted to the cylinder-centre and driven by one eccentric.

The constructive details of the trip-gear may be pronounced to be new, as will be seen on referring to fig. 4 and 5 (Plate 24) which show the trip-gear out of gear and drawn to an enlarged scale. It will be seen, that the motion rod *E* is connected with the crank-lever LL_1, which fits loose on the valve-spindle, or on the prolonged boss of the intermediate cam *K*. The latter is keyed fast on the valve-spindle *F*, and is constantly pulled to the right, by the dash-pot piston rod *P*; a protruding steel-plate *o*, is partly let in its circumference, behind which the trigger *N* with its protruding steel-catch *o*, assisted by the spring *S* may fall into gear, when the crank lever LL_1 is in its extreme position. The noise of the tripping into gear, is deadened by the cushion plate *i*. Assuming the trip-mechanism to be moving in gear, then the regulator-lever *R* will approach more and more towards perpendicularity, causing the cam *r* to get nearer to the circumference of the cam *K*; provided contact takes place and this movement of the crank-lever LL_1 is prolonged, then the steel-catch *n* is pushed out of gear from *o*, and the action of the spring in the dash-pot closes the inlet valves, as it is connected with the latter, by the rod *P*, and the segment *K*.

The symmetrical transmission of the governor-motion on the trip-gear, is not obtained by toothed segments in this valve-gear, but by a simple combination of levers. The construction of the inlet-valves offers no new feature; alone the exhaust-valve, shows a different form, claiming the advantage of reducing the effects of back-pressure. With this object in view, the cross-section of the Corliss-valve, is made similar to that of an ordinary cock.

Each dash-pot, carries an indicator, which shows at a glance, the degree of expansion, at which the engine is working. A governor, adopted and constructed by a number of French engineering firms, and known as that of Andrade of Paris, is fitted to this engine; it allows the speed to be regulated to a nicety, by shifting the counter-weight.

Although the engine shown on our Plate 24, is of the same constructive-type, as the one exhibited at the Paris International Exhibition, still it slightly differs from the latter in its dimensions. It was specially designed for driving the saw-mills of the Arsenal of Cherbourg, where it has been working very satisfactorily, for some time. It is of 50 HP (nominal) with a cylinder-diameter of $17^1/_2$" (450 mm.) and a stroke of 2' 11" (900 mm.). Its consumption of coal per indicated horse-power per hour is 2 lbs. (0.95 kg.) whereas its working-power varies as much as from 40 to 100 HP, without even influencing or affecting its speed more than $^1/_2$ revolution per min.

The engine exhibited at Paris was 1' $7^1/_2$" (500 mm.) in cylinder-diameter, and had a 3' 3" (1 m.) stroke; its effective working capacity was 60 HP with a boiler-pressure of 75 lbs. (5 atm.), $^1/_8$ cut-off, while running at 53 revolutions per min.

II. Engines, working with Rocking-valves of the Corliss-type, without Trip-gear.

1. Engines designed with rocking Equilibrium-valves.

a. Wilson & Schwartzkopf's Rocking valve-gear.

The rocking valve-gear in its simplest form, is as old as the Steam-engine itself; but it was soon abandoned, until in 1853 R. Wilson took out Letters Patent for a useful rocking equilibrium-valve. The latter was largely used for Steam-hammers, but at the present time, it is very seldom fitted to Steam-engines, because Corliss-valves have been largely used instead.

Fig. 107.

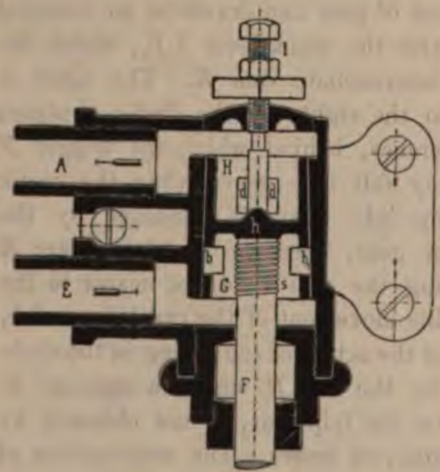


Fig. 108.

Modern improvers of the Steam-engine have tried to resuscitate the rotary valve-gear, and have so far modified it, as to impart rotary motion to these valves, whereas, the Corliss-form has been adopted, almost without exception for the rocking or oscillating valve-type. We purpose discussing both types in the following pages, and will enumerate a number of engines, fitted with such valves and working quite satisfactorily.

As Wilson's valve served as prototype, for a great number of subsequent equilibrium-valves, we may here begin with it. The valve, represented in longitudinal and transverse sections in fig. 107 and 108, is stated in the original Edition of this work, to be Wilson's Steam-valve; this is however an error, as it is in reality Wilson's Hydraulic-valve. The reader will find the actual Steam-valve drawn on our Plate XVII, which has been prepared from working drawings placed at our disposal by Messrs. Nasmyth, Wilson & Co. of Patricroft. We borrow the following description from the Practical Mechanics Journal:

'Fig. 1 is a vertical, and fig. 2 is a horizontal section of the valve and casing, both taken through the centre line of the steam-pipe. This valve mechanism consists of a valve casing, *A*, fitted by means of the flanges, *B*, across the face, *C*, of the steam cylinder. The steam enters the casing *A*, by the pipe, *D*, and immediately diverges to each side along the passages, *E*, to the ends, *F*, of an inner space, turned out cylindrically or slightly conically, to receive the oscillating valve piece, *G*, turned to work steam-tight in the casing. This valve piece is worked by means of the spindle, *H*, passing out through the lateral stuffing-box, *I*, and formed with a cross-head, *J*, fitting into a socket proper position, adjustable set-screws are brought to bear on the valve-spindle ends. The valve-spindle F is worked by a rod L, leading from the eccentric, which may be knocked out of gear when manual steering is desired; in this case the hand lever L_1 comes into play.

b. Shivre's Rocking valve-gear.

Shivre's Rocking-valve is based on the same principle, as that of Schwartzkopf. The annexed figures 111 and 112 illustrate this valve, in cross and longitudinal sections. The steam, entering by the pipe E passes into the external valve-chamber, forming a kind of steam-jacketing for the inner valve-chamber, in which the valve is inserted; an equal expansion of the metal, is thus secured. The steam, thence passes into the chambers $b\,b_1$ of the valve, which communicate with each other through the slot c; from these chambers the steam is alternately passed through r and r_1 into the cylinder-passages e and e_1, whilst the exhaust steam entering the chambers dd_1 — also communi-

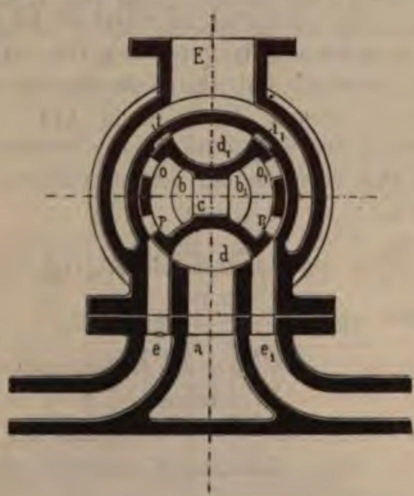


Fig. 111.

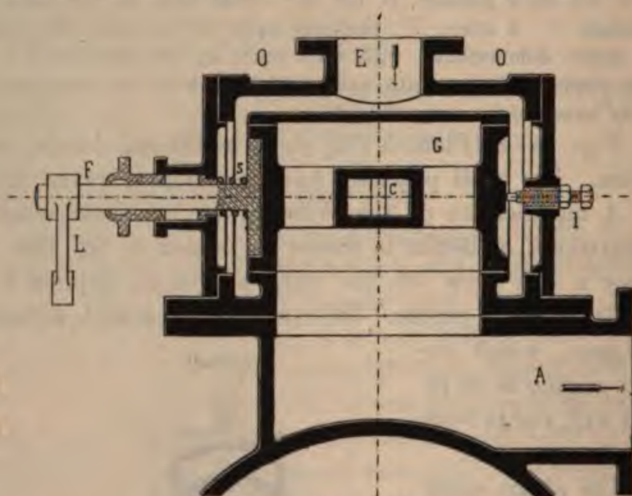


Fig. 112.

cating with each other — escapes through a into the exhaust-pipe A. The means adopted, for balancing the valve, are the same as we noticed, when describing the Wilson & Schwartzkopf valves.

A rocking motion, is imparted to the cylindrical portion of the valve, by the lever L which is keyed on the valve-spindle. The latter runs out in the form of a flat-rod (perpendicular to the spindle) which fits into a corresponding groove on the valve-face, and is kept tight by the spiral spring s. The set-screw t is for the adjustment of the valve.

c. Schleh's Rocking-valve.

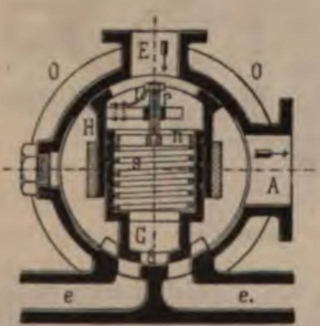


Fig. 113.

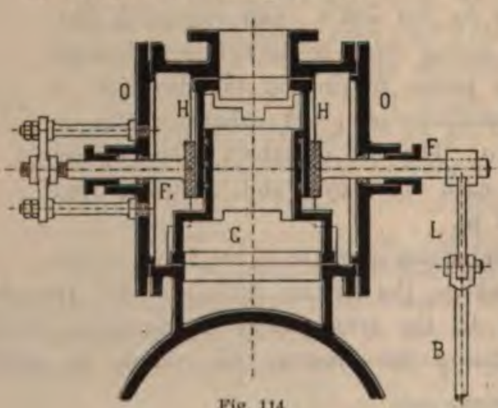


Fig. 114.

In 1877, the Journal of the Society of German Engineers, discussed a rocking-valve, designed by Eugen Schleh of Cologne, the ingenious construction of which, offers various advantages. Its chief merit, as will be seen on referring to fig. 113 and 114, lies in the cylindrical form of the valve- and valve-box, greatly facilitating their finish in the lathe, while the valve, has only to contend against the pressure of the exhaust steam which also facilitates the keeping steam-tight of the spindle- and valve-covers.

The steam enters through the pipe *E*, when the rocking of the valve gives the steam alternately to the cylinder-passages $e\ e_1$, whereas the spent steam, escapes through the valve-chamber, into the exhaust-pipe *A*.

The actual valve consists of two parts, namely the distributing valve *G*, and a double-valve *H*. The two are kept steam-tight by three of Ramsbottom's piston-rings, and are of circular-form; they are moreover so designed, that though both are balanced, they are nevertheless forced against their seatings, by the action of the steam when working. When the engine is stopped, a spiral spring *S* working against an adjustable disc *r* regulated by the set-screw *n*, keeps the valve close on its seatings, in order to prevent the leakage of steam into the exhaust valve-chamber when the engine is started. The set-screw *n* is held fast by a spring *i*, the end of which is let into it.

The valve-spindle *F* is fastened to the valve, by a ring accurately encircling the valve, and the latter is made to receive its rocking motion from the lever *L* and the link *B*; the lateral sliding of the valve is prevented, by the screw-bolt attachment, clearly shewn in fig. 114.

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2. Steam-engines, working with ordinary non-balanced Rocking-valves.

a. W. E. Carlile, of New-York.

Our worthy contemporary 'Engineering' published some years ago, a communication from W. E. Carlile of New-York, according to which the latter had introduced a valve, designed as shewn in the annexed figure 115, and used by him in Compound Marine-engines. For reason, that the cranks of these engines are set at 180⁰ apart, the upper and lower steam passages of the two cylinders, require each a set of these valves. The valve-chest *O O* is fitted with two valves *G* and *H* in two separate chambers, which valves are driven from one eccentric, so that for reversing purposes only two eccentrics are needed.

The steam enters again at *E*, and is controlled by the expansion-valve *H*, which is worked by an automatic variable cut-off link-gear; in this manner, the steam-way *e* is at times closed, according to the piston-travel. The steam is hence led through the port *a* into the high-pressure cylinder.

In the position that this valve is represented in our fig. 115, it is assumed that the steam is moving the piston of the high-pressure cylinder downwards, so that the piston of the low-pressure cylinder would be simultaneously moving in an upward direction, and its spent steam would be passing through the passages e_1 and *A* into the condenser, as shewn by the inscribed arrow in our fig. 115, where e_1 is supposed to represent the port of the low-pressure cylinder, and *A* the condenser pipe.

Fig. 115.

With a 180⁰ travel of the crank, the expansion valve *H* is still closed, but the valve *G* is so placed, that its steam-way *b* is over the passage *a*, placing *c* directly over the port e_1; in this position, steam from the high-pressure cylinder is passing on through the steam-way $abce_1$ into the low-pressure cylinder to be there further expanded. The valve *G* is also constructed in two parts, in a similar manner to the one we described, when treating the Schleh rocking-valve; it is kept steam-tight against its seating partly by the pressure of the steam, and partly by the intervention of a spring, when the engine is stopped.

b. Messrs. Edward P. Allis & Co. of Milwaukee.

This American Engineering firm has constructed engines fitted with various arrangements of rocking valve-gears; two of these the reader will find illustrated on our Plate XII. The first of these, represented by our fig. 1 and 2, is furnished with one simple rocking-valve, placed on the top of the cylinder, in the valve-chest *H*. It is worked, as an ordinary slide-valve, from an eccentric rod and from a valve-spindle lever *L*, which is made longer than the eccentricity given to the eccentric. The 'cut-off' is effected, by an automatic expansion-gear, furnished with a throttle-valve *V*, placed above the cylinder and connected with the governor. The latter is mounted on a spindle *m*, running parallel to the crank-shaft and carried by the throttle-valve cover; the governor *U* is cased in a cylindrical box, attached to one end of this spindle. The governor is driven by chain-wheel gearing nn_1, making as many revolutions as the crank-shaft; it is fitted with expansion-cone *O* after Meyer's well known governor-type, so that the valve-rod *n* is pushed down sooner or later, thus effecting the shutting-off of the steam.

The diameter of the cylinder of this engine is 16″ (406 mm.), its stroke is 2′ (610 mm.), and as the number of revolutions is put down at 125 per min. we obtain the very high piston speed of $8^1/_3$′ (2.54 m.) per sec. The connecting-rod is 5.3 times the crank-disc radius, and the flywheel's diameter is 12′ (3680 mm.). Two belt-pulleys of 6′ 4″ (1960 mm.) diam. and $17^1/_2$″ (450 mm.) on the face, are mounted on each side of the flywheel, for transmitting the engine power by belting.

For larger engines, the forementioned firm, does not merely use one valve, but applies two separate valves HH_1 as inlet-valves, while piston- or flat slide-valves *S*, are made to serve for the exhaust; our fig. 3 and 4 (Plate XII) refer to this arrangement. The motions of the inlet and exhaust valves are also rendered independent of each other, by the application of two eccentrics. The two eccentric-rods CC_1 are connected to a slide-link *A*, suspended about its centre to the oscillating lever *Z*. In order to secure a variable cut-off, the motion-rod *B* working the inlet-valves, may be hung from different centres on the link *A*, and according to its setting, the degree of expansion may be varied, though remaining fixed until re-set. This cut-off arrangement is therefore not automatic. The governor is placed over the cylinder, and is made to control an ordinary throttle-valve. The exhaust-valve S_1 is worked from the link A_1 by the motion-rod B_1 and the intermediate lever L_1.

The diameter of the cylinder and its piston-stroke are stated at 1′ $11^3/_4$″ (609.5 mm.) and 4′ (1219 mm.) respectively.

c. Charles E. Emery, of New-York.

An additional example of a large engine working with simple Rocking-valve gear is furnished by the Compound engine used for driving the Rolling-mills of the Phœnix Iron and Steel works. We reproduce a rough sketch of this engine on our Plate XII fig. 5 and 6.

It is of the overhead engine type, and accordingly the large cylinder is bolted to the top of the pyramidal frame, whilst the high-pressure cylinder, is carried on four columns securely bolted to the first named cylinder and to the engine-frame as well. As the piston-rod of the small cylinder is formed by the prolongation of the piston-rod of the other cylinder, two stuffing-boxes were required between the cylinders; for this reason, the top cylinder had to be arranged at some distance off the bottom cylinder, which arrangement renders the stuffing-boxes readily accessible.

The cylinder steam-supply is effected by a rocking valve of the Corliss pattern, fitted to each cylinder; the lower valve, is driven direct from two eccentrics, and drives the top valve by link-gear. It is evident, that under these circumstances, the valve-spindle levers are fitted precisely alike. The steam of the high-pressure cylinder is conducted into the low-pressure cylinder, by two symmetrical steam-pipes. The main steam-pipe is fitted with a regulating-valve *D* worked by hand, and between this valve and the steam-chest another double-seated valve *V* is also mounted, under the control of the governor.

gallons of sewage in twelve hours, the total height of the lift being 21′ 6″. The two pump-rods of each pair of engines are connected by a wrought-iron plate beam, one end of which is connected with the upper end of each plunger by double links. The arrangement seems a capital one, both for equalising the work and for connecting the two pistons. The amount of work transmitted by the beam is of course very small, so that the whole gearing connected with it can be made very light. The condenser of each engine is a cylindrical vessel, placed between the two main pump barrels, the air pump being placed beside one of the latter and worked by an arm on the plunger head.

At the time of writing, Messrs. Hathorn & Davey, were making for the Lincoln Sewerage Works engines of the same general type, but larger in size. In these engines Mr. Davey is using a valve gear, in which his usual differential arrangement is applied to rocking valves, as in the Chiswick engines, with the addition of a similar separate cut-off valve of the same type. This arrangement is shown in section in fig. 117 which has been already referred to. The position of the valves in reference to the cylinder is the same as in the Chiswick engines, but the auxiliary and cataract cylinders (*H* and *G*) are placed below instead of at the side of the cylinders. *A* and *F* are the low-pressure ports, *B* and *E* those for the high-pressure cylinder, *D* is the stop valve connected by a branch to the cut-off valve chamber, which communicates by ports up and down with the main valve chambers, in which work valves of the type already described. *C* is the exhaust passage. The gearing is worked by an adjustable pin, carried on an arm on the end of the gudgeon, another pin in the same arm being used, to move the valve of the auxiliary steam cylinder. The cut-off valve is simply worked by a link connected to a point near the free end of the main valve lever.

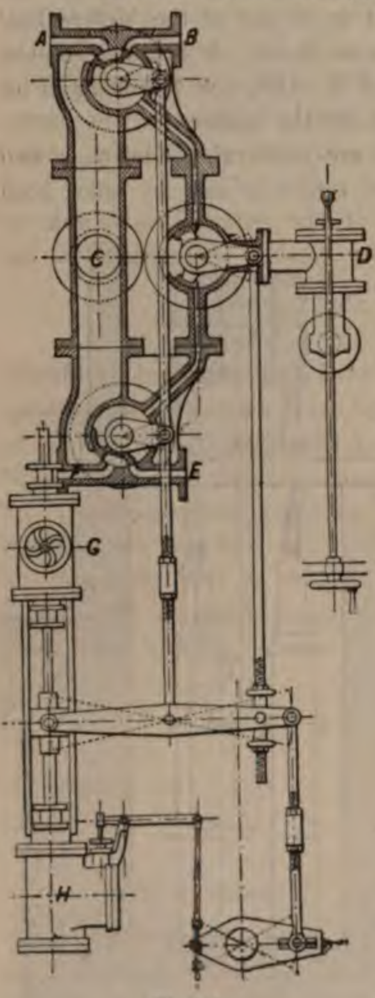

Fig. 117.

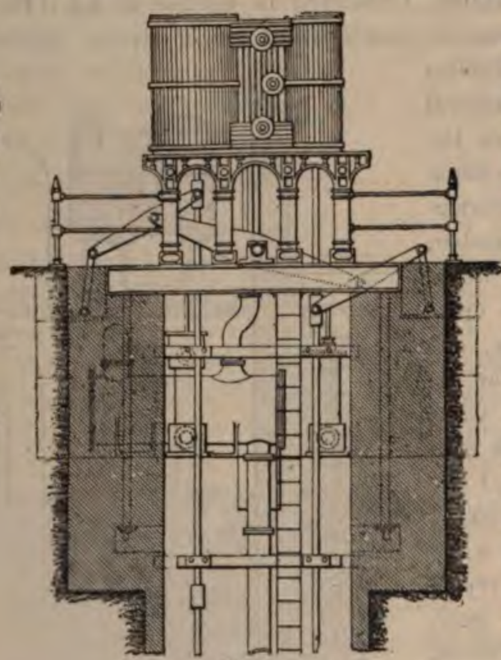
Fig. 118.

The steam for the two pairs of engines, is supplied by three Cornish boilers, each 15′ long by 5′ in diameter and containing a single furnace 2′ 6″ in diameter; they are fed by a small donkey pump. From what we have already seen of the excellent working of Mr. Davey's engines, we should expect particularly good results from this type, in which the special advantages characteristic of his system appear to be obtained with very great simplicity and in a minimum of space.

One of the two pairs now at Chiswick was exhibited by the makers with other machinery at Paris, where it gained a gold medal, and where its extreme simplicity of design and directness of action, contrasted very favourably with the very opposite characteristics, shown in some of the other pumping machinery.

More recently Mr. Davey has also designed another modification of his engine most ingeniously arranged so as greatly to reduce the distance between the cylinders while maintaining the long stroke and balanced pump rods. We illustrate this design in fig. 118 an engine which Messrs. Hathorn & Davey are making for the Chiltern Hills Water Company. The special feature of the arrangement, is that the piston rods are not directly connected by links to the ends of the rocking lever, but only indirectly by means of the well-known form of parallel motion shown. In this way the piston rods come much closer together than the ends of the lever, which is double, to allow them to pass downwards. This arrangement has the great advantage, of course that it renders this vertical inverted type of engine as suitable for deep well pumps as for low-lift pumps, like those at Chiswick. For the reasons already mentioned, the rocking lever — and of course also the rest of the linkwork — may be very light, and all the pins and joints are perfectly accessible. The Chiltern Hill engine has cylinders 15″ and 30″ in diameter and 5′ stroke, and is fitted with a separate expansion valve for the high-pressure cylinder in the way already described. The pumps (bucket type) are 13″ in diameter. The engine has a surface condenser, the water being passed through it on its way from the pumps to the reservoir.

The annexed wood-cut fig. 119 affords a perspective view of the external valve-gear of the Chiswick Engines, though the preceding description will render further elucidation on our part unnecessary.

e. Weise & Monski, of Halle a. S.

Referring to our Plate 25, fig. 1 — 3, the engine there represented as constructed by Messrs. Weise & Monski of Halle a. S. is exceedingly simple in its construction, being arranged with rocking-valve and fixed expansion. Our drawings are sufficiently explicit, to render further comment as to the valve-construction, unnecessary. The eccentricity of the link-crank working the valve, is 5″ (131 mm.); it is set to a lead angle of 38°, and as its inner and outer lap are respectively 1/8″ and 3/4″ (3 mm. and 20 mm.), steam is cut-off at about 3/5 stroke (0.63). The width of the cylinder inlet and exhaust-passages is 5/8″ (18 mm.) and 1 3/4″ (45 mm.); their length = 7″ (180 mm.).

Cylinder bore = 8 1/2″ (220 mm.): stroke = 11 3/4″ (300 mm.): piston 3 1/2″ × 1 1/4″ (90 × 35 mm.): crank-pin = 2″ × 1 1/4″ (50 × 35 mm.): connecting-rod = 2′ 2 3/4″ (686 mm.) or about 4 1/2 times the length of the crank.

A wedge fastens the link-crank to the cast-iron crank.

The bed-plate carries two pedestals, the bearing surfaces of each being 6 3/8″ × 3 7/8″ (165 × 100 mm.). The eccentric driving the feed-pump, is placed between. The flywheel is mounted behind the second-pedestal and is 4 3/4″ (120 mm.) on the face and 5′ 2″ (1570 mm.) in diameter.

f. H. Flaud & A. Cohendet of Paris.

The Compound-engines, exhibited by Messrs. H. Flaud & A. Cohendet, at the Paris International Exhibition, shewed an original arrangement of the cylinders. We illustrate this engine on Plate 25, fig. 4 and 5, whence it will be seen that the two single acting cylinders, are placed one within the other. The engines are worked from a single rocking-valve, worked by an eccentric. With the downward stroke of the inner cylinder piston, this valve passes steam into the high-pressure cylinder through the port *e*, whilst simultaneously, the exhaust steam from the outer cylinder is led through the passage *i* into the cavity of the valve, whence it passes into the channel *a* leading through a chamber into the condenser. As the cranks are set at 180° to each other, the movement of the valve must be sufficiently rapid, to ensure the closing of the inlet-port *e* at about half stroke (of the inner cylinder) — vide fig. 4 — in order that the exhaust-port, *a* may be shut in proper time, and so that due communication may be established, between the steam-ways *e* and *a* at the commencement of the downward stroke of the outer cylinder.

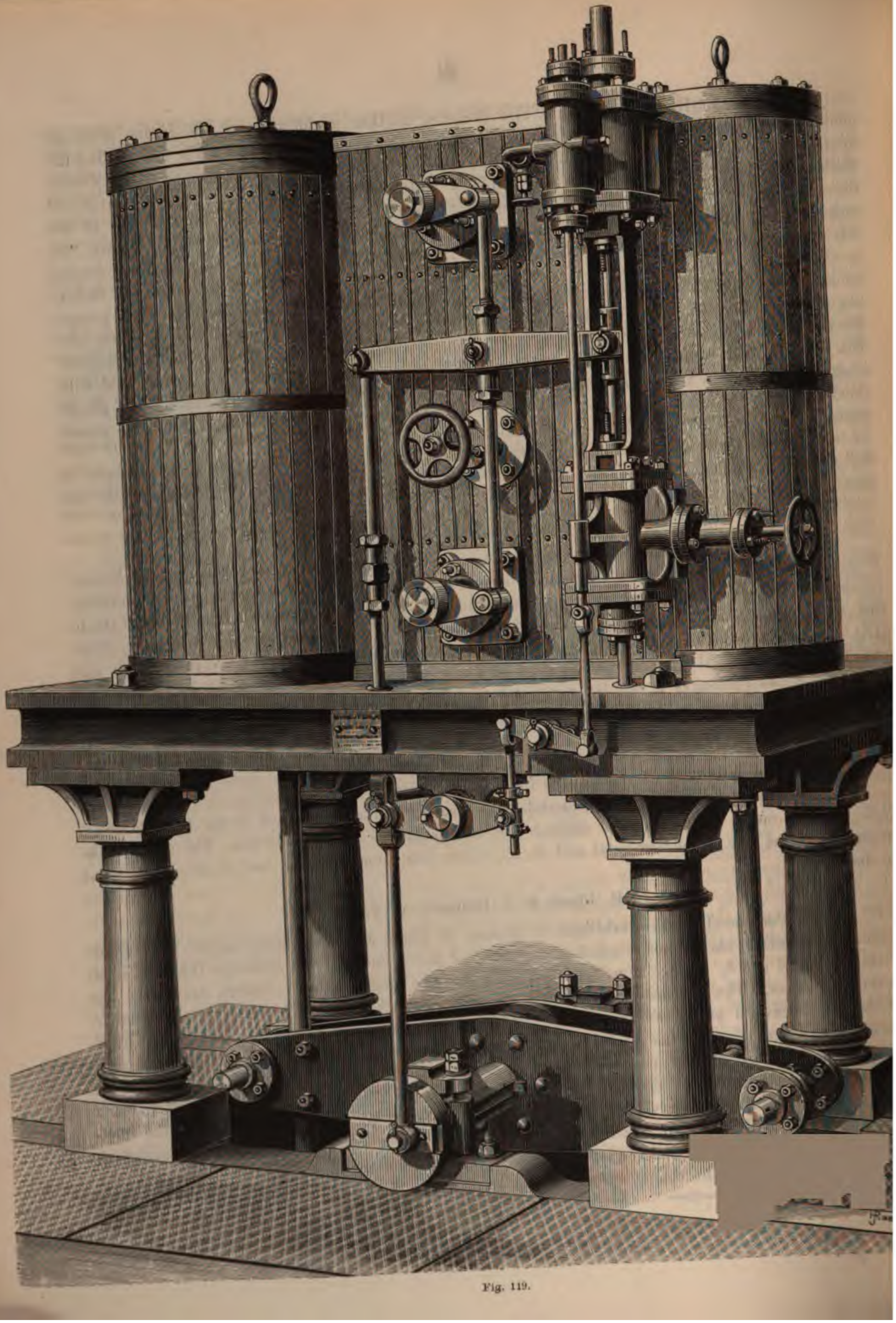

Fig. 119.

The action of the steam is consequently as follows: The steam from the boiler, enters the high-pressure cylinder forcing its piston down; the cut-off for this cylinder, subsequently takes place at about half-stroke, and the steam is allowed to expand during the remainder of the stroke. After this, it passes into the outer cylinder, where the expansive working is continued; ultimately the steam escapes through the lower engine-chamber into the condenser or into the atmosphere.

Prior to entering the valve chest *G*, the steam is made to pass a cylindrical throttle-valve which is under governor-control.

The bores of the two cylinders are $9^3/_4$" (250 mm.) and $19^1/_2$" (500 mm.); the stroke is $9^3/_8$" (240 mm.) and working at 500 revolutions per min. the engine is said to indicate 50 HP.

The engine resembles the now well-known Brotherhood type, and consists of three main parts, namely: the bed carrying the treble-bent crank-shaft running in stuffing-boxes, the sides of the low-pressure cylinder, and the cover of the outer cylinder, with which the high-pressure cylinder is also cast. The steam-passages could be kept short, because the valve-chest is bolted to the cylinder-cover.

As will be seen on referring to fig. 4 and 5 (Plate 25), the pistons are kept steam-tight by packing-rings; thus the high-pressure piston and the external circumference of the outer piston are packed in the usual manner, by these piston-rings being let into them. The inner circumference of the low-pressure piston, differs however in this respect; for the rings are here let into the outer surface of the inner cylinder, and on its inner ring, the piston is fitted with a trunk, sliding steam-tight, against the last-mentioned packing rings.

g. Daniel Adamson, Dukinfield, near Manchester.

The quadruple action engines illustrated on Plate XIII, were constructed by Mr. Daniel Adamson for driving a cotton mill having 48096 spindles, with all the requisite preparation. They are driven by steam produced from two steam boilers, of the double-flued Lancashire type, each 30 feet long by 7 feet diameter, having two flues each, 2 feet 10 inches outside diameter, and crossed by five conical tubes welded solid into the flue rings. The blow-off pressure of safety valves is fixed at 110 lbs. per square inch.

It will be observed, that two steam-cylinders are fixed upon one bed-plate, a piston-rod passing through each, coupled to cross-head and parallel motion and forward by connecting rod to crank pin in the usual way, and this system of applying the power from No. 3 and 4 cylinders is repeated, so that No. 1 and 2 constitute one engine, and No. 3 and 4 the other, the balance cranks being fixed at right angles, which causes a somewhat unscientific action between No. 2 and 3 cylinders; but this, in cotton mill engines, is said to ensure uniformity of motion, which, on the work done, more than compensates for the irregularity of steam action between No. 2 and 3 cylinders. To modify such undesirable application, a steam receiver is fixed between the cylinders under the floor of the engine room. Advantage is taken of this receiver, to superheat the steam, the heating medium being high-pressure steam at full boiler pressure, having a temperature of about 344 degs. Fahrenheit, maintained in a steam jacket, surrounding the exhaust receiver.

The interior vessel of this intermediate receiver is crossed by conical pipes welded solid into an inner cylinder; these pipes reduce the area of receiver, but proportionately increase the superheating surface. The high-pressure steam filling the jacketed casing, passes through the conical tubes, with the further object of breaking up the current of exhaust steam, as it passes onward from No. 2 to No. 3 cylinder. This superheating receiver is adopted with a view not only to prevent condensation, but to take advantage of the law of expansion of gases, by increasing the temperature.

The exhaust-pipe, between No. 3 and 4 cylinders is again jacketed, and steam superheating adopted as before described, No. 4 cylinder being further coupled by exhaust to condenser, as shown. The vertical air-pump is worked by a rocking shaft, actuated by a lever coupled to crosshead pin, by two connecting rods, and the short lever below the house floor is coupled by vibrating links to the crosshead of air-pump, and guided by an ordinary vertical slide motion; the air-pump bucket has a stroke about a third of the piston travel to keep down the speed of bucket, and to secure a less violent action of the discharged water by a close topped air-pump. The cylinders are not steam jacketed, but covered by $2^1/_2$ inches thick of a non-conducting heat preserving material; on this substance, they are lagged with wood; the ends of cylinders between the glands and faced flanges for bolts are also filled up with the same cement to further contract the radiation of heat, and then covered over with sheet iron for a finish and protection. The engine having a 5 feet stroke, makes 43 revolutions per minute, or a total piston speed of 430 feet per minute. No. 1 cylinder is 17 inches diameter; No. 2, 22.5 inches diameter; No. 3, 30.25 inches diameter; and No. 4, 42 inches diameter. The relative area between No. 1 and 4 is as 1 is to 6.1. The mechanical action of the quadruple engine, is admirably adapted for producing a uniform power, such as is required in a cotton, woollen, or flax mill, or for the grinding of corn, the force on the crank pins being nearly the same on every portion of a revolution; again with four pistons between the boiler pressure and the condenser, any chance of leakage of steam, without yielding its full power, is proportionately provided against. No provision need be made, in the strength of the several working parts, beyond what is due for security, to drive a uniform power by a uniform force. The valves on all the cylinders are of the Corliss rocking-type, the length of the steam and exhaust-port being the diameter of their respective cylinders. All the valves are actuated by a rectangular central steel spindle, having a reciprocating motion on its own centre. The diagrams, taken from the quadruple action engines when performing full work, showed that no irregular percussive force was in operation, establishing every likelihood of great durability in the working parts, and economy in lubricants. At first sight, this multiple steam cylinder action may appear complicated, and also costly, to secure, what engineers generally consider can be accomplished in one, or at most, two cylinders, without the wear and tear of machinery and boilers, incident to the higher pressures.

The practical economy of the quadruple engine in its consumption of fuel, may be estimated by comparing the results obtained in two mills — in one of which a triple cylinder engine was used, whereas the other was worked by a quadruple acting engine; these results are as follows:

Mills:	Albert:	Victoria:
Engines used for driving do. . . .	Quadruple acting.	Triple cylinder.
Number of spindles in do.	48240.	57360.
Average coal consumption per week-during 6 months trial	35 tons 12 cwt.	59 tons 3 cwt.
Average coal consumption per horse-power per hour:	$1^1/_2$ lbs.	$2^1/_2$ lbs.

At the time of these trials, the triple cylinder engines had been put down something like about 12 years, while the quadruple engines had been working 12 months, without costing anything in repairs; in addition the Albert Mill was engaged on coarser work, yet almost the same weight of work was turned out of the two mills.

For a fuller description of these engines we refer the reader to the Transactions of the Iron & Steel Institute No. II for 1875, and tender our thanks to Mr. Adamson for the proffered use of his lecture before this Association.

h. H. P. Fenby's High Speed Horizontal Engine.

The object aimed at, in producing this engine, was to obtain a perfect action for the steam combined with a quick cut-off actuated by the governor, but so contrived that a high speed could be attained, without the knocking or releasing of any loose triggers or parts commonly used in obtaining a quick cut-off.

The engine, exhibited at the Paris International Exhibition, of which we give drawings on Plate 24, figs. 6—10 was a model made to test the principle, and though of a small size, the correctness of the system, has been thereby fully substantiated.

The cylinder is 3″ diameter with a 6″ stroke; it is cast with one end in, which serves to secure it to the end of the bed, and also to form a stuffing-box for the piston-rod. This stuffing-box is of novel construction, being composed of 36 punched brass washers, pressed into a bored hole, every sixth washer having a hole in it, a quarter of an inch larger than the piston-rod, so as to form a condensing chamber for the steam. By the aid of these chambers and the very long stuffing-box used, the escape of steam is effectually prevented. An auxiliary stuffing-box of the ordinary type, was provided in case of any leakage of steam, but it was not found necessary to pack it.

The piston is two inches thick and contains six hard brass expanding rings. The guide for the piston rod head, is cast all in one with the bed, and is bored out to the same diameter as the cylinder; the piston-rod head is made as a light cylindrical tube of cast iron, having the piston-rod secured to it, by two fine thread nuts. It also has a taper take-up joint for the connecting rod. The crank shaft bearings are both cast upon the bed.

Both the steam and exhaust valves are of the simple rocking type, the steam valves being worked, by specially constructed cams described further on, and the exhaust by an eccentric on the crank shaft. Light wrought iron tubes are used instead of solid rods for working the valves, on account of the quickness of the cut-off; the engine running three hundred revolutions per minute, cutting off the steam in the ninetieth part of a second.

The cam, which works the two steam valves, is keyed upon the crank shaft, face to face with the cam which controls the cut-off. The cut-off is varied by the cam being twisted, round to different positions, in relation to the fixed admission cam. This twisting of the cam is effected by the governor drawing a socket, which works upon a spiral key on the shaft, through the centre of the cam. The socket slides through the cam on a feather, parallel to the axis of the crank shaft, the feather serving to connect the cam to the socket. The spiral key-way in the shaft, is of such a pitch, as to allow the governor, to be capable of regulating the admission of steam, from seven-eighths to about one-fourteenth of the stroke.

The speed of the engine, can be altered to a nicety whilst running by means of a shifting fulcrum on the governor-stand, worked by a screw and small hand-wheel. By this arrangement, the engine may be made to commence to cut-off at one tenth or any of the intervening points down to seven eighths of the stroke, or the engine may be started with a heavy load on and full steam, the fulcrum being then run back again, to where the desired speed is maintained.

Fig. 6 (Plate 24) is a horizontal section through the cylinder, though otherwise representing a side elevation; Fig. 7 is a plan; Fig. 8 is a part section of crank gear and governor: Fig. 9 is a cross section through cylinder showing valves; Fig. 10 shows the steam and cut-off cams.

The same letters refer to the same parts on all the views.

The two admission valves are shown at the top (fig. 6), while the two exhaust valves are represented at the bottom of the cylinders. The first named valves, are worked by valve rods, which are attached to the top of cam levers, having flanged runners kept against the cams, by a coiled spring (see fig. 6). It will be observed, that as the cam runners, are placed diametrically opposite one another as regards the crank shaft, the admission valves are the reverse of one another. The opening of the valves is therefore performed by the spring, while the closing of the valves is effected directly by the cams, and always at a definite point, fixed by the governor.

Fig. 8 illustrates the socket, which is drawn through the cut-off cam *b* by the action of the governor, along the spiral key-way in the crank-shaft. The cut-off cam, cannot follow the lateral movement of the socket along the shaft, the two cams being always kept together by the flanged runners. The result of this arrangement is, that the cut-off cam merely changes its position in relation to the admission cam, which is keyed on next to the eccentric working the exhaust. The cut-off cam has a small fly-wheel upon it. This fly-wheel, actually does the duty of maintaining a regularity of motion in the cut-off cam, so that no shock is communicated to the governor by reason of the cam trying momentarily to skid back on the spiral keyway.

The governor sleeve has a constant lift of 1″, but by means of a shifting fulcrum the amount of motion communicated to the sliding socket (vide fig. 8) may be varied at will.

It is evident that when the fulcrum is nearest the governor, the engine will run at a much higher speed before the governor rises to its normal height, on account of the leverage to be overcome. But when the fulcrum, is in its extreme furthest position from the governor, the latter rises to its normal height, at a much lower speed. Should it be required to keep the engine always at the same speed, but to alter the power, this can be effected, by attaching a spring to the fulcrum lever immedialety under the centre of the shifting fulcrum, when nearest the governor. When the governor rises and the fulcrum is directly over the spring, no stretching of the spring occurs, but as the fulcrum is drawn away from the spring by the screw and hand-wheel, the spring power increases, in proportion as the leverage alters. It will thus be seen, that the actual force of lift required of the governor will always remain constant, and thus a constant speed is maintained irrespective of the power at which the engine is set by the position of the fulcrum. It should be mentioned, that the strength of the spring is such as to balance the increased leverage. The engine was constructed by Messrs. Greenwood and Batley of Leeds.

i. Automatic Variable Expansion-gear of Messrs. Oswald Loesch of Zittau and Richard Lüders of Görlitz.

In 1877 Messrs. Oswald Loesch of Zittau and Richard Lüders of Görlitz, took out Letters Patent in Germany for an automatic variable expansion-gear, the complicatedness of which, will be seen from our Plate XIV figs. 1—5.

To ensure efficient drainage of the cylinders, the valves are placed in pairs at each side of the cylinder-bottom. The valve proper *(G)* — vide fig. 5 — forms a three-way cock, and places the steam-port alternately in communication with the main or exhaust steam-pipes. The same valve-box is fitted with an extra segment-valve g independent of the valve-proper; the duty of this segment, is to effect, the cutting-off of the steam under the action of the governor. The external valve-gear is driven by an eccentric-rod from the wrist-plate A. The hollow spindle F of the valve G is attached to a lever L which transfers the rocking motion of the gear-disc on to the first named, by the usual motion rod. The axle *(f)* of the segment g, is made to pass through this hollow spindle, and similarly receives its motion intermittently by the link-gear e, from the same wrist-plate A. This is effected by placing the point of suspension *(d)* of the motion-rod *(e)* not in rigid connection with the gear-disc A, but by adopting the following mechanism, solely controlled by the governor: A second wrist-plate A_1 is mounted on the pivot z in front of the first gear disc *(A)*; the toothed segment r_2, is bolted to the second wrist-plate. The pin Z carries two additional teeth segments $r r_1$ in front of the gear-disc A_1, mounted scissor-fashion under the sole control of the governor; the last mentioned segments are arranged, to gear into the circular racks RR_1 running loose on the pins. It is these racks which impart motion to the segment-valves gg_1 through the motion rods ee_1 and levers ll_1; the pins dd_1 move in concentric slots in the circular racks. When the disc is moving in the direction of the inscribed arrow, the right inlet-valve is opened for the admission of steam, and the two rods E and e obtain a uniform motion: the angular distance between the valve proper G and the segment-valve g, thus remains unchanged, till the circular-rack begins to gear into the tooth-segment r_1, when as a consequence, the speed of the rod e is increased, eventually shutting-off steam, by the segment-valve g, closing the steam-port. According to the greater or lesser speed of the rolling-action of the circular-rack R_1 on to the toothed segment r_1, the sooner or later will the cut-off of the steam ensue. With the return stroke of the gear-disc, the segment-valve g, keeps close up to the valve-proper G, owing to a spring s pressing against the lever b_1, and also on account of the play afforded to the pins dd_1 by the forementioned circular slots. The segment-valve g becomes separated from the valve-proper, as soon as the circular-rack again gears into the fixed toothed segment. During the return-stroke, the rolling direction of the circular-rack becomes naturally reversed, and as soon as the disc A has assumed its central position all the moving parts of the valve-gear are in their original position.

j. Outridge's Box-engine.

The Outridge Box-engine as constructed by Mr. A. P. Postlethwaite of the Runnemede Engineering Works, Egham, was exhibited for the first time, at the Smithfield Club Show of 1877. In its issue of 18th. January 1878, "Iron", probably published the most concise description of this Engine, so that we purpose reproducing this review, along with the several minor improvements, which have been effected in the Outridge Patent Engine, since the notice referred to, appeared. It is appropriately termed the 'box' engine, for all the working parts, except the eccentric and valve-rod, are contained within the cylinder; the two ends of the shaft, one of them carrying the fly-wheel, merely projecting beyond. Governor and feed-pump, if added, are, of course, fixed outside; but neither of these can be regarded as an integral or essential part of an engine. The whole motor thus occupies, a floor space no greater than that covered by its cylinder. This size, which, with a boiler-pressure of 65 lb. and a speed of 320 revolutions a minute, is capable of developing twenty-five horse-power occu-

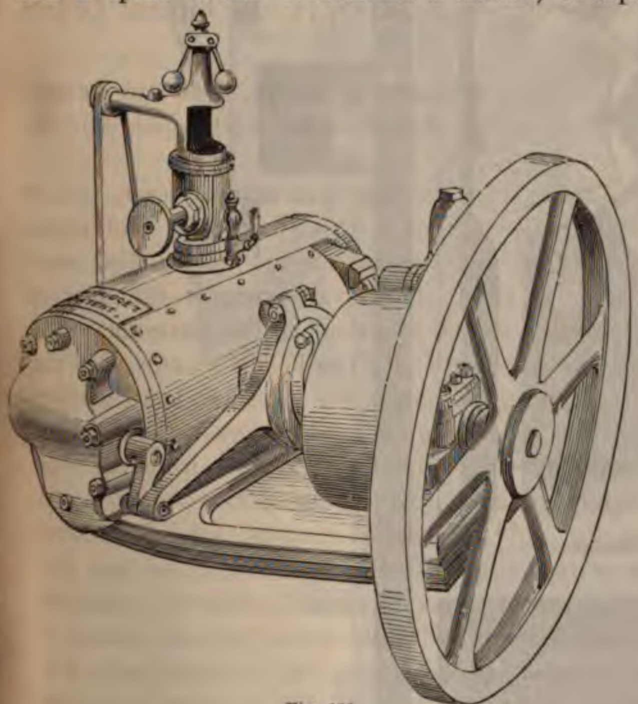

Fig. 120.

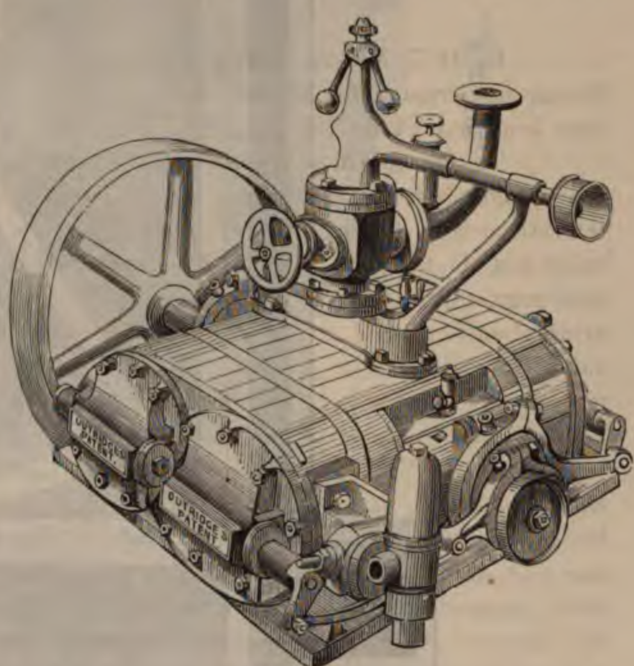

Fig. 121.

pies a ground-space of only 32 by 14 inches, the height over all being 13 inches, and it weighs no more than about $3^1/_4$ cwt.; the diameter of cylinder is 9 inches and the length of stroke 6 inches. This engine, although actually designed to drive a stone-breaker, is of the type supplied for steam launches, yachts, and gunboats, and even for propelling torpedoes themselves under the water.

Our fig. 120 and 121 afford perspective views of the single and double cylinder Outridge engine. Although these engines are eminently suited to small powers, they are by no means limited

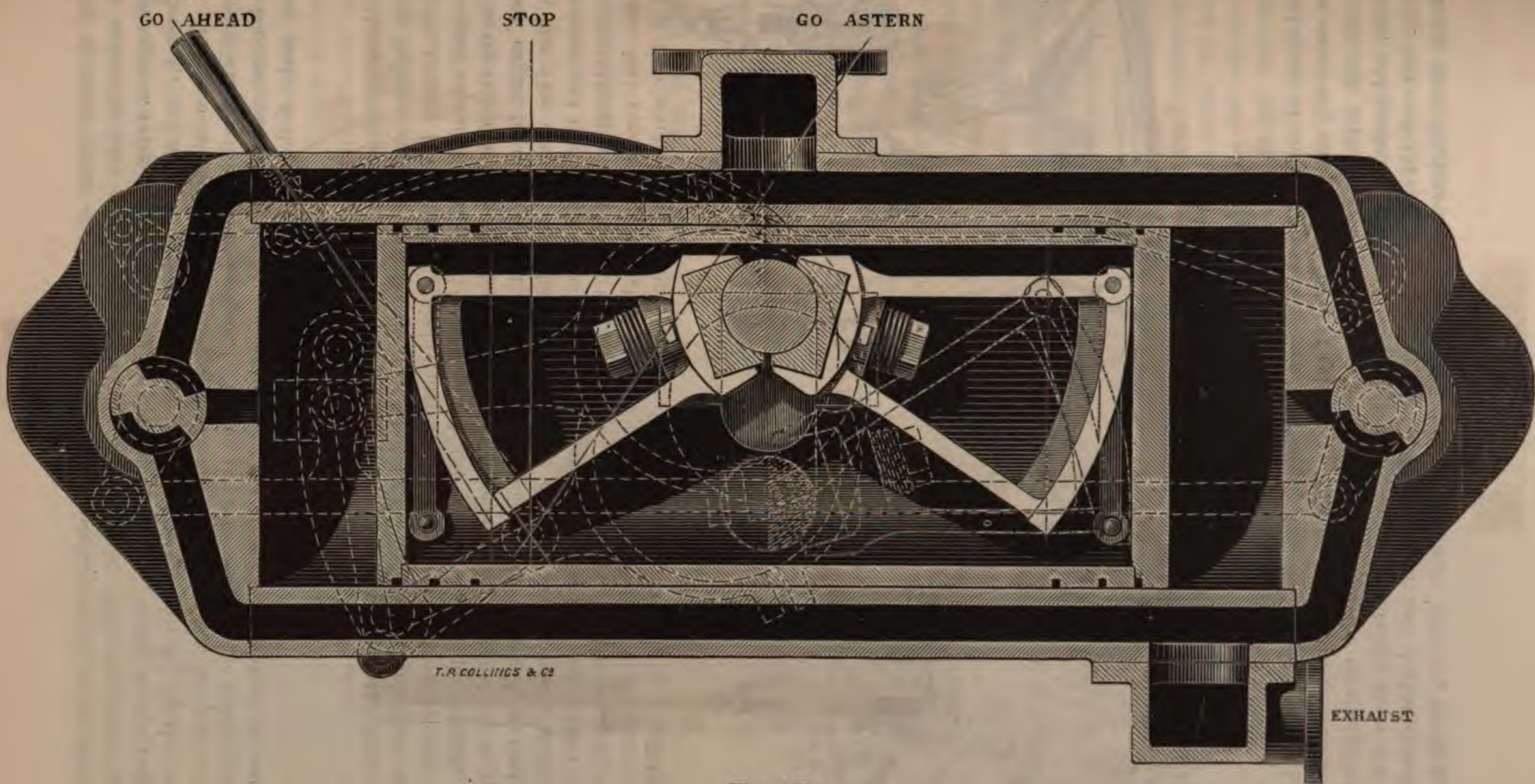

Fig. 122.

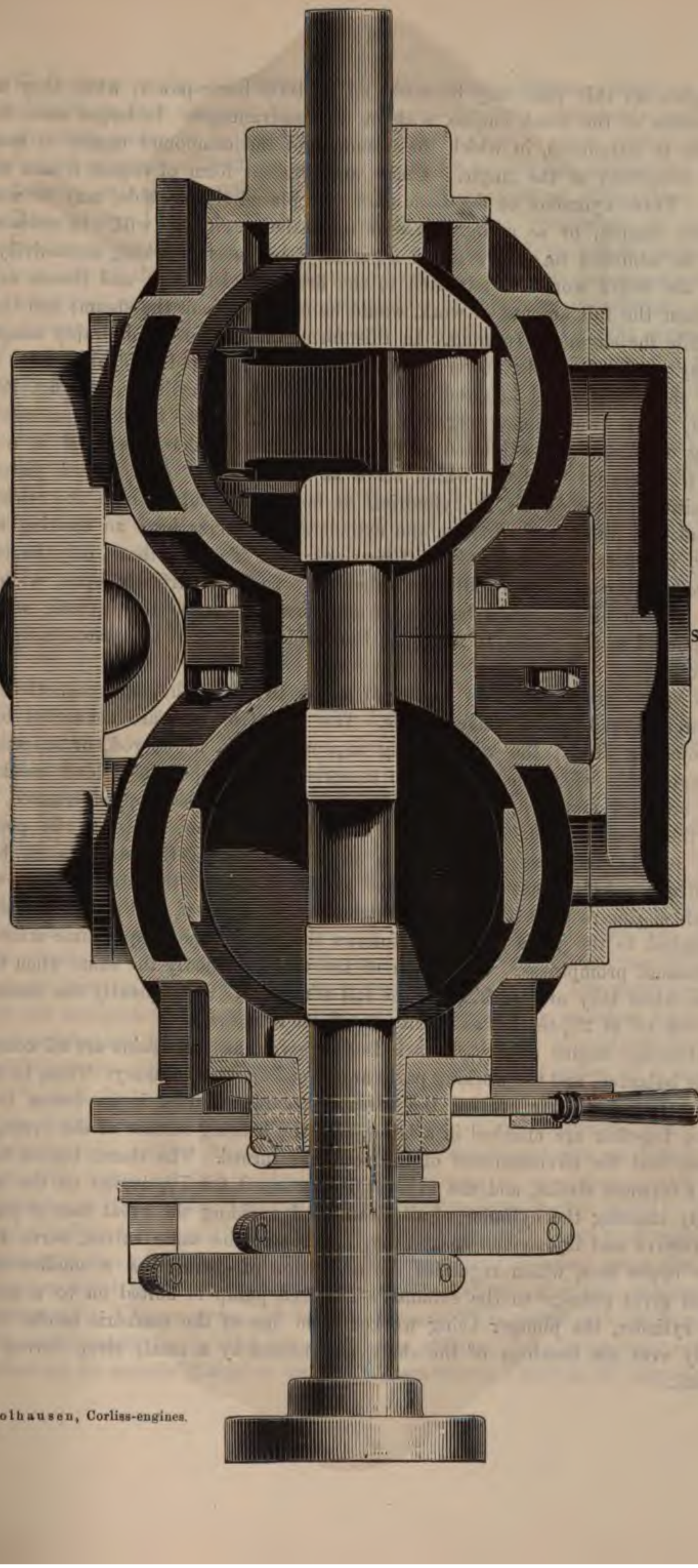

Fig. 123.

to them; for engines on this plan may be made up to 1000 horse-power, when they more closely attain the proportions of the trunk engine, without its disadvantages. In larger sizes, however, the expansion principle is introduced, in which the economy of the compound engine is combined with the lightness and simplicity of the single. A new and efficient form of engine is also manufactured on this principle. Three cylinders of the same diameter, placed side by side, may be worked simply as a high-pressure engine, or as a high-pressure expansive engine at will. In ordinary working, the steam would be admitted to each cylinder separately; but when working expansively, high-pressure steam from the boiler would be admitted to the first cylinder only, and thence expanded into the other two, when the full amount of work, would be obtained from the steam; and this alteration may be made, while the engine is running. In this form, the engine is admirably adapted for tug-boats, and for any work where the power required, varies greatly and suddenly.

Fig. 122 shows a vertical longitudinal section through the cylinder, and fig. 123 a vertical transverse section, of a two-cylinder engine on the same principle; these engravings were made from the working drawings, also exhibited at Islington. The cylinders are fixed in a very simple manner, having feet cast on to them, which serve as a bed-plate. The hollow piston, which is shown in the position of half-stroke, is cylindrical at both ends, but open in the centre for giving access to the crank and its brasses. Indeed, the cylinders themselves have an opening in their side, closed by a door, which carries the crank-shaft bearings; and, if one of these, only be left closed so as to afford a secure bearing to the shaft, the other may be kept perfectly open, while the engine is running. The motion of the piston backwards and forwards causes the sectors, which are supported by links jointed to the piston, to roll upon the inside surfaces of the piston ends, thus causing the crank to revolve.

The two valves are actuated by means of a rod, to which they are connected taking on to short levers securely keyed to the valve spindle. The eccentric bars are connected to the sweep, by means of projecting studs, the whole being supported by a bridle rod, or suspension link (if such a term is applicable when the metal is in compression) attached to a lever working through a sector in the ordinary manner. By this lever, the engine may be stopped, started, reversed, or linked up with the greatest ease. As there is a constant relation, between the position of the piston and that of the eccentric, the valve is so arranged that the steam shall be cut off at 5-tenths of the stroke. As the cut-off takes place at the middle of the stroke, when the "angular speed" (as French engineers term it) of the eccentric is at its greatest, and as this speed is multipled by the lever attached to the valve spindle, it follows that, when the proper time arrives, the valve is closed with unusual promptness. The action of the valve is exactly the same when the eccentrics are linked up, as when they are working at the full admission. Consequently the steam is admitted as freely, when cut off at $2^1/_2$-tenths, as when cut off, at 5-tenths.

In the Outridge engine only $^1/_{16}$th inch lead is given, as the strains are all compressive; the engine is carefully balanced, and the working parts are turned up with accuracy. Thus, in respect to the finishing of the sectors and their brasses, the brass is accurately fitted in its recess in the sector; and then the two together are chucked in a lathe, and the bearing surface of the brass, is bored out at the same time, that the circumference of the sector is turned. The steam begins to exhaust at $7^1/_2$ tenths of the forward stroke, and the exhaust is continued for $7^1/_2$ tenths on the return stroke, thereby effectually clearing the cylinder of all steam, and avoiding the great loss of power, so often the result of excessive and injudicious cushioning. Although the same valves, serve for admission and exhaust, the upper face, which regulates the admission of steam, has a smaller area than the lower face, which gives passage to the exhaust. The feed pump is bolted on to a facing cast on the side of the cylinder, the plunger being worked from one of the eccentric bands. The governor is placed directly over the bearings of the shaft, and turned by a small strap driven by a pulley on the main shaft.

It will be seen by fig. 122 that, for the distribution of steam, plug- or rocking-valves is used. Valves fitted in this manner, have been known to wear remarkably well for a length of time, and very little power is required to move them. Another great feature in these valves, is that a quick cut-off is obtained; and the eccentric may be 'linked up' without the usually attendant evil of wiredrawing the steam, which is common with the use of slide-valves. This is due to the peculiar arrangement, for connecting the levers with the eccentrics, the speed of the lever being much greater at one point of the engine's stroke, than at the other points. The valve is arranged so as to cut off the steam, while the lever is travelling at its greatest speed, and no matter whether the eccentrics be linked up or not, the motion of the valve is uniform.

The clearance-spaces are reduced to a small minimum, as the piston comes home to within an eighth of an inch from the cylinder end, and because there are no steam ports, in the ordinary sense of the term. Thus, only about $^1/_{40}$th of the cubic contents of the cylinder is lost, as compared with $^1/_{12}$th, which is a fair average of the general practice in good engines of the ordinary type; in this way very nearly the full effect of the steam is obtained. The form of valve adopted is also favourable for securing the maximum effect, by affording the full pressure at the commencement of the stroke; and again, as the cut-off takes place rapidly, there is little leaking of the steam.

The lubrication of the working parts is effected by oil being poured into the hollow space between the ends of the piston to a depth of $1^1/_2$ to 2 inches, so that, at each revolution of the engine, the crank-pin is partially immersed; the splashing caused by the passage of the crank-pin through the oil effectually lubricates the sectors and other working parts within the piston. The oil-ways of the crank-shaft bearings, are channels open to the interior of the piston, so that the oil trickling from the crank-shaft and other parts, enters the brasses and effectually lubricates them, thereby lessening the chance of a hot bearing. A lubricator is fitted on to the steam-pipe, and the passage of the steam carries the oil along with it to lubricate the valve, and the interior of the cylinder, in the ordinary manner. When this lubricator and the oil reservoir in the piston are once charged, the engine may be run for twenty-four hours, without attention.

The materials of which the engine is composed are carefully selected for combining strength with lightness. The crank-shaft is bent out of the best hammered steel, and the cylinder, its covers, the piston, valves, and all the other working parts, are made of a very hard, close-grained cast-iron mixture. All the pins are of steel, and the joints and eyes case-hardened. Although the working parts, with the exception of the valve-rods, are contained in the cylinder, and are closed up, so that no dirt nor grit can get in, yet every part is readily accessible for oiling, tightening up, or repairs. In fact the working parts, with the exception of the piston, may be taken out without breaking a single joint, of which there are only two in the engine. The parts are but little liable to wear, with the exception of the crank-pin brasses; but these may be taken out and replaced with a new pair by a labourer, little skilled in engine work. Very slight foundations are required; indeed the engine exhibited, was simply fastened in two balks of timber 10 inches by 4 inches, and secured only by four $^7/_8$-inch bolts. This absence of vibration, is due to the fact that the power is self-contained, there being no outer bearing to take the thrust of the connecting rod.

The chief merits of this form of engine, are that weight and size are reduced to a minimum, owing to the parts being so few, and all the metal being in compression wherever practicable; frictional resistance is the smallest possible, as the parts are generally held in equilibrium; and great economy is effected in steam owing to there being scarcely any dead space. Extra large bearing surfaces are also afforded, the length of the main bearing being twice the diameter of the shaft. The engine which was exhibited was fitted with bearings of patent bronze, which is much harder than gun-metal. The crank-brasses, which are accurately fitted into the jaws of the sectors, are under the same conditions as the brasses of the ordinary connecting rod; and any wear may readily be taken up by merely giving a turn to the set-screw, which is of large diameter and very fine pitch. This operation, which may be performed by merely removing the side door without breaking any joint, only takes four minutes to accomplish, when the engine may be started again and will run noiselessly.

The following table gives some of the main dimensions of the smaller sizes of one and two cylinder Outridge-engines.

Single-cylinder engines.

Nominal horse-power	2	4	6	8
Indicated horse-power, with 65 lbs. boiler pressure	6	12	18	24
Diameter of cylinder	6½"	7½"	9"	11"
Length of stroke	3½"	4½"	6"	6¾"

Double-cylinder engines.

Nominal horse-power	4	6	10
Indicated horse-power, at 65 lbs. boiler pressure	12	18	30
Diameter of cylinders	6½"	7½"	9"
Length of stroke	3½"	4¼"	5"

Amongst the latest improvements brought to bear on the Outridge Box-engine, may be mentioned, the use of one broad packing ring in place of the three Ramsbottom packing rings, formerly used. An improved method of set-screw for adjusting the crank-brasses, has also been introduced; by this method a long set-screw is used, which is put in at the back of the crank-brasses, and is held securely by a lock nut on the interior of the rolling end of the sector. Lastly a different method of supporting the sectors has also been lately introduced.

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3. Engines working with two pistons and balanced Rocking-valves.

Type: P. Hlubek of Vienna.

The modern engine-type designed by Mr. P. Hlubek, Managing Engineer of the Machine and Waggon-works Co. Lim. of Simmering near Vienna, also works with rocking valve-gear, and is moreover fitted, with such an ingenious mechanism permitting a very exact automatic range of expansion, as to entitle it to a place amongst engines working with self-acting variable cut-offs.

It is not asserting too much, in affirming that this valve-gear as well as the entire arrangement of the engine displays much that is new; our Plate 26 will confirm this assertion. The novelty of this valve-gear, lies chiefly in the original arrangement of the admission and exhaust of the steam, taking place in one valve, as well as in the use of cam-discs peculiarly placed under the control of the governor.

The longitudinal section fig. 4 and transverse sections fig. 6 on Plate 26 show that the interior of the valves are longitudinally divided into two separate steam-tight chambers, the one (*e*) of which is for the admission and the other (*a*) for the exhaust-steam. The first named is furnished with open seatings, for allowing the steam to pass from the lateral steam-channel — vide fig. 4. — The alternate gliding of the longitudinal slots of the chambers *e* and *a* over the cylinder-ports, effect the distribution of the steam. The lower slot of the chamber *e* is for balancing purposes, whilst the corresponding slot of the compartment *a* communicates with the exhaust passage. The packing of the valve-seating is effected longitudinally by cast iron rings pressed against their sides by disc and springs; whilst radially a steam-tight contact is obtained by a wedge of longitudinal traverse, which is pressed by springs against two checks, thus forcing out the latter. The valve-spindle is made flat where attached to the longitudinal partition, whereas it is of cylindrical form when passing through the stuffing box; the one end of the valve-spindle carries a small crank bent upwards and furnished with a conical roller — vide fig. 5. — This roller is placed between two corresponding tappet-discs SS_1 mounted on the gearing axle which is driven at the same speed as the main shaft. The inner surfaces of these tappet-discs, form inclined planes, which push the crank o to and fro; this alternate motion imparts a rocking movement to the valves, or effects the distribution of steam to the cylinder, inasmuch as the tappet n of the disc determines the period of cut-off, whilst a larger tappet determines the beginning of the exhaust. On the other hand, the tappets of the disc S_1 cause the contrary movement of the valve, and with it the beginning of compression-period, and eventually the commencement of admission. In fig. 13 (plate 26) we have represented the contact-surface of a pair of these tappet-discs unrolled on, or reduced to a flat plane; the upper and lower outlines of fig. 13, correspond respectively to the right and lift tappet-discs (S_1 and S). A 'variable' expansion is obtained by rendering the tappet n which determines the beginning of expansion or actual shut-off, so adjustable that during the rotation of the gear-axle it may come sooner or later in contact with the crank of the valve-spindle; this range of the tappet-adjustability is shewn in our fig. 13, from n to n_1. The last named wood-cut, shows an analogous projection l, which comes into play with the reversing of the engine, though the latter is of no moment when the engine is working in the direction of the inscribed arrow.

The tappet or projection n of the disc S is adjusted by the governor in the following manner. The forementioned gear-axle w carries behind the tappet-disc S a loose toothed wheel t to which the tappet or projection n is rigidly screwed; this wheel is driven from a spur wheel t_1 mounted on what we may call the expansion-shaft w_1. In order that the wheel t may rotate in the same direction as the gear-axle w, the expansion shaft w_1 will have to rotate in the contrary sense; in this sense, we should obtain a uniform shutting off of the steam. If however, the expansion-shaft w_1 is driven momentarily at a quicker or slower speed, than the gear-axle w, the relative position of the tappet or projection n will become changed, and come in contact at a different period with the valve-spindle crank. The reader will find in our fig. 7, a graphical demonstration of the somewhat complicated mechanism, by which the governor determines the revolving speed of the expansion shaft. The spur-wheel z keyed on the shaft v driven from the crank-shaft, drives the gear-axle w. The expansion-shaft w_1 fits loose in the boss of the wheel z_1 the coupling being effected as follows: The disc (b) cast in one piece with the boss of the wheel z, has two supports (aa) attached to it, which carry a small worm-shaft c; this worm (c) is made to gear into a corresponding wheel c_1 keyed on the expansion-shaft (w_1): in this manner the expansion-shaft is forced to move according to the rotation of the disc b or the shaft v. The shaft c carries a second worm wheel f, which receives its motion from a worm mounted on another shaft g similarly carried by the disc b; a toothed wheel h is keyed on the end of this shaft g able to revolve freely between the spur-wheels k and i. The whole of this mechanism is cased in a box, which though prevented from taking part in any rotary movement is able to move sideways according as it is pushed by the lever-combination actuated by the governor (vide fig. 5). The toothed wheels k and i are rigidly connected with this box, and according to the lateral movement of the latter, the pinion h will gear into one of these wheels, so causing the shifting of the expansion shaft w_1 in addition to its revolving-motion; the desired degree of variable expansion is thus attained by this double movement. In order to keep the action of the governor on the projections n within certain limits, the ratio between the worm-wheel c_1, and the worm c is so chosen, that the two become automatically disengaged, when the extreme range of expansion is attained. Two spiral-springs are used for re-effecting the coupling, and these are placed at each end of the worm c; when disengagement ensues either the one or the other of these springs becomes compressed, the resulting counter-pressure re-effecting the working into gear of the worm and wheel.

The governor is driven by bevel-gearing from the shaft *v*; to economise space its balls are inverted, so shortening the length of the governor spindle and of its suspension-rods. The governor is fitted which compensating weigths, and its normal speed may be varied either by shifting the counterweight or by shortening or lengthening the leverages.

The engine has the following reversing-gear attached to it: The shaft *v* consists of two parts, one end of which has a helical whilst the other has a straight groove or slot in its surface; when the collar which slides in these grooves, is worked by the reversing lever shewn in our elevation fig. 1 and 2 (Plate 26), the shaft *v* is turned round about 180°, causing a change in the distribution of steam to the cylinder, corresponding to the reversing of the engines.

The working-principle of these engines, embodies, as we have already seen, an entirely new system, the chief characteristics of which may be said to consist in the coupling of two pistons working in one cylinder, with cranks set at 60° to each other, with a threefold admission of steam for every engine-revolution. It should however not be forgotten, that engines working with two pistons running in contrary directions in one cylinder, have been proposed and tried by several inventors, and in one case (according to The Engineer) even as a locomotive. The details have been variously disposed, as by employing the double piston, two principal advantages are gained, namely great steadiness in the running of the engine, and double the power with very little extra space, the increase in the space occupied by the engine, being very little more, than that of the extra length of the cylinder. The weight of the engine is thus much less than ordinary double-cylinder engines of the same power. Several minor advantages are secured from the balance principle — as for instance, the pressure on the crank-shaft bearing is for a considerable part of each revolution almost nil. These bearings, are therefore not so liable to heat or cut, and the friction is in several parts less, than in ordinary engines.

In the Hlubek-engine, the fore-piston is connected in the usual manner with its piston-rod, cross-head and connecting rod to a middle crank working on the main-shaft. The hind-piston has its piston-rod protruding through the hind-cylinder cover; working on to a cross-beam, the piston-motion is transferred by suitable guide-rods, arranged at the cylinder-sides, on to two cross-heads connected in the ordinary style to two outside cranks on the same driving-shaft. The valves, formed as already described, are placed under the three cylinder-ports, the middle one of which is made sufficiently large (fig. 3), so that it may not be covered at each stroke commencement by the corresponding piston; but as this clearance space is symmetrically arranged, the hind-piston is compelled to remain in front of the other end of the port, in order to separate the central admission of steam from the cylinder space behind the piston. For this reason, the pistons are made somewhat longer than usual.

To elucidate the steam-distribution as well as the working principle of this engine, we have sketched the main piston-positions in fig. 8—12 (Plate 26). In fig. 8, the pistons are represented in their nearest approachment to each other, the admission is taking place through ports *b*, *c*, the exhaust through port *a*, and consequently the pressure on the crank *k* is annulled whilst the crank k_1 is in its most effective position. In fig. 9, the crank *k* is on its dead-centre, steam is entering through ports *b*, and emission is taking place through ports *a* and *c*; both pistons are working. In fig. 10, the crank k_1 is on its dead centre, admission is taking place through ports *a* and *b*, whilst port *c* is exhausting; the crank *k* is in its most advantageous position. The last named has arrived on its opposite dead-centre in fig. 11, steam is entering at *a* and *c*, whereas port *b* is exhausting, whilst both pistons are working. In Fig. 12, the crank k_1 is similarly on its other dead-centre, the port *c* is admitting, whilst ports *a* and *b* are exhausting; crank *k* is working.

We may conclude from this description, that a most uniform transmission of power, is thus attained, inasmuch as pressure is exerted on both pistons, when the two cranks are nearing their change of piston-motion, though they are then exerting little rotative force on account of the small crank-lever-age. If on the contrary, the cranks are approaching the position corresponding to the largest crank-leverage, then the pressure on the one piston is annulled.

The advantages, resulting from the application of this engine-type, may be summed up as follows:

Working with no actual dead-centre effect, a remarkable uniform motion is attained, enabling the starting of the machine at any portion of the stroke.

The partial equalisation of the steam-pressure, coupled with the advantageous positions of the cranks, dispenses with the need of solid masonry foundations, balks of timber framed together, being all the foundation required.

Economy of standing-room required, and reduction of weight as compared with other engines of equal power. Another advantage, equally important, is the admissibility of high-pressures with early cut-offs of 0.05 and 0.07 stroke for small and high engine speeds respectively, whilst the uniformity of speed and rapidity of cut-off, enables the engine to be run at high speeds.

The practical tests, instituted by Mr. L. Schlu and Professors J. Radinger and H. Ludewig, — under whose supervision one of these engines of 11" (280 mm.) cylinder-bore and 22" (560 mm.) stroke, was tested under the brake and indicator, — are probably the most favorable ever yet recorded of a steam-engine of equal size. These trials were conducted at the Simmeringer Machine & Wagon Works, and the last mentioned engine, shewed under the brake an effective horse-power of 18,038, the sum of the indicated power was 22, 21, so that the working capacity of this engine showed 0.81, taken with high-pressure indicator-diagrams with $3^1/_2$ atmosph. pressure in the valve-chest.

One of these engines, is driving by belting, part of the tools of the forementioned works since 1874, without having yet required any special foundation.

The cross-beam, is shown arranged for taking up the air-pump piston. The engine bed, is cast in two pieces, namely the valve-chest to which the cylinder is bolted, whilst the slide-bars and crank-shaft pedestals etc. are bolted to the other portion of the bed. The air-pump is driven direct from the crank-shaft. The steam supply-pipe, $2^3/_4$" (72 mm.) in diam. (or $^1/_{15}$ the cylinder cross-area), passes round the side of the cylinder, and branching off on account of the central-valve, it enters the horizontal steam-passage communicating with the three valves. The exhaust-passage, is placed under the whole width of the valves, and leads into a steam-pipe of $3^7/_8$" (100 mm) diam. ($^1/_8$ the cylinder cross-area).

Our Plate 26, renders a further description of the engine details unnecessary.

4. Engines working with balanced Rotary-valves.

a. Dingler's Machine Works, Zweibrücken.

Type: L. Ehrhardt.

The opinion has been expressed, that of all the engines exhibited at the International Exhibition of Vienna, none created greater interest than the one exhibited under the name of the 'Dingler-engine', fitted as it was with a valve-gear patented by Mr. L. Ehrhardt, the then Managing Engineer of Dingler's Machine Works.

As this engine is already largely known, we have merely illustrated it on Plate XV; the working principle is represented in the annexed fig. 124 and 125 and fig. 4 and 5 (Plate XV). The high- and low-pressure cylinders are cast together; their pistons kk_1 are connected in the usual manner to cranks KK_1 set at 180° degrees. The crank-shaft is carried on two pedestals, outside of which two flywheels are mounted for transmitting the engine-power by belting. The valves *GG* shewn in the annexed woodcuts, are represented in the same position in fig. 4 and 5 (Plate XV), Steam is entering through the valve G_1, forcing the piston *k* forward, whereas simultaneously the same valve is exhausting the expanded steam from the low pressure cylinder, into the condenser *z*. The valve *G* effects the direct passage of the steam from one cylinder to the other.

The tapered valves are placed under the cylinder, in an inclined position; they are worked from a shaft, parallel with the engine-centre. The construction of these double-valves may be referred to the longitudinal and cross-sections, shewn in figs. 6—13. It will be seen that all the steam-ways are symmetrically arranged, in order to balance the valve and to obtain sufficiently large areas; it is true the valve experiences an axial-thrust *pp*, which is however taken up by the end-seating. The steam from the boiler, enters the valve-chest, through the steam-jacket *m*, and may pass into the cylinder in two different ways, as shewn by the inscribed arrow. According as the lap is fixed upon, so a certain rate of expansion is obtained for the two cylinders kk_1. The inside valve rr_1 is worked direct from the governor, thus resulting in an 'automatic expansion-gear'. The 'cut-off' of the external valve as drawn on Plate XV answers to 0.65 stroke in the high-pressure cylinder, and the earliest automatic cut-off effected by the internal valve is fixed at $^1/_{20}$ stroke. The usual ratio of expansion takes place at $^2/_5$ stroke, in the high-pressure cylinder, whilst that of the low pressure cylinder is always equal to 0.65 stroke.

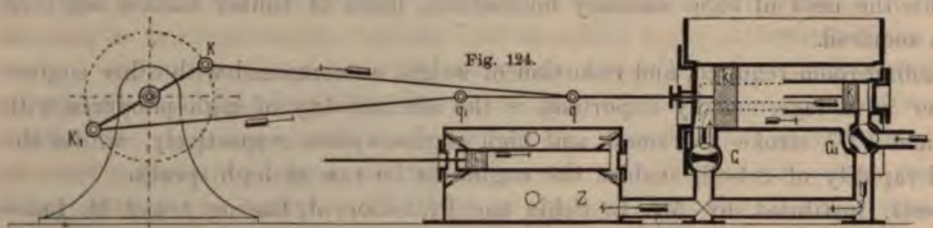

Fig. 124.

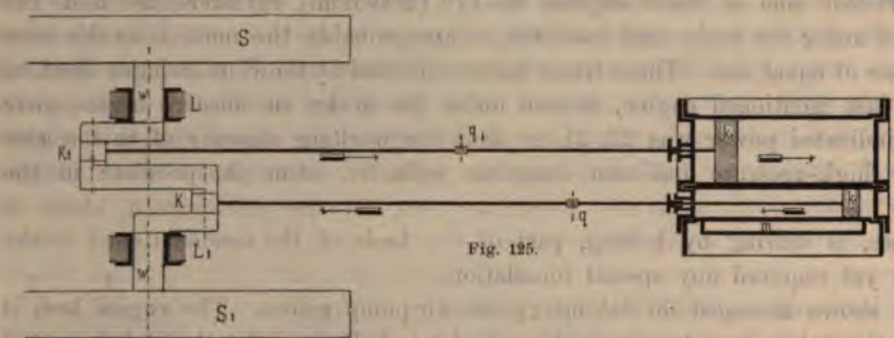

Fig. 125.

With a high and low pressure cylinder-diameter of 5″ and 10″ (125 and 250 mm.) and a 1′ 7½″ (500 mm.) stroke, the engine is run at 115 revolutions per min. with a boiler-pressure of 10 atm., whereby a mean piston-speed of 6′ 2″ (1.9 m.) per sec. is obtained.

The cylinder-piston shewn in section in fig. 14 (Plate XV) is accurately fitted in the cylinder without any packing rings. The fly-wheels are each 5′ 3″ (1600 mm.) in diameter and $4^5/_8$″ (120 mm.) on the face. The diameter of the air-pump is $4^3/_4$″ (125 mm.); its stroke is 7″ (180 mm.).

b. The Hüttenberg Ironworks Co. of Klagenfurt.

Type: A. Musil.

The valve-gear, designed by Mr. A. Musil of Klagenfurt, is similar to the Ehrhardt type, in its working principle, inasmuch as both, use a rotating valve, and a fixed expansion valve, entirely depending on the governor. The similarity, however, ceases here; for the two types differ materialy from each other in their constructive details.

The reader will find this engine illustrated on Plate 27, figs. 1 and 2 giving us side-elvations of this engine, with special regard to the valve-gear on both sides of the cylinders and fig. 3 is a plan of the whole arrangement; in figs. 4 and 5 we have sections through the cylinder drawn to an enlarged scale, and the constructive-details of the valves are shewn in figs. 6—8.

It will be seen that two-valve chests are bolted to the bottom side of the cylinder, each of which receive the boiler-steam for the cylinder, as well as the exhaust-steam, in the manner shewn by the inscribed arrows in fig. 5. The valve is balanced by the opposite position of the slots or steam-ways, and on account of the arrangement of double chambers *aa* and *ee* (fig. 6) the valve is only required to make half a revolution for every revolution of the crank-shaft. The chambers *aa* of the tapered distributing valve, are open towards the exhaust-side, and so place the cylinder in communication with the exhaust-pipe, as shewn by the inscribed arrows in figs. 5 and 7. Admission of the steam, takes place from the other side, through the expansion-valve openings *iiii* (figs. 5 and 8). Owing to the symmetrical arrangement of these steam-passages, the valve is entirely balanced both in a radial and in an axial direction, so that the governor in working the valve, has only to overcome the resistance offered by the stuffing-box. The working of the valve can be easily inferred from fig. 6. In the position that the valve is drawn in, the crank is on its dead centre (vide fig. 4); the valve-edge *c*, has opened the steam-passage at its two outlets, to the extent of the lineal lead, and when rotating in the directions of the inscribed arrow, it remains open, till the valve-edge c_1 has shut-off the port; expansion now takes place, but on account of the piston being already nearly at its stroke-end, the admission of steam takes place almost during the entire stroke. If the valve-edge *d* passes over the port, then the cylinder is in direct communication with the exhaust-pipe, through the openings *aa*, remaining thus, till the valve-edge d_1 closes the port; by this time the crank is again on its dead-centre, and the working of the valve, as just explained, is repeated. According to the ratio, existing between the width of the ports and the width of the valve-edges, the periods of admission and emission, as well as the duration of expansion and compression, may be fixed at will. The duty of the automatic expansion-valve, is to close the steam-passages *gg*, so that the steam in the chambers *ee* may only similarly expand. In figs. 9—13, we have shewn the position of the expansion-valve for various 'cut-offs', and these diagrams prove that automatic cut-off may ensue, at almost all periods between 0.0 stroke and full stroke.

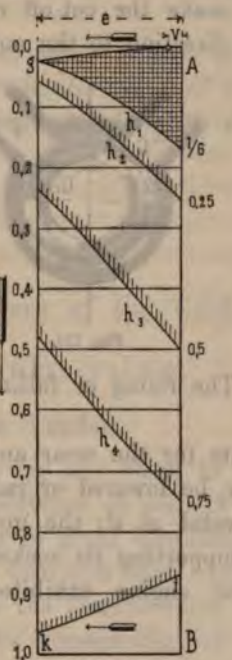

Fig. 126.

Fig. 127.

To still further elucidate the working of this valve-gear, we append the annexed diagrams — figs. 126 and 127 — relating respectively to the steam-admission and exhaust. The curves Ag and A_1g_1 described by the valve-edges c and d are equal to each other, because the width of the port is equal, or $e = a$. For the same reason the curves ik and i_1k_1 described by the valve-edges c_1 and d_1, are also equal. The curves h_1 h_2 h_3 and h_4 show the contractions and the shutting-off of the ports *gg*, corresponding with different positions of the expansion-valve.

According to the indicator-diagrams taken off this engine, of $10\frac{3}{8}''$ (265 mm.) cylinder-bore, and 1′ 10″ (550 mm.) stroke, the working of the valve-gear is very uniform, for speeds varying from 60 to 120 revolutions per min.; the mean piston-speed varies accordingly from 3′ 8″ (1.1 m.) to 7′ 4″ (2.2 m.) per second; all under the assumed boiler-pressure of 78 lbs. (5.2 atm.) per sq. in. The steam and exhaust pipe are each $5\frac{1}{2} \times \frac{7}{8}''$ (140 × 25 mm.), or $\frac{1}{15.7}$ the piston area.

The remaining constructive-details may be inferred from our Plate 26, where all the dimensions are inscribed, though we may add that the Porter governor used, is driven by bevel-wheels from the valve gear-rod at equal speed as the crank-shaft, and that with a collar slide of $3^1/_8$" (80 mm.) the governor can regulate automatic cut-off up to $^9/_{10}$ stroke.

c. Machine & Wagon Works Co. Lim. of Simmering near Vienna.

Type: Radinger.

Prof. J. J. Radinger of Vienna has designed a rotary valve specially adapted for high speed engines, which made its first public appearance at the Vienna International Exhibition. This arrangement is shown on Plate 28, figs. 1 and 2 shewing an engine so fitted in side elevation and plan; fig. 3 is a longitudinal section through the cylinder and valve-chest, and in figs. 4 and 5 we have drawn the valve-gear in section, on an enlarged scale. The steam is distributed by four valves, the external pair of which regulate the exhaust, whilst the other two telescope into each other and determine the admission and degree of variable expansion. The steam enters through the top and bottom of the valve, whence it passes through certain openings into the cylinder-ports. These openings are arranged diametrically opposite each other, for thoroughly balancing the valve, and on account of the cylinder-ports being at right angles to each other, the valve is only required to make half a revolution for every revolution of the crank. The valve-spindles are attached to three pinions gearing into each other, the central one of which is driven by bevel-gearing worked from the crank-shaft; these valve-spindles are carried through the valve-chests and are kept steam-tight by the stuffing-boxes shewn in our sheet of working drawings.

In order to make the cut-off rapid and exact, the inner or expansion-valve is made to revolve in an opposite direction to the outer distributing valve. We have represented the position of this double-valve in fig. 128 when the admission is beginning, whilst fig. 129 illustrates the position of the valves when the admission is about ceasing with a cut-off at $^2/_5$ stroke. The inlet-ports are marked with ee_1, G is the admission and G_1 is the expansion-valve.

Fig. 128.

Fig. 129.

This expansion-valve, mounted on the prolonged governor-spindle, receives as aforesaid, a contrary revolving direction to the outer valve, which motion is obtained by driving it from the lowest bevel-wheel b shewn in fig. 1, 4 and 5. The rising or falling of the governor-collar, causes the expansion-valve to shut-off sooner or later.

To compensate for the wear and tear between these two valves, and to facilitate their adjustability these may be lowered or raised towards each other by turning a worm-wheel f carried on the governor-pedestal at d; the governor-spindle may be also adjusted by the screw and lever combination shown supporting its socket in fig. 4 (Plate 28).

The ten-horse engine exhibited was $10^1/_4$" (265 mm.) in cylinder bore and had a 2' (630 mm.) stroke.

d. Emmerich Machine Works, Emmerich on the Rhine.

The annexed wood-cut fig. 130 shows an engine fitted with rotary-valves and constructed by the Emmerich Machine Works. The details of this rotary valve are represented on Plate IX, figs. 4—6. The distribution of the steam is effected by this single valve, and according as it is shifted longitudinally by the action of the governor, a variable expansion is obtained. This valve is arranged on the top of the cylinder, and its spindle is worked by worm and wheel from the crank-disc. Our figs. 5 and 6 on Plate IX give us a longitudinal and transverse section of this valve, whilst in fig. 6, we give the valve-surface reduced to a plane in relation with the cylinder-ports. The inner surface of the valve-chest is furnished with two rectangular openings, (e for the exhaust, a for the inlet), and with two other passages C and D leading to the cylinder-ends.

Similarly the valve-surface when unrolled, shows — vide fig. 4 — four rectangular openings E connected with four steam-ways G in the valve-interior, and also the four openings F in communication with the four steam-ways H.

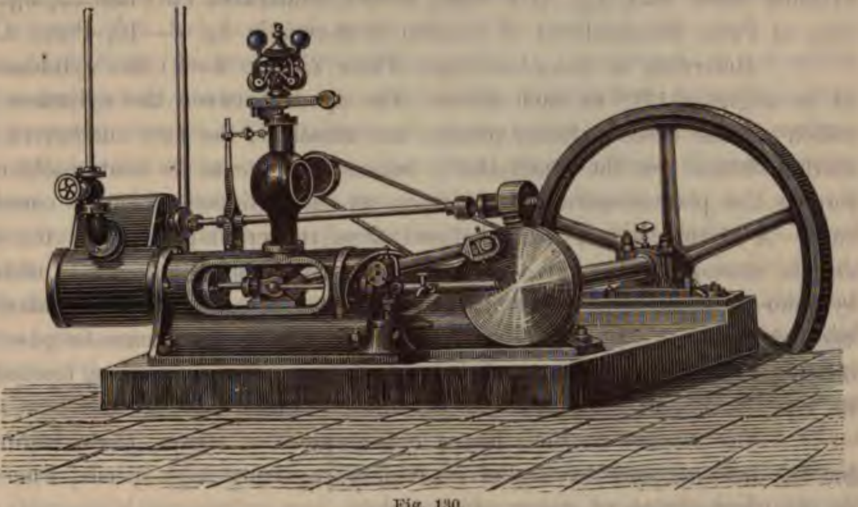

Fig. 130.

On account of the quadruple arrangement of these steam-passages, for every crank-revolution, the valve only makes one quarter of a revolution.

With the uniform rotation of the valve, the steam at one time passes from eFH into the cylinder-port C, whilst at another time, it enters the port C from eEG; in accordance herewith, the exhaust is alternately placed in communication with the cylinder-ports C and D.

The shifting of the valve in its axial directions, can ensue without in any way disturbing the inlet or emission of the steam, on account of the rectangular form of the passages running parallel to the valve-axis. The inclined direction of the passages $C, D, G, H,$ vary the time of cut-off, and so give us the variable expansion-gear.

III. Steam-engines, working with Circular-valves of the Grid-iron type.

1. Fitted with rotary Circular-valves.

a. Brotherhood & Hardingham, London.

Although the circular-valve has now little right to lay any claim to special novelty, still it is only in recent years that it has attained a certain importance on account of its being adopted for various noted engine-types. It possesses the advantage of great simplicity in its construction and in its working, but equally shares the defect of uneven wear and tear, which renders it difficult to retain it in unimpaired working order; for these reasons the circular-valve is mostly introduced in such types of high-speed engines, where economy in the consumption of steam is deemed of secondary importance.

The circular-valve differs from other rotary-valves only in its form, but not in its working-principle.

Probably, the three cylinder engines of Messrs. Brotherhood & Hardingham of London, have done more to disseminate the circular-valve, than any other engine-type. It is, in fact, admirably suited for these engines, since leakage of steam is of little consequence, with such heavy steam-consumers.

These original steam-motors, which are particularly adapted for the direct driving of Centrifugal-pumps, Circular-saws, Electric and other machines requiring high speeds, became chiefly known in Germany through the Vienna Exhibition, though they are there used less, than in England, France, and Belgium.

The reader will find one of the older types of the Brotherhood engines with 7" (180 mm.) cylinder bore, and $5^7/_8$" (150 mm.) stroke, illustrated on Plate 25, fig. 6—8, whilst a later construction of Peter Brotherhood of London is shewn in fig. 6—10, Plate XIV.

Referring to the older type (Plate 25, fig. 6—8) the cylinders are cast in one and are set at an angle of 120° to each other. The space between the cylinders is taken up by the crank to which all the three cylinder-pistons are attached; the two end-covers of this space form steam-tight stuffing-boxes for the crank-shaft, because the steam is continually entering this central-space and forcing the pistons outwards, as soon as these pistons are only counteracted by atmospheric pressure. A circular-valve, worked direct from the crank-pin, effects the distribution of steam in a very simple manner. The valve-seat, is furnished with three equal ports, leading each to the upper cylinder-portions. The valve-face has a cavity, which places the central-space in communication with the exhaust-pipe, whilst a smaller opening allows the steam to pass up the lateral-pipe on to the other piston-side, as soon as the corresponding piston is moving towards the crank, so as to establish an equalisation of pressure.

On account of their heavy consumption of steam, these engines, can only be recommended for the intermittend driving of machinery requiring high-speeds, where little importance is attached, to the consumption of steam or of fuel.

The improved construction shewn by our Plate XIV, fig. 6—10 was designed with a view of obtaining still greater running speeds. The three cylinders are cast as formerly in one piece. The balanced circular-valve (fig. 10) is driven from the crank K by the small pin b and the crank k (fig. 9). In the position shewn in our fig. 8, the boiler-steam, passing through the circular-valve G and the steam-way e, is entering the cylinder through e_1, whereas the exhaust-steam enters the steam-tight central-chamber by the passage a, and is thence conducted into the exhaust-pipe.

The valve-seating is formed by the left engine-cover, and by the easily removed-piece g. The governor U influences the plug-valve H, the spindle r of which, carries a disc o furnished with projections nn_1, playing on two sliding-peices RR_1; these alter the position of the valve, as they approach or recede from the governor-centre, according to the action of the centrifugal force or of the spiral springs ss_1.

b. Thomas C. Watts, Engineer of London.

The Watt's 2 and 4 cylinder engines made their first public appearance at the Bristol Meeting of the Royal Agricultural Show (1878), and in a Circular before us, it is announced that 'the main objects kept in view in designing these engines have been to produce a cheap, economical, durable, simple and compact engine for general factory use, for driving without gearing, fans, pumps, exhausters, hydro-extractors etc.' or for attachment to lines of quick running shafting.

The whole of the working parts are enclosed in a casing, protecting them from dust, grit, exposure etc., forming the only foundation necessary, and carrying the fly-wheels clear of the ground.

Some engines of this type, as we have just seen, exhaust the steam into this casing or base, involving steam joints and stuffing-boxes. Watt's engines exhaust in the ordinary manner and avoid all steam joints and packing, and by allowing of inspection when running, leakage of pistons, etc., can be readily detected.

The valve works practically in equilibrium, and can be arranged to 'cut-off' at any desired point of the stroke.

In fig. 9 and 10 (Plate 25) we illustrate one of these 2 cylinder High-pressure Engines, whilst fig. 11 and 12 are taken from a 4 cylinder Compound Engine of the same type.

Beginning with the 2 cylinder engines, these engines are constructed with a strong framing of cast iron, and with two inverted cylinders placed above a crank shaft, as clearly shewn in fig. 9 and 10, Plate 25. This crank shaft is supported in suitable bearings at its ends, and at its centre is attached to the frame. The cylinders are fitted with trunk pistons to each of which is jointed one end of a connecting rod, whose other end is fitted upon one of the cranks.

For small or light engines these connecting rods are made by preference of phosphor bronze, and *H*-shaped in transverse section, but for large engines the connecting rods form steel tubes, with heads or ends of phosphor bronze. The pistons of these cylinders are single-acting, being moved in one direction only by the steam pressure. The lower ends of the cylinders, or the ends nearest the cranks, are open, and the other ends of the cylinders are closed.

The ends or covers are cast solidly, or in one piece with the body of the cylinder, to avoid the work of fitting separate ends or covers on the same.

To avoid the necessity for the ordinary long steam passages, and the consequent loss of steam and of the useful effect of steam engines of this class, a novel arrangement of the valves and ports and mechanism for operating the valves has been devised; the admission ports are formed for this purpose through the ends or covers, and a valve is fitted upon the same within a suitable casing secured upon each of the cylinder ends.

One valve is used for each pair of cylinders, as shewn, and operated to control the admission and exhaust of the steam by alternately uncovering and covering the admission ports and exhaust port in the usual manner.

When a circular rotating valve is used, as in the engine illustrated, it is operated by means of a vertical rod, shaft, or spindle, arranged between the two cylinders, and connected by bevel gear wheels, with the crank shaft from which it receives rotary motion. To reduce the friction of this valve on its face, the rod or spindle is provided, with an adjustable collar, which works on the top of the bearing or bush of this spindle; the upper end of the latter is made square, and fitted in a square hole in the valve, while allowing it free movement on the spindle, so that the valve may bear properly on its face independently of the weight of the spindle and its gearing. Around the upper part of the valve, a flange is formed to fit the interior of the casing, which flange takes off a great portion of the downward pressure of the steam upon the valve.

The steam enters by the pipe or passage between the top and bottom flanges of the valve, which has a port or aperture. Each time this aperture passes over the port of either cylinder, steam is admitted to the same, while the exhaust steam passes from the other cylinder through the cavity of the valve and the exhaust port to the exhaust pipe. By thus fitting the valve upon a square portion of the spindle it always adjusts itself freely to its seat, and the accuracy of its working is not affected by the wearing of the spindle or the gearing.

Holes may be drilled in the port face or seat, to contain lubricating matter.

When this form of valve is used, the governor is driven by means of gear wheels from the shaft or spindle.

If desired, instead of a circular valve a slide valve of the usual form, may of course be substituted, and moved to and fro over the port face by small rods and cranks operated by an eccentric or cam on the crank shaft; in some instances the cam or eccentric and rods for operating the valve may be at one end of the crank shaft, instead of being in the centre of the engine.

The steam is exhausted in the usual manner, or discharged directly through a suitable exhaust pipe, instead of into a casing or hollow base, for the reason that when the exhaust takes place in this last-named manner, the leakage or loss of any steam through defects in the pistons cannot be easily detected, and stuffing boxes and steam joints have to be provided.

In cases where a fly-wheel pit would not be objectionable the base can be shortened, making the engine considerably lighter and more compact than is otherwise practicable.

The valve stem, is divided into two parts connected to a long sleeve by cotters or pins; this sleeve has in it spiral grooves, into which the cotters or pins fit in such manner that when the sleeve is raised or lowered the upper part of the stem, and with it the valve, will be shifted or turned half way round upon its seat, thereby altering the relation of the valve to the crank in the required manner.

In engines, where the slide valve and cam are employed, any of the well-known arrangements for adjusting the cam on the crank-shaft may be adopted to afford the means for reversing the engine.

The two cylinder engine we have illustrated, has a pair of cylinders 15" in diameter and 18" stroke, and is estimated to indicate 250 horse-power.

In fig. 11 and 12 (Plate 25) we have shewn the adaptation of this type as a four-cylinder Compound Engine.

It will be seen that the small and large cylinders are concentric with each other, and that the pistons of the large cylinder are annular, as in other compound engines. The high-pressure pistons are provided at their lower ends with flanges, which are fitted to flanges on the pistons and by means of screws passed through these flanges; thus the two pistons exert their joint action on the crank through the medium of one connecting rod. This arrangement of the pistons permits the use of a condenser in an engine with single-acting cylinders.

The valve, in this engine, may be a rotating valve, as shewn; it is provided with passages and cavities for the distribution of the steam as follows: — The port or passage, supplies the steam to the admission ports of the high-pressure cylinders, and steam is conducted from these cylinders by a passage to the large or expansion cylinders, and is exhausted from the latter through the passage, whence it passes to the exhaust pipe. The rotation of this valve is effected by means of a vertical spindle geared with the crank-shaft, and connected with the said valve as in the engine first above described.

At the London Meeting of the Royal Agricultural Society (1879) Mr. Watt's showed a new three cylinder engine, which has been pronounced to be a decided improvement on anything of the kind yet made. Alone as this engine is worked by a piston-valve, not belonging to the valve-gears now under discussion, we may here conveniently refer the reader to 'The Engineer d. 11. July 1879 pg. 23 and 24,' for a description and illustration of this new type.

c. G. Lushka, Engineer, of Bielitz.

A peculiar combination of the circular-faced valve and of a rotary plug-valve has been designed by Mr. G. Lushka, Engineer of Bielitz (Austrian Silesia). We illustrate this arrangement in the annexed fig. 131—134.

The valve seating has two equal segment openings ee_1 forming the cylinder-ports, whilst the valve-face is furnished with the passage o for the admission, and with the outlet o_1 for the exhaust, the first named passage o being made smaller than the second outlet o_1.

The latter forms the outlet for the pipe p which passes through the cover of the valve-chest, and is rendered steam-tight by the stuffing-box shewn; this pipe forms the rotary axis of the valve, for which purpose it carries a bevel-wheel r.

The lateral openings ii placed in pairs with a view of balancing the valve, allow the boiler-steam to pass through the circular-valve opening o — according to the position of the valve in fig. 131 — into the cylinder-port c. The circular-slide rotates at equal speed with the crank-shaft, on account of its having to distribute the steam to both cylinder-ends. With a view of obtaining a variable expansion-gear, the circular-valve has a sleeve *cd* placed over it, which is made in two cylindrical parts, with steam-ways corresponding to the forementioned openings *ii*. The cylindrical piece *cc* is kept fast by the bolts *sss*, whereas the other outer cylinder *dd* is furnished with toothed segments, into which the worm *w* gears; the spindle of this worm may either be turned by hand or by the automatic action of the governor. Consequently the edges *nn* of the cylinder *dd*, may be turned over the steam-way of the inner cylinder, whereby a range of expansion can be obtained, from 0.0 to 0.4 stroke. In the position, shewn in our engraving (fig. 133) we should get a cut-off corresponding to $^1/_7$ stroke.

Fig. 133.

Fig. 134.

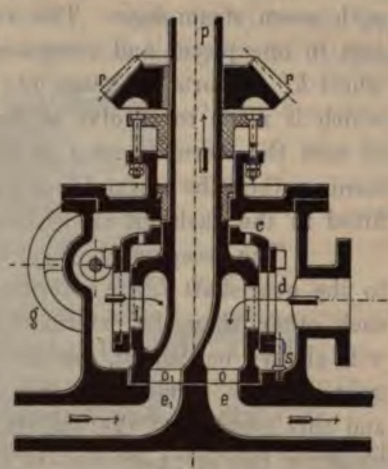

Fig. 131.

We are informed, that the chief object kept in view in the design of this valve, was to obtain a distributing valve specially suited to high piston-speeds, the easy working of which, should be secured by perfectly balancing the valve.

In the writer's opinion this arrangement may be considerably modified, by not observing an equal lineal lead for different ratios of expansion; because, the double cylinder of the expansion-arrangement might then be dispensed with, as illustrated in fig. 134. In this case, the steam would begin to work expansively, after turning the valve to the extent of the angle *a*. If the cylinder *d*, be turned to the same extent, we should obtain a different lineal-lead.

Fig. 132.

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2. Valve-gears, working with Circular-faced Valves with intermittent rotation.

Prof. H. v. Reiche, Aix-la-Chapelle.

We illustrate on Plate XVI a new and highly original Circular-valve, which Prof. H. v. Reiche made public in 1874.

In designing this valve, the inventor sought to obtain, what may be termed the ideal automatic expansion-gear. It must be conceded, that Prof. v. Reiche, so far succeeded, that he has combined all the advantages inherent to Corliss valve-gears, without in any way inheriting, any of the defects of the latter. His valve-gear, admits of all ranges of expansion, whilst the opening and shutting of the valve is instantaneous. This is brought about, not by the unyielding inflexible motion of the crank-shaft, but by the free action of the power stored up in the valve-gear; lastly, the inlet-ports remain equally and fully open, for all conceivable cut-offs.

Fig. 1 (Plate XVI) gives us a plan of this admission valve, arranged at the side of the cylinder; fig. 2 is a section of the exhaust-valve under the cylinder. The exhaust-valves are worked from cams yy_1, the shaft *z* of which is driven by spur-wheels I and II at equal speed with the crank-shaft.

We reproduce the gearing mechanism of the inlet-valve on an enlarged scale in fig. 4 and 6; the rocking circular-faced valve is denoted by *g*, *e* is the valve-seating, both of which are furnished with seven steam-ways. The valve-spindle carries a combination-wheel, consisting of three wheels cast in one piece, and composed of the escapement wheel *c*, the worm-wheel *d*, and the ratchet-wheel *h*. A worm *kk* gears into the worm-wheel *d*, and this worm has an axial slide on the shaft *w*, which is made to revolve at four times the speed of the crank-shaft; the tendency of this worm is to turn the worm-wheel *d* in the direction of the inscribed arrow, but if the latter is prevented from turning, then the worm *kk* is pushed back by the teeth of this wheel, and in so doing, the spring *s* fitted in the dash-pot *ii* become compressed.

The escapement-wheel is furnished with seven teeth, into which the pallets *p* and *n* attached to the gear-shaft *l*, are alternately pushed. As these pallets are always at a smaller distance from each other, than the external diameter of the ratchet-wheel, it follows, that the teeth of the latter will always be caught, by the one or the other pallet, provided the alternate lateral slide of the gear-rod *l* be sufficiently large. We obtain through the spring-power of the escapement-wheel *c* and this gearing of the pallets, an intermittent rotary motion of this wheel *c*, so that we may conceive, the stoppage due to the interference of the pallet *n*, to represent the period of expansion, whilst the engagement of the pallet *p* shall correspond to the admission-period, because in the first instance all the seven steam-ways would be closed, but opened in the second case. With each revolution of the crank and engagement of the pallet, the circular-valve makes twice $^1/_{14}$ revolution.

Fig. 1 and 3 show, that the lateral slide of the gear-shaft *l*, is effected by a rocking-lever from the cross-head; this might also be done by an eccentric. By paying due regard, to the engagement, between the escapement-teeth and the pallets *np*, a variable steam-admission or cut-off may be evidently obtained.

The mechanism on the right hand of the cylinder is drawn in fig. 4, under an assumed cut-off at $^1/_{10}$ stroke, and the pallet *n* has just relieved the wheel *c*, so opening the ports. The distance *x* denotes half the travel of the gear-shaft, consequently the extremities of *n* and *p* now at 1 and 2, will be at 3 at 4 at the termination of the piston-stroke.

If it is desired, to vary the distribution of the steam to the cylinder, all that is necessary, is to remove the extremity of the pallet *n*, somewhat further from the valve-centre, which causes an earlier admission, whilst the extremity of *p* is also slightly approached towards the same centre, so resulting in a later cut-off. The first named adjustment, may be done by hand when the engine is stopped, through the thumb-screw and ring *o*, whereas the cut-off is retarded by the automatic action of the governor. For this last named purpose, the hind portion of the pallet *p*, is furnished with a screw-thread and nut *r*. This nut is made to rotate in two adjusting-collars *aa* of the gear-shaft *l* as it is furnished with long teeth into which the toothed-segment *q* gears. It will be seen on referring to fig. 2, that the axle *v* is moved direct from the governor-collar; the nut *r* has a right and left hand thread upon it, which enables the symmetrical adjustment of the pallets *p*, on both sides of the cylinder.

Each valve is provided with a dash-pot *o*, for taking up any sudden shocks; but as the latter may occur with each $^1/_{14}$ revolution of the ratchet-wheel, the ratchet-wheel *h* is fitted with 14 catches, which work on to a steeled buffer-piston *Q*. These catches are so adjusted, as to leave the buffer at their proper time.

The governor, making four revolutions for every revolution of the crank-shaft, and driven by the bevel wheels V and VI from the shaft *w*, is not in the least affected, by the reaction of these shocks, and has only to overcome the resistance of the screw.

F. W. Turner, St. Albans Iron-works, St. Albans (Hert.).

The double-action reversing steam-engine of Mr. F. W. Turner, though merely depending on a trunk-piston arrangement for its continuous motion, has a circular-valve attached to it, for reversing purposes, and on this account it may here receive a passing notice. In our fig. 135 and 136 we give different adaptations of this engine for yacht and stationary purposes. The engine is controlled by a high speed governor, and the link motion, with eccentrics, weigh-shaft, levers, and numerous joints and pins are entirely dispensed with, the reversing apparatus being of the simplest description, consisting of a circular valve placed in the piston, which is actuated by means of a steel spindle sliding in a socket placed in the cylinder-cover. This is not subject to the slightest wear from the motion of the engine, which socket being provided with a handle, can be operated much quicker and with less labour to the attendant than many other reversing gears; it answers also the purpose of a stop and regulating valve. It is only necessary to use two cylinders, when an engine is required without fly-wheel and without a dead-point, in which case they are thoroughly under control, by means of the reversing lever, by which they can be stopped and started in either direction and at any position of the stroke; the crank-shaft, pins, keys, etc., are made of steel, the bearings (which are all adjustable) are made of phosphor bronze or best gun metal; the ordinary slide valves are used with improved action, which prevents them canting or wearing unequally, and admits of any desired lap, lead, or cut-off. The whole of the working parts are enclosed, and therefore cannot be injured by dust and dirt getting into the bearings. When necessary they can be examined and disconnected by opening the door at the side, and by removing the cylinder-cover, the valves, piston, and rods can be taken out and replaced in

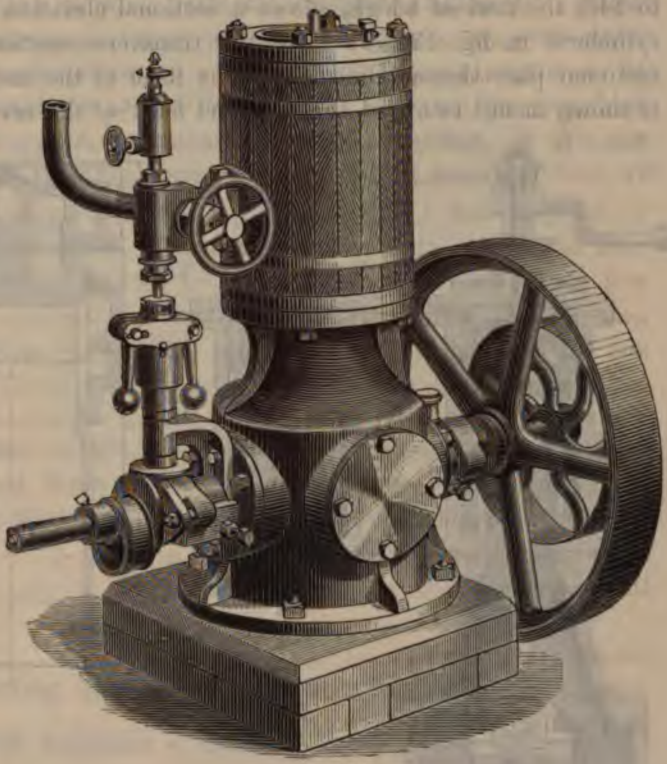

Fig. 136.

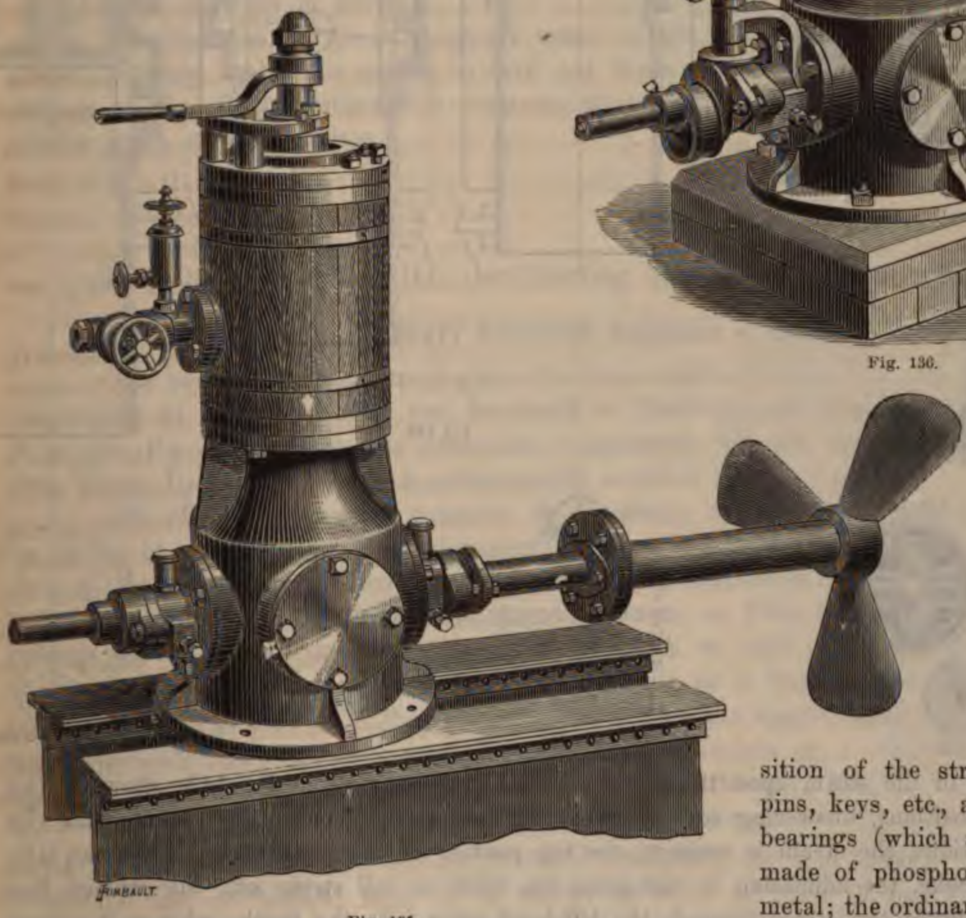

Fig. 135.

a very short time. They can be run at a high velocity, without danger or injury. By a simple arrangement, the whole of the bearings can be thoroughly lubricated; but should this be neglected, they will run for many hours without injury.

The internal working of these engines will be understood from our sectional views, figs. 137 to 143, the first of which, shows a sectional elevation of one of these reversing engines with double cylinders; in fig. 138 we have the transverse section of the cylinder, whilst fig. 139 represents sectional plan through line *AB*. The form of the end of the cylinder piston with the cover removed is shown in fig. 140, and the face and back of the reversing valve are drawn respectively in figs. 141

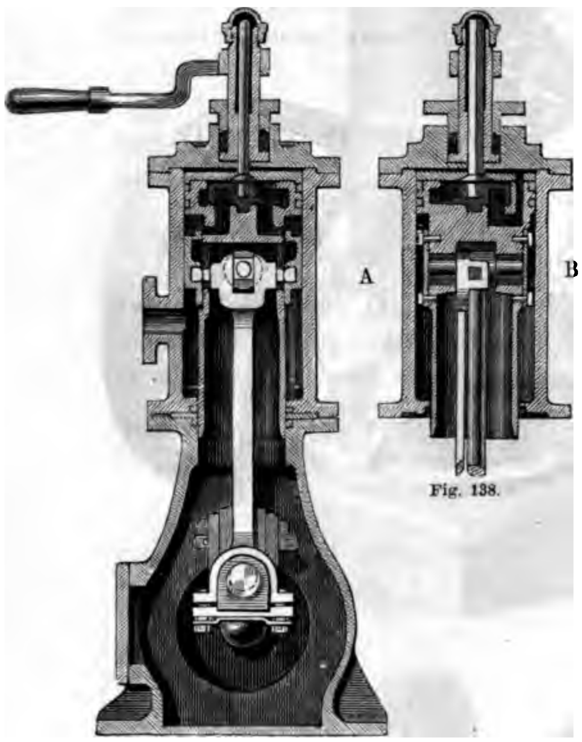

Fig. 138.

Fig. 137.

Fig. 140. Fig. 139.

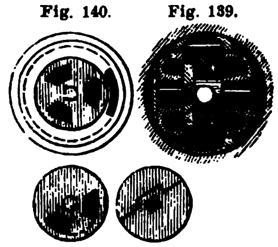

Fig. 141 and 142.

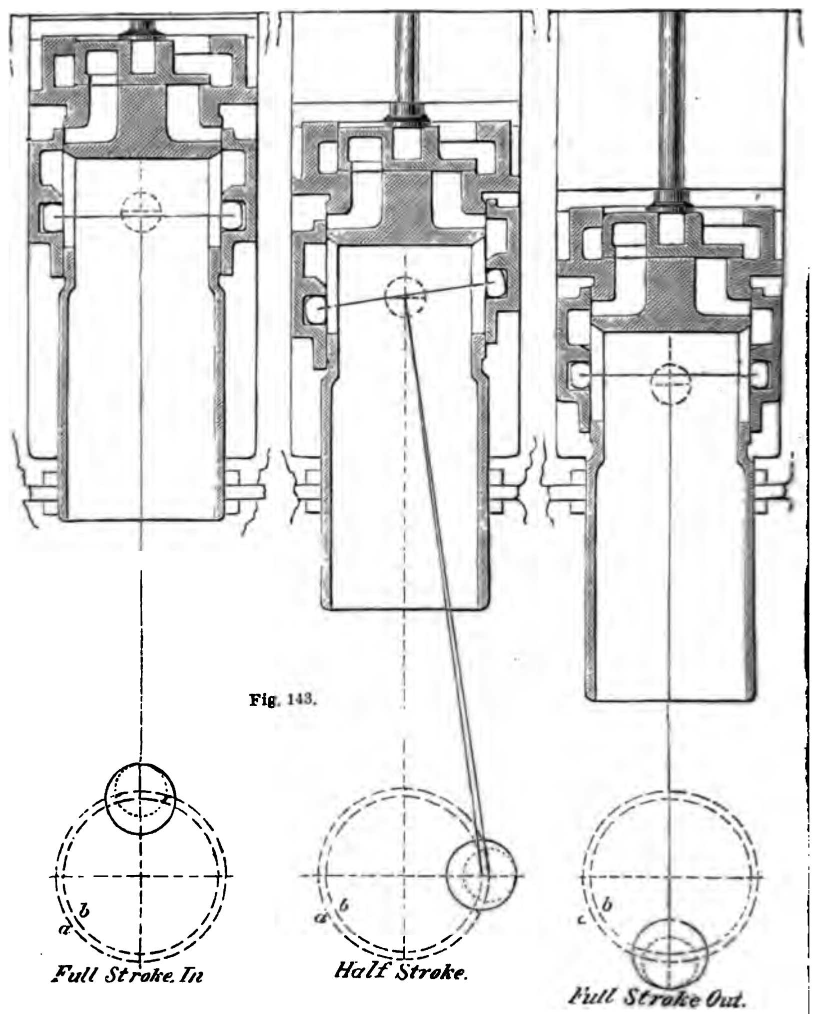

Fig. 143.

and 142. The action of the steam upon the piston will be understood from fig. 143, showing the piston in the three positions, answering to full stroke in, half-stroke, and to full stroke out. In the first of these positions, the steam is entering the top portion of the steam cylinder by the left-hand valve; at half-stroke, the admission is still going on, while at full stroke out, the exhaust has commenced, which relieves the steam through the left-hand valve into the trunk, whence it passes into a feed-water heater under the cylinder. The reversing action, actuated by turning the handle, shown at the top of cylinder in fig. 137, places the passage of the right-hand valves in communication with the cylinder top, and so reverses the piston motion; the direction of motion of the engine is thus determined by the slide-valve used.

There is little doubt that the engines we have just described, have many points of superior merit over the ordinary engine class. Thus, the accumulation of dust, more or less common in all industrial undertakings, is a source of constant annoyance to the engine user, on account of its propensity to wear out the bearings, but in the engine before us, neither dust nor dirt, can enter the bearings of the engine, as the whole of the working parts are enclosed. Again, our modern engines are all subject to concussion, and subsequent injury or breakage, due to the accumulation of water in the steam-cylinder either from condensation or priming, but Turner's engine is free from this serious defect, as the slide-valves drain the top of the cylinder, while as they are driven from their underside no stuffing-boxes, are required. Another important advantage, is the compactness of these engines, so necessitating little standing room, as the following tabulated sizes will amply prove:

Approximate actual horse-power when running at following speeds, with 45 lbs. pressure of steam	3 HP.	6 HP.	8 HP.	10 HP.	12 HP.
Ditto at 60 lbs. pressure	4	8	11	13	16
Revolutions per minute	350	320	300	250	220
Diameter of cylinder in inches	6	9	11	13	14½
Length of stroke in inches	4½	6	7½	9	10

The fact that a five horse-power motor of the design just described, only weighs 5 cwts. should certainly enable the maker to turn out these engines at a cost much below the ordinary average, so that these double-action reversing steam-engines may become a formidable rival to the smaller types of steam-motors.

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3. Valve-gears, with oscillating Circular-valves and Trip-gear.

Henry Berchtold, Engineer of Zürich.

The peculiar disengagement-gear of a steam-engine, exhibited at the Vienna Exhibition and constructed by Messrs. Scheller and Berchtold of Thalweil, near Zürich, attracted much attention. It is true, the arrangement was somewhat complicated, but the present head of this engineering firm, Henry Berchthold of Zürich, subsequently modified the valve-gear.

We shall here content ourselves in describing the latest improved arrangement illustrated by fig. 8—11 on Plate 29. This valve-gear, has been constructed in four different ways. The principle of the second arrangement — using oscillating circular-valves — may be gathered by our annexed figs. 144—146, whilst the third arrangement is shewn on Plate 29, fig. 8 to 11; the fourth type belongs to the class of ordinary slide-valves, to which we shall eventually refer in their order.

In the second arrangement (fig. 144 and 146), as in the first, the two circular inlet-valves GG_1 are placed on the top of the cylinder, exactly over the engine centre-line. They are made with eight equal grid-openings, and move forwards and backwards on a similarly formed valve-seating or port. Each spindle is connected by set-screw with a lever L, the eye of which is attached by a small rod e to the dash-pot piston-rod Q. The spiral-spring S has the constant tendency of forcing the piston Q out of the dash-pot O toward the cylinder, which corresponds to a shutting of the cylinder-ports. The other end of the hollow piston Q carries a steel catch-plate K kept from unintentional movement by a flat-spring i. The two catch-plates KK_1 of the two valves GG_1 are placed opposite to each other, so that the triggers nn_1 of the bolt N common to both, may alternately gear between them. This bolt N is made to slide in the support P, which is arranged to swivel freely round a centre pin z, bolted fast on the bracket T supporting the governor-spindle.

The opposite extremity of the support P, is furnished with an anti-friction roller, running in a groove of the cam-disc A keyed fast on the governor-spindle. The form of this groove, was so chosen, that for every revolution of the governor-spindle B or cam-disc A, the triggers nn_1 consecutively force the catch-plates kk against the action of the springs ss_1, so eventually opening the inlet-valves, on both sides of the cylinder, during each full stroke of the piston.

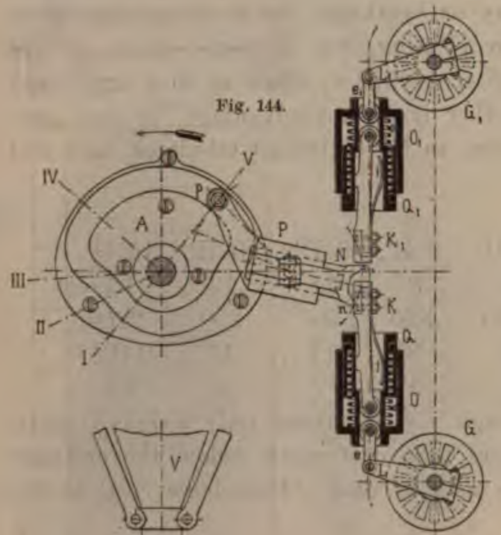


Fig. 144.

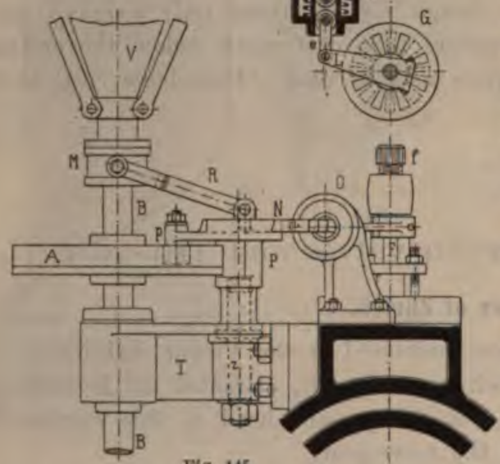


Fig. 145.

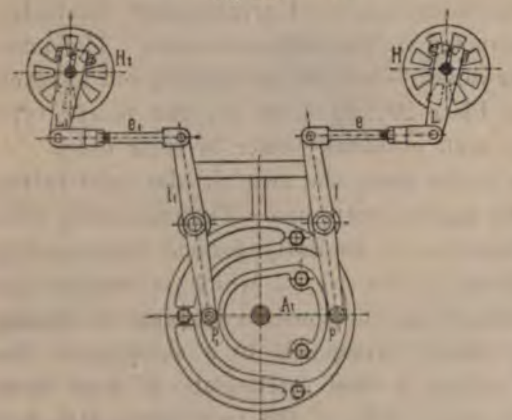


Fig. 146.

As the trigger-ends nn_1 are able to describe circles of different radii, contact with the catch-plates kk_1 may be thereby hastened or retarded, or in other words, this mechanism may be made to serve for obtaining 'variable' cut-offs. With this object in view, the bolt N is connected direct, by the forked rod R with the sliding-collar of the governor, and as our wood-cuts show, according to the rising of the governor-balls, the radii of the circles described by the extremities of the triggers nn_1 will become smaller, so effecting an earlier disengagement, whereas with a falling of the governor-balls, these radii become greater, and later cut-offs will ensue.

In the annexed wood-cut fig. 144 the extreme inward position of the bolt is denoted by the roman number I; in position II the catch-plate is in gear, and at III the travel of the lap has been run, the ports begin to open, and are fully open at IV. V represents the extreme outward position of the same bolt, or the limit of automatic disengagement.

The exhaust-valves HH_1 are also furnished with eight grid-openings, and are driven direct from a second cam-disc A also keyed fast on the governor spindle B, as may be seen on referring to fig. 146.

This constructive arrangement is however no longer adopted, and though the principle of the mechanism has been retained, the dash-pot has been altered.

Of this improved construction, our figs. 8—11 on Plate 29 give various sectional views: thus in fig. 8, we have an end-view of the working-mechanism of the oscillating circular-valve with the cylinder in cross-section, plan and elevation are shewn in figs. 9 and 10, and our fig. 11 represents transverse-section through the valve-chest. These drawings show, that the vertical gear-shaft with its cam-disc, as well as the direct connection of the governor-collar with the disengagement-bolt, have all been reintroduced in the new construction. On the other hand, we perceive (fig. 10) that the steel valve-spindle carries a peculiarly formed crank-lever, fastened by a wedge and two screws. The smaller arm ($2^1/_2'' = 60$ mm. long) of this lever is furnished with a small fork fitted with a small anti-friction roller r, which works against a steel screw, let in on the top of the dash-pot piston. The other arm ($4^1/_2'' = 90$ mm. long) of this lever carries the catch K. A flat spring is constantly pressing this arm into the groove of the cast-iron roller u, so that the catch K may come into gear with trigger

N at the proper time. The dash-pot has a bracket cast on, for supporting the valve-spindle which is kept down by a thumb-screw shewn in fig. 11.

Our fig. 147 sketches the successive disengagement periods, brought about, by altering the rocking radius of the catch N and corresponding with certain positions of the piston.

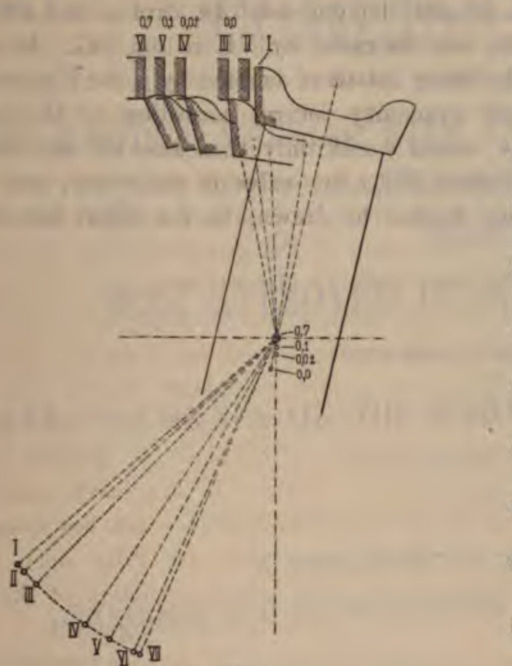


Fig. 147.

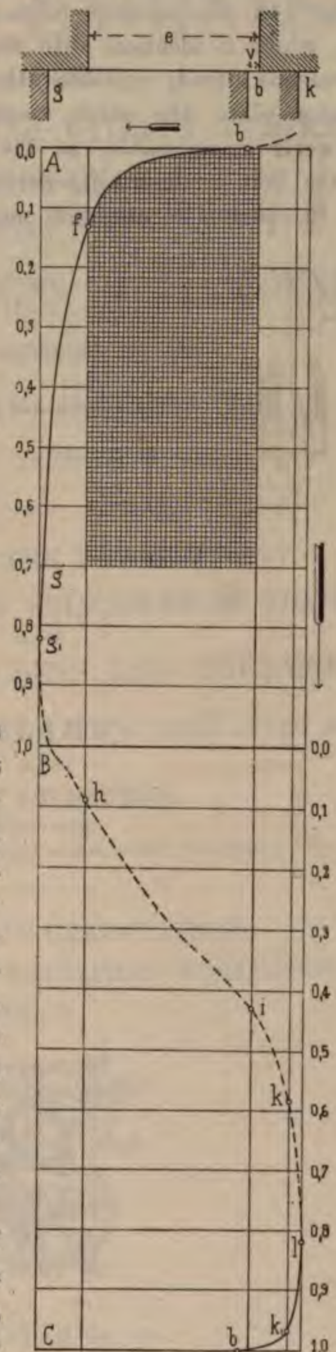


Fig. 148.

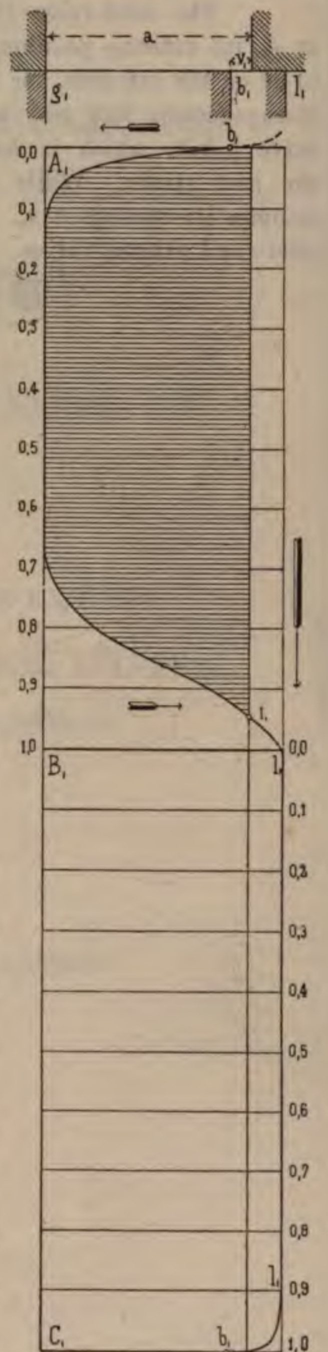


Fig. 149.

In accordance with our fig. 144, I denotes the extreme position of the disengaging-bolt during the forward travel; II shows the beginning of engagement between trigger and bolt. The additional positions, marked with III—VI, may be inferred from the inscribed piston-positions at the time of disengagement. In position VII the bolt has attained its other extreme range shewn in fig. 144 by V. To ensure a never failing automatic disengagement during the piston-stroke, the latest admissable cut-off, must not correspond with the extreme position of the bolt; for safety's sake, disengagement should ensue somewhat sooner, as shewn in fig. 147 at VI ($^7/_{10}$ stroke).

On account of the swinging motion of the bolt, opening both circular valves, automatic cut-offs might be obtained up to full stroke, but as a slow and easy gearing of the trigger-gear is preferable and the valve, owing to its overlapping, is obliged to travel further than its grid-openings would independently demand, a portion of the semi-revolution of the cam-disc has to be utilised for this purpose, so that in reality automatic cut-off may only take place, between the still relatively high range of 0.0 and 0.7 stroke.

The exhaust-valves do not differ, from the description afforded by fig. 144. The travels of the working-edge of the inlet- and exhaust-valves in relation to the piston-stroke are graphically shewn in figs. 148 and 149, and the excellent distribution of the steam due to the proper fixing of the cam-disc form, is at once apparent from these outlines.

The inlet-valve (fig. 148) has already fully cleared the port at 0.14 stroke, and attained at g_1 its extreme position, which is identical with the one indicated by VII in fig. 147. In order to be on the safe-side, for reasons already explained, the latest cut-off is denoted by g, for if automatic disengagement had not taken place, the valve would gradually return, according to the dotted curve g_1hik, which is however inadmissable, as the steam would only then shut-off at i during the next stroke. While the bolt is describing the curve klk_1, the valve is stationary, and only resumes its motion at k_1. In conclusion, attention may further be drawn, to the slight lap of the inlet- and exhaust-valves.

CORLISS-ENGINES

AND ALLIED

STEAM-MOTORS WORKING WITH AND WITHOUT AUTOMATIC VARIABLE EXPANSION-GEAR

INCLUDING THE

MOST APPROVED DESIGNS OF ALL COUNTRIES

WITH SPECIAL REFERENCE TO THE

STEAM-ENGINES OF THE PARIS INTERNATIONAL EXHIBITION OF 1878.

A TREATISE ON THE DEVELOPMENT,
PROGRESS AND CONSTRUCTIVE PRINCIPLES OF THESE ENGINES
FOR
ENGINEERS, MACHINISTS, STEAM-USERS AND ENGINEERING COLLEGES.

A TRANSLATION OF **W. H. UHLAND**'S WORK WITH ADDITIONS
BY
ANATOLE TOLHAUSEN,
CIVIL ENGINEER,
FOUNDER OF THE SCIENTIFIC AND MECHANICAL SOCIETY, MANCHESTER ETC.

WITH NUMEROUS ILLUSTRATIONS,
AND AN ATLAS OF PHOTO-LITHOGRAPHED WORKING-DRAWINGS.

VOL. II.

LONDON
E. & F. N. SPON, 46 CHARING CROSS.
NEW-YORK: 446 BROOME STREET.
1880.

Index to Vol. 2.*)

*) An alphabetical Index of the Engineers mentioned in this Work, will be found appended to the Supplementary Volume.

Supplement

VOL. II.

B. Engines working with Slide-valves, with and without Trip-gears.

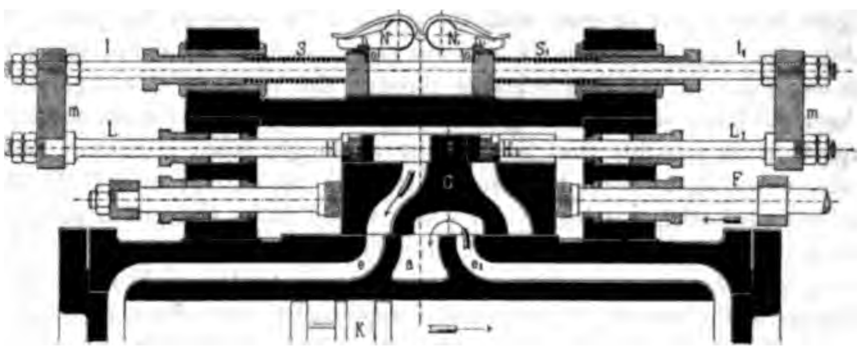
I. Engines fitted with Double Slide-valves.

1. Valve-gears arranged with short Valve-boxes and long Steam-passages.

a. H. Ochwadt, Engineer of Louisenthal.

Considering the predominating application of the ordinary flat slide-valve, it is a matter of little surprise, that practical men have shewn a decided preference to this well known type. Hence numerous attempts have been made to modify it, so that it might embody all the working conditions of Automatic Variable Expansion-gears. This practical activity has brought to light, a variety of constructions, in which we sometimes meet with the re-introduction of the ordinary double slide-valve (Meyer, Farcot and Breval amongst others), fitted with trip-gears, whilst at other times, we come across new and exceedingly ingenious combinations, which may be pronounced in no way inferior to the original Corliss valve-gears, but, as in fact presenting, many advantages over them.

Fig. 150.



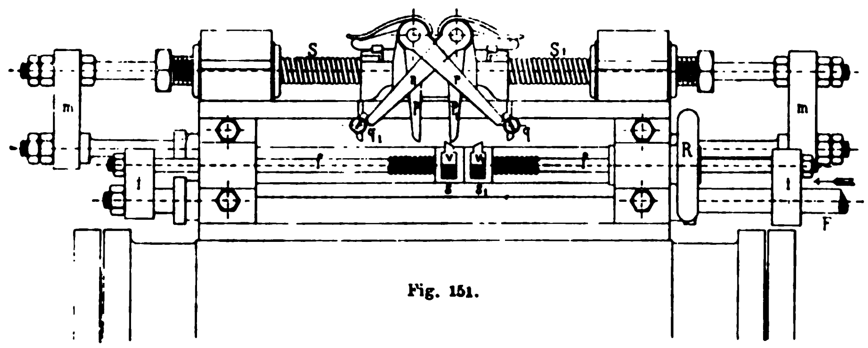


Fig. 151.

The ordinary double slide-valve gears, certainly share the defect of having long steam-ports when no lengthening out of the valve is adopted, as in the valve-gears of Allcock, Galloway & Ransome, etc. This valve-gear, naturally is still more perfect, where separate slides are used, that is to say, where the inlet and exhaust valves are separated from each other, and arranged on the top and bottom of the steam-cylinder, somewhat similar to the Corliss valve-gears. We then obtain four separate valves. We shall have occasion, to revert to the latter type later on, allowing the double slide-valve gears to receive attention first.

The annexed woodcuts Fig. 150 and Fig. 151, represent a double slide-valve designed by H. Ochwadt of Louisenthal, near Saarbrücken. It is specially adapted to High-speed Engines such as Marine or Locomotive-engines, and its chief characteristic consists in its working up to any degree of expansion or cut-off, without requiring any expansion-eccentric.

With Engines fitted with reversing gear, the main slide G is moved by the valve spindle F either by the use of a loose or of two fixed eccentrics. Our illustrations presume, that the valve, has assumed its extreme right-hand position, and that it is on the point of moving back in the direction of the arrow; the steam-piston K is supposed to be continuing its motion, as indicated by the inscribed arrow. On the top side of the main-valve, two expansion-valves slide independently of each other; they are connected, through the rods LL_1, ll_1 and cross-pieces mm_1, with the steel catch-plates oo_1. When the nibs nn_1 of the levers NN_1, are in gear with the catch-plates oo_1, the springs SS_1 are in compression, as shewn in our woodcut. For disengagement purposes, the valve-spindle F is rigidly connected with a rod ff through the cross-pieces ii. This rod ff has a right and left screw-thread cut about its middle, on which two nuts move horizontally, according as the rod ff is turned by the hand-wheel R. These nuts are furnished with steel-nibs vv_1, which catch against the levers pp_1, in such a manner, that the nib v catches against the lever p when moving to the left, and so that the nib v_1, carries the lever p_1, to the right; the inclined contact surfaces of nibs and lever, slide over each other when returning, and the nibs by overcoming the tension of the springs SS_1 fall back without moving the levers.

The position of the nibs vv_1 shewn in our figures, would correspond to a steam-supply up to nearly full stroke, because (taking only one side into consideration) the tripping of v against the arm p attached to the lever N, effects the disengagement of n and o so late, that when this occurs, the cylinder piston K has almost completed its stroke.

With the continued movement of the main-slide G in the same direction, its projecting piece g, again carries the slide H with it, and compresses the spring S till the catch-plate n is again behind and in gear with the catch o. As soon as the port e, has been opened by the main-slide, the expansion-slide H, remains (on account of n_1 and o_1 being in gear) in the position shewn in our Fig. 150, till it is released through the tripping of v_1 against p_1 and steam is cut off from the right-hand side of the cylinder. If to ensure early cut-off, the nibs v and v_1, were so far moved apart, it is possible that they might no longer come in contact with the arms p and p_1; in this case, however, to effect the shut-off through the expansion-slide H, the nib v_1 would trip against a second projecting catch-swivel q which would in its turn press against a second lever-arm r rigidly connected with N, and so effect disengagement between n and o. These remarks similarly apply to v_1 q_1 and r_1 in respect to the steam-supply to the right-hand side of the cylinder. The variableness of the cut-off, is consequently supposed to take place by hand; it could however be rendered automatic under the direct control of the governor, by the introduction of a suitable mechanism, though the whole arrangement would be then somewhat more complicated.

b. F. Aug. Schulz, C. E. of Zeitz.

F. Aug. Schulz, Civil-Engineer of Zeitz, patented in Germany a variable Expansion-gear in 1877, which we illustrate on Plate XVIII. (figs. 1—9). As its chief point of novelty, Mr. Schulz claims, that only one eccentric is needed for the expansion-valve — *i. e.* two in all — whence we may conclude that the Patentee was not aware of any variable expansion-gears working with only one eccentric; for his Patent Specification states: A Variable Expansion-gear, arranged with flat slide-valves, which though only fitted with one expansion-slide worked from one eccentric, allows a range of expansion from 0 to $^3/_4$ stroke.

Between the main and expansion-slides, a plate h is inserted, which separates steam-tight the two valves; the form of this plate h is shewn in fig. 7, and it is made not to move with either of the valves. The main-slide G (fig. 6) worked from the eccentric rod B and valve-spindle F from a separate eccentric, is so formed, that when in its extreme positions, steam can freely pass through the openings of the plate h. Fig. 8, shows the expansion-slide H which is always moved in the one direction, indicated by the inscribed arrow, (fig. 2) by its own eccentric, whilst the steam-pressure on the swelled valve-spindle F, brings it back again, and so closes the steam-port. By means of the short spindle z, the eccentric-rod B_1 moved by the expansion-eccentric, communicates an oscillating motion to a lever bb_1, (fig. 3) the eyes of which form the swing-centres of two triggers NN_1, each furnished with ordinary steel nibs nn_1. The top trigger N falls of its own weight, whereas the bottom trigger N_1, is lifted by a counter-weight, against vertical catch-plates o and o_1, respectively; the latter are each fastened to one of the two half-cylindrical sleeves m and m_1, (vide Fig. 9). With the motion of the triggers NN_1, the sleeves mm_1, are alternately pushed in the direction of the inscribed arrow, thus opening the steam-ways; this action is transferred through the steel semi-rings q rigidly attached to mm_1, on to the valve-spindle $f\,F_1$. To prevent the sleeve m from turning, the bottom sleeve m_1, has a groove into which a rigid key or bolt i fits. It will be easily understood, that the prolongation of the valve spindle F, runs loose between the sleeves mm_1, and that it merely requires the disengagement of the triggers NN_1, in order to allow the valve-spindle to fly back, which corresponds to the shutting-off of the steam. The disengagement of the triggers NN_1, is under the direct control of the governor, which by the intervention of the lever-mechanism shewn, works the tappets rr_1, which in their turn play on the trigger-ends. Inside the guide-box d is a weak spring, which brings the sleeves mm_1, in their initial position, through the piston p pressing against them. The travel of all these moving parts is regulated by the air-cushion formed behind the piston Q of the dash-pot O. To prevent jarring, the piston p and the guide g are fitted with leather-washers.

It will be conceded, that this somewhat complicated valve-gear arrangement, is of an original design and ingeniously devised in its details. With these advantages in its favor, it appears to the writer the more inexplicable, to place the valve-box so far away from the cylinder. As a consequence, comparatively long steam-ports are introduced, which it is perhaps needless to observe, are sought to be obviated in even the most common valve-gears.

c. E. Skoda of Pilsen.

Type: F. Wellner.

Steam-engines are being built at the works of E. Skoda of Pilsen, fitted with the well known Meyer's Variable Expansion-gear. The steam-distribution is however, very simply converted into an Automatic Variable Cut-off gear, from the designs of Mr. F. Wellner. This assertion was amply proved by the Engine exhibited at the late Paris International Exhibition.

The reader will find this original valve-gear shewn in side elevation in Fig. 10 and in plan section in Fig. 11 of Plate XVIII, whilst Fig. 12 of the same Plate, gives the disengagement mechanism drawn to a larger scale. The corresponding Engine was of 2 ft. 1 in (630 mm.) stroke and had a cylinder diameter of $12^3/_8$ in (316 mm). The main-slide G is exactly a repetition of the well-known Meyer slide, whilst the other two expansion plates hh_1 rigidly connected together, receive their motions, from a separate eccentric and from the disengagement gear shewn in Fig. 11. The expansion rod F_1 has a steel catch-plate o let in, so as to fall alternately into gear with corresponding nibs nn_1, of two triggers NN_1, carried on a kind of sliding-piece T controlled by the governor*); it is thus similar to the Bede & Farcot Automatic Variable Expansion-gear, described on pg. 76. These triggers are made to strike against projections rr_1, vertically adjustable through the governor, and by these means disengagement is effected; in the position indicated by our drawing, disengagement would already have taken place at 0.0 stroke. The steam ports are not closed in this constructive example by a spring, but the in-coming cylinder-steam is utilised to effect instantaneous cut-off, and herein lies the principal novel feature of this Valve-gear. For this purpose, the expansion slide-rod is furnished with two additional small pistons ee_1, inside the valve-box, which work steam-tight in two cylinders qq_1. The hind portion of these cylinders is in direct communi-

*) This description stands corrected in the following particulars: The expansion-eccentric gives motion to the sliding piece T carrying a vertical frame, in which the governor-tappets rr_1, can slide. The stationary triggers hold the valve-spindle F in its end-positions, till disengagement has ensued, whereupon, on account of the steam-pressure on pistons e or e_1, giving the expansion-plates, the tendency of moving in the same direction as the main piston, the steam-port is closed by the expansion-plate. When the main-piston has attained its opposite stroke-end, as shewn in Fig. 11, the expansion-valve is still kept stationary by the trigger N_1, till disengagement etc. repeats itself.

cation (these steam ways are only shewn by dotted lines in our drawing) with the corresponding cylinder side. If we assume, that the expansion-plates hh_1, under the same piston travel (Fig. 10), are in their left position, and that disengagement had not taken place, then steam would still be rushing in, at the left cylinder side, and be simultaneously entering the behind piston e, thus counterbalancing the pressure on the latter. It would, however, be different with the piston e_1, for on account of its hind portion being in communication with the right hand side of the cylinder, the pressure exerted on this side would only be equal to the atmospheric pressure, or to the condenser vacuum; consequently, the moment disengagement ensues, the steam pressure will bring the pistons ee_1 in the positions shewn, simultaneously causing the plate h_1 to close the expansion-port. For the return stroke, the expansion plate h_1, must move to the right, so as to clear the right-hand steam-port; but as the expansion-plates together with their pistons are already in their extreme right position, it becomes necessary to shift them into their extreme left position shortly before the dead-centre is reached, so that their travel to the right may be taken up by the trigger N_1. Owing to the commencement of compression behind the right piston e_1, the pressure on the latter is almost annulled, and as the steam expands in the cylinder, the steam-pressure in the valve-box begins to exert itself on the left piston e. This causes the latter to slide over to its extreme left position, when the steel catch-plate o immediately comes into gear with the trigger N_1, whereupon the same action, is repeated on the right cylinder-side.

d. Th. Ehlers, Engineer of M. Gladbach.

As an example of a very simple, though of perhaps not quite rational Automatic Variable Expansion-gear working with slide-valves, we reproduce Mr. Th. Ehlers design in the annexed Figs. 152 and 153.

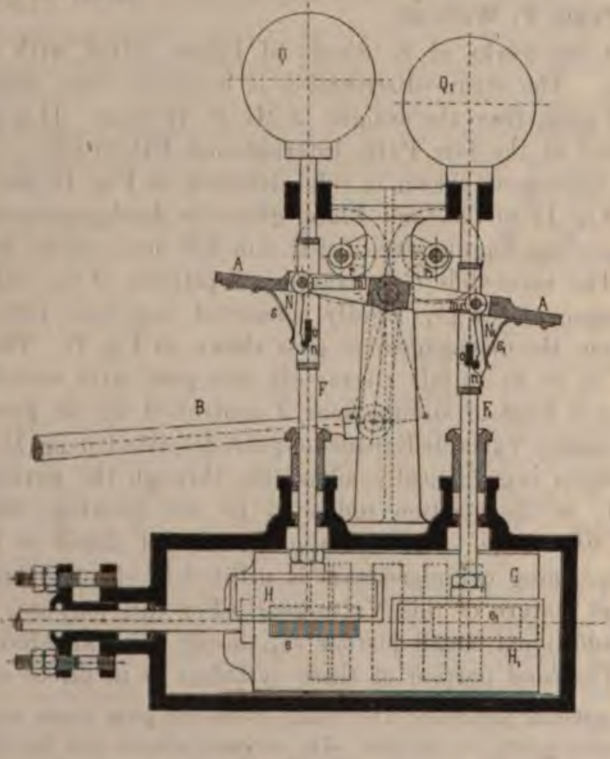


Fig. 152.

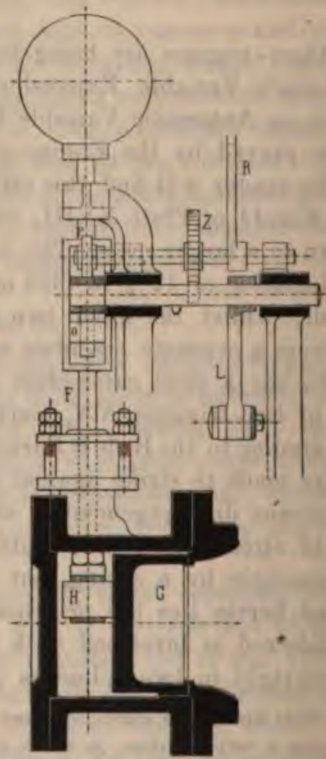


Fig. 153.

The main-slide G, made very large and after Meyer's principle, is worked as usual by an eccentric. The back of the slide is furnished with two steam-ways, arranged vertically to the cylinder steam-ports; these steam-ways are alternately opened and shut by vertical sliding expansion plates HH_1. The following mechanism is introduced for automatically closing these steam-ways: A steel wedge oo_1, is driven into each of the expansion valve rods FF_1, so as to fall respectively into gear with the steel nibs nn_1, of the triggers NN_1, which action is assisted by the spring ss_1, as shewn in our woodcuts. These triggers are hung on a wrought-iron beam A, the rocking motion of which is caused by its connection with the eccentric rod B, the lever L and the swing-axis w. Confining ourselves to the motion of the expansion-slide H, the horizontal arm of the trigger-lever N strikes during its ascending motion against a cam r, the position or excentricity of which, is controlled by the governor; we may here insert, that the angular motion of the one cam, is equally transferred to the other cam, by a pair of equal toothed wheels z. The knocking-out of gear of the nib n and catch-plate o is effected by the cam r rotating and pressing sufficiently against the arm m of the trigger N. As the expansion-valve spindle F is weighted by the spherical ball Q, it follows that when disengagement ensues, the expansion plate H will fall, and so close the steam-way e of the main-slide G. In order that the cross-areas of the steam-ways ee_1, may be sufficiently large, the main-slide G has to be made of a corresponding extra large size, but the resistance, resulting from the steam-pressure, may be diminished by making the sliding surface on the cylinder, no larger than with the Meyer slide, and cutting off the protruding sides, so that the pressure on these protruding parts of the slide G is annulled.

e. Wilson's Patent Automatic Variable Expansion-Gear.

On pg. 83 the intention was announced of reverting to the Wilson Patent Automatic Variable Expansion-Gear. In compliance herewith, the reader will find this cut-off illustrated, as attached to a Horizontal Engine on Plate XIX, though the writer of these lines, has since thought it advisable, to describe it, in connection with Slide-valve gears as Wilson's Circular-valve has already been discussed in these pages.

Fig. 1 Plate XIX is a side elevation, Fig. 2 is a plan of the same, partly in section, and Fig. 3 is a transverse section through the cylinder and valves. The letters of reference apply to the same parts in each of the three views.

The cylinder is provided with independent supply and exhaust valves, each in separate valve chests. The Supply valves A. are made with back plates A_1. to remove the pressure from the valves, in the manner patented by Mr. Wilson in the year 1856; by this arrangement the valves are perfectly balanced. The exhaust valves B. are made in the ordinary manner, and are kept against their faces, by steam pressure acting on the back of the valves; each valve chest has a communication with the steam-jacket of the cylinder. It will be seen by Fig. 3, that the exhaust passages are placed on a level with the lower sides of the cylinder, so that any water, which might collect in the cylinder from condensation of steam, will be drained off through them. The exhaust-valves are worked by an eccentric upon the crank shaft, acting on the valves by rods and levers, in the usual manner. Upon the crank shaft is also fixed the eccentric C. for working the slide-valves A., by means of the eccentric-rod C. 1. and the rod C. 2. which is jointed by a gab to the lever D. fixed to the shaft E.; motion is also transmitted to the lever D. 1. and shaft E. 1. by a connecting link E. 2. The lever D. is prolonged, and provided with a handle, for moving the valves by hand, when starting the Engine. The supply valves A are acted upon by the plungers F, which pass through stuffing-boxes in the valve-chests, and they are assisted by springs at their outer ends, by which the pull upon the valves can be regulated. The means of giving motion to the supply valves, so that the steam can be cut off at the required portions of the stroke, determined by the governor, are as follows: The spindle of each supply valve A. is connected by a link G., to one of the catch-plates H: these catch-plates are loose upon the shafts E and E. 1. which are supported by journals in the plate *I* and bracket *I.* 1. fixed to the cylinder casing. In each catch-plate *H*, is a notch *J.* into which the points of the catches *K* enter; these catches are carried by the double levers *L*, keyed on the shafts *E* and *E.* 1; the catches are free to move up and down in the said levers. The catches *K* are lifted out of the notches, by the inclines on the cut-off plates *M.* which are loose upon the shafts *E* and *E.* 1. As soon as the catches *K* are lifted out of the notches *J.* the catch-plates *H* being released, allow the valves *A* to be instantly closed by the combined action of the springs, and the steam-pressure on the plungers *F.*; the shock is absorbed, and the valves brought to rest, by the buffers or stops *N*, which are connected by the rods *N.* 1. to arms on the catch-plates *H.* The time for releasing the valves according to the amount of steam required by the Engine, is regulated by the governor, in conjunction with the differential hydraulic regulating apparatus, in the following manner:

The governor is driven by the shaft *O* to which motion is communicated from the crank shaft; the sleeve *P* of the governor acts on the vertical rack *Q* and at the same time upon the lever *R*, by which the supply of water-pressure to the cylinder *S*, is adjusted. The water cylinder *S* is provided with a piston, and water is admitted alternately above and below, the piston, by the action of the governor. The rack *Q* gears into one side of the pinion *T*, and the rack *Q* gears into the other side of the said pinion, which is mounted on a stud, fixed in the horizontal arm of the elbow lever *U*, the vertical arm of which is jointed to the rod *U.* 1. The other end of the rod *U.* 1. is jointed to the vertical arm of the elbow lever *V*, the horizontal arm of which is connected by the rods *W* the levers *W.* 1. and the rods *W.* 2. to the cut-off plates *M.* By these means, the position of the cut-off plates is varied, and the catches are thus thrown out, sooner or later, by the united action of the governor and of the regulator, and thus perfect uniformity of motion is secured, however variable the load or pressure of steam, so long as the steam is maintained at a pressure sufficient for the maximum load on the Engine.

f. Goldie & Mc. Culloch, of Galt, Ontario (Canada).

According to Prof. Radinger's report of the Centennial Exhibition, it would appear that the 40 *HP* Horizontal Engine exhibited there, by Messrs. Goldie & Mc. Culloch of Galt (Ontario), was the only Canadian Engine exhibit. We reproduce a sketch of this type on Plate *XX*, Figs. 3 and 4, whence it will be seen, that it is fitted with Automatic Variable Expansion-gear.

The main-slide *G* is worked as usual, from a separate eccentric. The steam-chest *A* surrounding it, is bolted to the cylinder, and made as small as possible, because the expansion slide *H* does not actually slide on the back of the main-slide, but on the contrary, works on an independent surface; consequently the steam is allowed to expand in the valve-chest with each piston-stroke. The two expansion-valve spindles FF_1 are carried beyond the valve-chest *B*, and fitted with steel catches oo_1. These catches are raised by working in gear with the spiral cam *n* of the gearing rod *w;* the latter revolves at equal speed with the crank-shaft, and by the forementioned rising action of the catches, steam is admitted into the valve-chest *A.* In order that the travel of the slide *H* be as small as possible, grid-iron valves are used. As soon as the cam *n*, becomes disengaged from the catch *o*, the steam-pressure playing on the end-area of the valve-spindle, closes the grid-iron valve *H*, the dash pot (air cushioned) *O* preventing any concussion.

It falls to the lot of the governor, to push the catches nn_1, and the rod *w* in a horizontal direction, so that owing to the peculiar form given to these, the raising of the valve-spindle FF_1, may ensue sooner or later. The connection between the governor-rod *R* and the spindle *w*, through the cranked lever *M*, may be inferred from Fig. 3, though we should observe, that the coupling *K* allows the rod *w* both to rotate and to slide horizontally.

This Engine with a cylinder-diameter of 15 in. (381 mm.) and a stroke of 22½ in (572 mm.), worked at 85 revs. per min. and developed a mean piston-speed, equal to 5 ft. 3 in (1.6 m.) per sec.

g. Thomas & T. Powell, Engineers of Rouen.
Type: Correy.

For many years, the Engineering Firm of Messrs. Thomas & T. Powell of Rouen, has constructed Compound Engines fitted with Correy's Expansion-gear. Although this firm has not omitted to avail itself of certain minor improvements, as revealed to them by continued practice, still on the whole, the latest Engines of Messrs. Thomas & T. Powell are similar to the first turned out by them, if we except certain constructive details. The Engine type represented on our Plate 30 may therefore be accepted as of long approved design.

A description of the Correy-gear will be found in "Engineering" Vol. XX pg. 354, and in Vol. XXV pg. 504; a copy of the paper read by Mr. Powell on the same subject, will be found published in Vol. XXVI pg. 36 of the same journal. A short illustrated description of the Engine represented on Plate 30, similarly appeared in Engineering issue of 17th Jan. 1879 pg. 51, which we here re-produce:

The engine exhibited at Paris was compounded, with cylinders placed side by side in the usual way. The valve of each, is at its upper end, (the lower ports being, therefore, very long), and their spindles are connected by a crosshead, and driven together by a triangular cam upon a weigh-shaft lying below the flooring. Cut-off valves are fitted to the small cylinder only, a pair of plain plates being used, worked by separate spindles and moving on the back of the main-slide, which is through ported. To the lower end of each cut-off valve-spindle is attached a bored socket, into which passes from below a round rod driven by a small eccentric on a second weigh-shaft, the connexion between the rod and the socket being made and unmade by a kind of trigger gear controlled by the governor. The expansion valves are thus always opened by the eccentrics, and when the trip-gear is disengaged (which may be from 0 to 0.8 of the stroke), they are at once closed by their own weight, and by the unbalanced steam-pressure above them, their too sudden fall being prevented by a dash-pot as usual. The mode in which the actual disengagement of the trip-gear takes place is very neat, and successfully gets rid of any of the tendency to side-way motion, which in some cases injures the accuracy of such arrangements. The governor weigh-shaft carries a cam having a serrated edge, and the trip occurs by the contact of a steel knife-edged pawl with this cam, the special point in the construction being that the line of pressure between cam and pawl always passes through the axis of the former, and there is thus no tendency to displace it. The work to be done by the governor is in this way almost nothing, being confined entirely to moving the cam and the light linkwork-gear which works it; the actual disengagement throws no work on the governor, but is done by entirely independent means, as pointed out above. Any too quick motion of the governor, consequent on its having such an exceedingly small resistance to overcome, is prevented by the use of the oil cataract, shown in the engraving, between the air pump and the centre column. The type is one greatly in favour with many French manufacturers, so much so, that it is asserted that Messrs. Powell have found it impossible to introduce direct-acting engines, and have therefore wisely contented themselves with perfecting the older form of machine. The trials described in Mr. Thomas Powell's paper, above referred to, certainly show most satisfactory progress in this direction. One engine, indicating 138 horse power, used 15.43 lb. of water per indicated horse power in the cylinder and 1.47 in the jacket and pipes, — a total of only 16.91 lb. Another pair indicating 355 horse power used only 14.43 lb. of water per indicated horse power in the cylinder, the jacket consumption not being measured. Exceptionally good results were also obtained from an old engine to which the Correy gear had been applied; its construction being one that allows of adaptation to existing Engines with very little trouble.

For those however, not conversant with the Correy-gear the following explanatory references to the drawings on Plate 30 will be found interesting: The distribution of steam to the high and low pressure cylinders is effected, by slide-valves receiving equal travels from a cam *A*. Two expansion plates $h\,h_1$ working independently of each other and each driven from an eccentric *B*, slide on the back of the main-slide *G*.

The cylindrical top part (*e*) of each of the expansion eccentric rods *E*, slides in a socket *f* (Fig. 8) of the valve-spindle *F*; this socket is fitted with a catch *n*, through the annular opening of which, the eccentric rod is able to slide freely. When this socket assumes its lowest position, a recess or step *o* of the eccentric rod comes opposite the bolt *n* into which it gears, owing to the action of the spring *s*. As a consequence, the socket *f* with the valve-spindle *F* follows the motion of the eccentric *e* with the up travel of the eccentric, and the expansion-plate *h* is moved, so opening the valve through-port, till the trigger *p* knocks against the contact-plate *r* which is under governor control. When this happens, the lever *k* is forced back, by which disengagement of the two rods *e* and *F* is effected. To explain this disengagement action more clearly, the valve-spindle *F* is made of a rather large cross-area, on which the full pressure of the steam acts, so that the moment the bolt *n* becomes liberated, the steam forces the expansion-plate down, thus closing the through port. All jarring is prevented by the use of the dash-pot *Q*. The eccentrics are set, so that they attain their highest position when the piston is at $^8/_{10}$ of its stroke, this being consequently the limit of the range, under which automatic expansion ensues.

In case the expansion-plates should remain, contrary to expectation, in their highest position, then the sockets are carried along by the rods *q* (fig. 8) fastened to the prongs of the eccentric rod.

Our Fig. 9 displays the position of the two expansion-plates which are independent of each other, and also the distributing valve rod *L* placed at the side of the valve-chest, as well as the contact plate *r* fitted to the governor rod *m*. The main-slide is represented in plan in Fig. 7.

The high-pressure cylinder has a stroke of 3′ 8$^1/_2$″ (1130 mm.) its diameter is 14 in (355 mm.). The low-pressure cylinder has a stroke of 5 ft. (1524 mm.); its diam. is 2′ 3″ (685 mm.). With a boiler-pressure of 4$^1/_2$ atm. the crank runs at 32 revs. per min.

Messrs. Thomas & T. Powell, construct these Beam-engines in three sizes viz: From 18—35 indicated horse-power with one centre-pillar, from 36—75 *HP* with two pillars, the side supports of which, rest in the walls of the engine-house, and in Engines of over 75 to 200 *HP* the same arrangement is retained, with the addition of staircasing for rendering the top parts of the Engine easily accessible.

h. Boudier Frères, Engineers of Rouen.

On Plate 31 will be found a Compound Beam-engine, constructed by Messrs. Boudier Frères of Rouen; Fig. 1 gives us a side-elevation, Fig. 2 represents the trip-gear as applied to the High pressure cylinder, and in Fig. 3 the cams are shewn on an enlarged scale.

As far as the general construction of this Beam-engine is concerned, it does not differ from the accepted type. The valves are placed at the top end of the cylinder, and worked by a suitable cam-arrangement.

Of special importance, is the expansion gear arrangement, with which the high-pressure cylinder is supplied. As shewn by Fig. 2, the expansion-slide is of the grid-iron type, and it is forced to open and shut twice during each revolution of the crank. The valve-gear is worked from a weigh-shaft, placed under the floor-line in a slanting direction to the engine centre-line. This weigh-shaft drives, in the first instance, the governor by bevel-gear, and then the distributing valves by the forementioned cam *A*, and lastly, the same weigh-shaft transmits motion to a second shaft fitted with two pairs of cams aa_1, and bb_1, by means of a pair of toothed-wheels. Each of these cam-pairs, comes in contact with an anti-friction roller carried in a bracket or frame *C* round the weigh-shaft *B*. One pair of these cams ($a\,a_1$), works the frame during the one piston-stroke gradually towards the valve-chest which motion corresponds with an opening of the expansion-slide. For this purpose, the rod of the last named frame, is furnished with a trigger *N* gearing on to the steel-nibbed end of the dash-pot spindle *F*, which is connected through cross-rods with the expansion-valve. In this manner, the dash-pot spindle is pushed upwards by the trigger *N*, but this motion is merely continued till the trigger *N* comes in contact with the nob *r*, which is under governor-control, when disengagement ensues. That is to say, the counter-pressure of the nob *r* against the trigger, releases the latter from the dash-pot spindle, which is tantamount to a shutting of the expansion slide.

The cam *a* continues to force the frame upwards, till the end of the stroke is almost reached, but as with the beginning of the return stroke, the trigger is again obliged to come into action, the frame must necessarily be brought into its opposite extreme position; this is accomplished by the second cam pair $b\,b_1$.

As shewn in Fig. 2, a throttle-valve under governor control, is inserted in the steam supply pipe. On account of the valve box being placed at the top end of the cylinder, the clearance space at the bottom side of the cylinder, becomes remarkably large, so that the final advantage of the Automatic variable Expansion gear, may well be drawn into question.

i. E. Windsor & Son, Engineers, of Rouen.

Amongst the Engines exhibited at the late Paris International Exhibition, the Compound Beam-engine of Messrs. E. Windsor & Son, of Rouen, attracted much attention. This type is constructed in various sizes, up to 300 indicated horse-power by the forementioned firm, though the engine exhibited, was announced as of 100 nominal horse-power. It is this machine, which we illustrate on Plate 30, in Figs. 1 to 3.

Following the description given in "The Engineer"*) the engine is surmounted by a platform and gallery in cast iron surrounding the beam, which are supported by ten cast iron columns, four of which in the centre carry the frame, to which the entablature is fixed, on which the plummer-blocks of the beam, are mounted. The beam, which is 24 ft. 7 in. long, weighs about 10 tons. The diameter of the fly-wheel is 23 ft., the form of the rim, rectanglular, and the weight about 15 tons. The shaft on which it is keyed, as well as the crank, which is nearly 3 ft. 7 in. in length, are made of wrought iron. The connecting rod, which is worthy of notice for its symmetry of form and the rigidity with which it works, is made of cast iron. The two cylinders, which work on the Woolf system, are steam jacketted, the height of the outside casing being about 8 ft. 6 in., and are lagged with oak and copper bands lined with cowhair felt, to prevent condensation. The governor is placed between the four columns which support the beam, and transmits its movement to the patent valve gear, acting directly on the slide or expansion valve of the small cylinder without the use of a throttle valve. The mechanism of the expansion gear is shown in the detail engraving, where *A*, is a cylinder in brass; *a*, an orifice between the cylinder and its jacket; *C*, pipe communicating between the jacket and condenser; *D*, pipe conducting to the hot-well; *E*, piston of the cylinder *A* without packing; *I*, rectangular orifices four in number, equal and symmetrically placed opposite the ports of a circular valve, carried by a rod passing through the piston rod; *H*, is a guide attached to the cross-bar *K*, allowing a vertical motion to the socket, *J*, which is pierced by two helical grooves, and fixed to the rod of the circular valve by a pin or cotter; *F*, is a rod which supports the socket, *J*, and is articulated with the lever of the coupling on the governor. A collar or ring of bronze is fixed to the tappet cam, *M*. *M* is a grooved cam actuating the expansion valve, cottered on the spindle, *N*; *O*, is a tappet pressing on the cam, and put in motion by the variable projection of the boss; *P*, is a lever carrying the stop or tappet *O*, and transmitting motion to the expansion valve through the rod, *Q*; *R* is the rod of

*) d. 7 Feb. 1879. pg. 99.

the counterweight, for the back motion of the valve. The pipe *C*, which leads to the condenser, is fitted with a cock. The steam is admitted through the jacketting into the valve chest by means of the starting valve. The expansion-valve, of a circular form, is kept in contact with the interior surface of the valve chest, by the pressure of the steam. The motion is governed by the rod attached to the lever *P*, which keeps the stop *O*, in contact with the embossed cam, which in moving causes the lever *P*, to describe the arc of a circle, varying in length, according to the development of the boss, in contact with the stop. The cam is driven by toothed gear on the spindle which governs the valves, and the rectilinear movement of the cam, ascending or descending, is determined by the movement of the piston *E*, which is connected with it by a ring and the vertical connecting rods, and the cross-bar *K*. The piston with its rod, cross-bar, connecting rods, ring, and embossed cam, represent a certain weight, which tends to lower it when the relative position between the embossed cam and the stop or tappet undergoes a change, but a certain amount of counter-pressure is met with, in the jacket of the cylinder on account of its being in communication with the condenser, or at least with the pipe leading to it. On the other hand, owing to the pressure established underneath the piston, or rather to the base of the cylinder, being in connection with the hot well of the condenser, we see that the head of the cylinder communicates with the counter-pressure in the jacket, by the constant opening *a*, while at the same time it is subjected to the influence of the pressure underneath the piston in proportion to the size of the openings *I*, which are variable. A certain counter-pressure is therefore established in the top of the cylinder, whose value is dependent on the relation between the pressure below the piston, and that in the jacket, and also, between the sections of the constant opening *a*, and these variable openings *I*.

To produce an equilibrium, it is necessary for the counter-pressure above the piston to be equal to the pressure below it, *plus* the weight of the moving parts, and this is obtained by suitably regulating the sectional area of the orifices *I*. When the speed of the engine varies, the form of the governor is altered, and the motion of its clutch is transmitted through the rod *F*, to the socket *J*, and the latter is raised or lowered according to the variation of speed. This vertical motion is transformed into a rotary movement of the circular valve of the piston, by the action of the helical grooves drilled in the socket *J*, on the cotter at the base of the rod, and instantly effects an alteration of the proportion between the areas of the variable openings *I*, and *a*, and disturbs the equilibrium, and produces a vertical motion of the whole of the movable parts. If the speed be accelerated, the governor clutch is raised, the grooved socket descends, and the play of the cotter slightly opens the orifices *I*. The result is that the counter-pressure above the piston is decreased, the whole movable parts descend by gravity, the embossed cam offers to the stop, a section whose projections are less pronounced, and the admission of the steam is reduced. Inversely, if the governor is required to accelerate the speed of the engine, *i. e.*, if it has sunk a little, the play of the socket *J*, on the cotter slightly closes the variable openings *I*, the counter-pressure becomes greater than the surrounding pressure, and the movable parts, acted on by a contrary influence, are raised. These different motions of the piston and embossed cam are very smooth, being the result of dispositions which allow the suppression of any intermediate parts. The resistance is reduced to the friction of the cotter, which governs the motion of the embossed cam and of the tappet, and the action is so sensitive that any alteration of speed, even if imperceptible, produces an immediate effect on the inlet of the steam.

The valve gear of this engine was without doubt, the widest departure from the numerous modifications of the Corliss valve in the Exhibition, and for the simplicity of action, was alone worth inspection; but, in addition to this, the engine reflects great credit on its constructors for symmetry of design, high-class workmanship, and excellent performance. The condenser and air pump are placed at the side of the steam cylinders below the bed plate, and are worked direct from the beam, as well as the feed-pump for the boilers.

According to the statements of the exhibitors, the performances of these engines are most satisfactory, and the result of numerous trials gives a consumption of 1 kilog. (2.2 lb.) of fuel per horse-power per hour in lifting water. Several engines delivered by them for private industries, consume on an average, only 0.812 kilog. (1.76 lb.) of coal per hour, and per indicated horse-power.

The Engine just described, developed an indicated power of 350 horses.

It will have been observed, that the Expansion-gear last described, can scarcely be strictly termed, a trip-gear arrangement, but as its effect is very similar, its discussion at the end of this chapter, appears permissable. The same remark applies to the fore-described valve-gear of Messrs. Goldie & Mc. Culloch, for in the sense of the preceding valve-motions, it is a distinct two valve-arrangement, rather than a double-valve gear. It is evident, however, that with the many modifications of the simple D slide, it would lead to too numerous sub-divisions were we to adopt a strict classification; therefore in the following examples, we have allowed a certain latitude in the classification, for sake of convenience*).

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k. Alex. Shanks & Son, Engineers of Arbroath. (N. B.)

The Automatic Variable Expansion-Gear, of Messrs. Alex. Shanks & Son, of Arbroath, belongs to a valve-arrangement displaying a short valve-chest and comparatively long steam-ways.

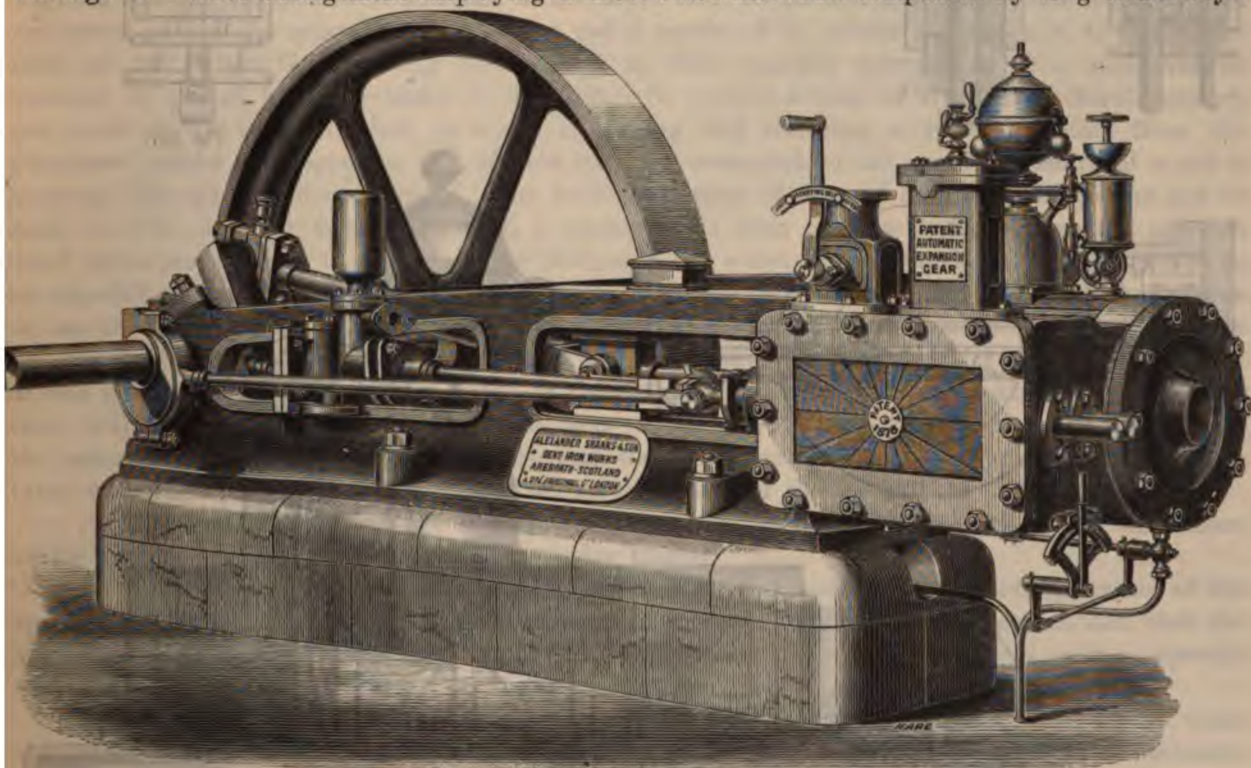


Fig. 154.

*) The heading of this Chapter in the original Edition, does not deal with Engines working with slide-valves *without* trip-gears; hence it appeared advisable to the writer of the present Edition to generalise this Chapter to wider limits. We however, soon found it impossible to deal even with the most important slide-valve gears, in the space here at our disposal; and we thus came to the conclusion, that the only way, in which we could satisfactorily deal with this matter, was to prepare a Supplementary Volume to this Corliss-engine Work, in which we propose to treat exclusively of Slide valve-geared Engines. Accordingly, a Supplementary Volume is in the Press, which will be obtainable through the same channel.

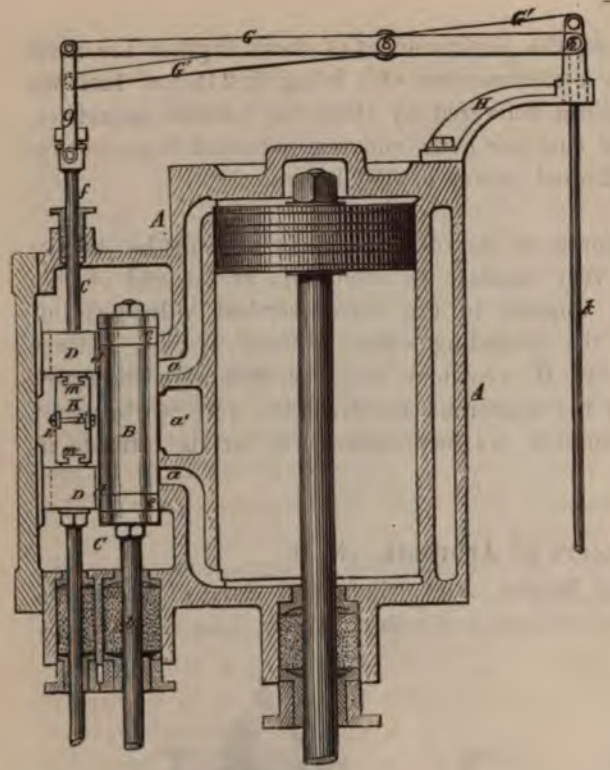
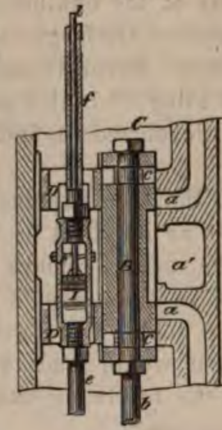


Fig. 155.

Fig. 158.



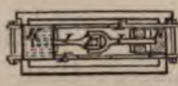


Fig. 159.

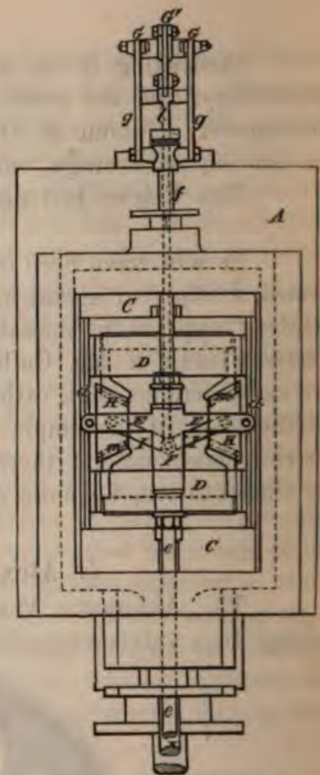


Fig. 157.

Fig. 156.

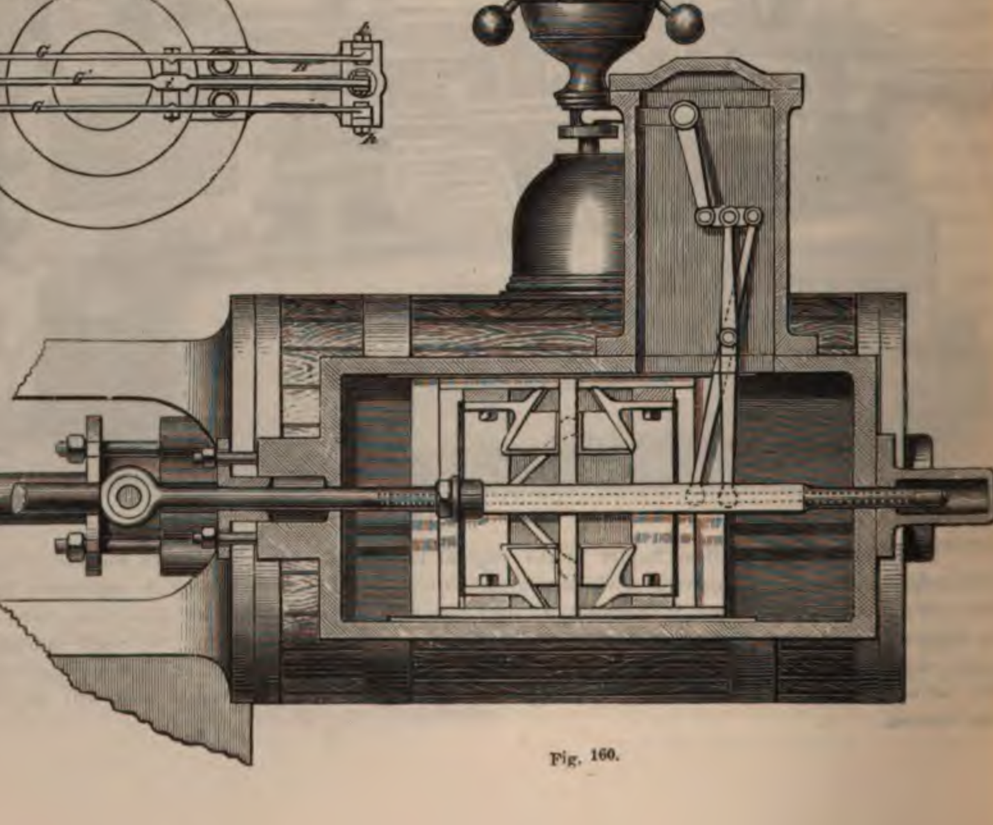


Fig. 160.

In Fig. 154, we give a perspective view of a 16 *HP.* Horizontal Engine, constructed by the forementioned firm, and fitted with this Automatic valve-gear. Confining our attention to the latter.

Fig. 155, represents a Sectional Elevation of a Cylinder with Slide-valve gear.
„ 156, represents a Cross Section of same.
„ 157, represents a Front Elevation of ditto.
„ 158, and 159, are Sectional Details, which will be referred to.
„ 160, represents an arrangement of this Gear suitable for Horizontal Engines.

A, is the cylinder of the engine with its steam ports *a*, *a*, and exhaust port a^1, over which works the main slide-valve *B*, which may be of any usual or suitable construction, and be driven by an eccentric, through the intervention of the rod *b*, or in any other convenient manner.

The valve *B*, is perforated or provided with ports at *c*, *c*, for the passage of the steam therethrough from the steam chest *C*, into the ports *a*, *a*, alternately, as is well understood; and on the back of the valve are fitted, (so as to be capable of sliding along suitable guides *d*, *d*,) the expansion valves *D*, *D*, by the motion of which, the said ports *c*, *c*, are each closed in turn, and the steam supply cut off at the required period or portion of the stroke of the piston, as regulated by the governor, according to the varying duty of the engine.

The expansion valves *D*, *D*, are connected with the governor and the expansion eccentric, in the following manner: — *E*, *E*, are cross arms formed in one, with a hollow slotted bar *F*, (see Figures 158 and 159) which is attached at its lower end, to the rod *e*, leading from the expansion eccentric, and at its upper end to a hollow rod *f* connected by means of links *g*, *g*, to one extremity of two levers *G*, *G*, having their fulcra at their opposite extremities, at *h*, in an arm or bracket *H*, carried by the cylinder *A*. The levers *G*, provide a fulcrum at *i*, for a central lever g^1, one end of which is attached to a rod *k*, leading and receiving a vertical motion from the governor, whilst the opposite end of this lever is connected to the upper extremity of a rod *l*, passing through the hollow rod *f*. The lower extremity of the rod *l*, is attached to one end of each of two links or knuckle joints *I*, *I*, connected at their opposite ends on the right and left hand sides respectively, to two blocks or wedges *K*, *K*, which are arranged between and so as to be capable of sliding along the cross arms *E*, *E*; they are provided with grooves fitting projections *m*, *m*, on the expansion valves *D*, *D*, in such a manner that as the blocks or wedges *K*, *K*, are by the inclining or straightening of the links or knuckle joints *I*, *I*, under the variable action of the governor, moved the one towards or from the other, the expansion valves *D*, *D*, in their turn will be caused to approach or recede from each other, thereby varying the lap and causing the steam to be cut off by the said valves as they are operated by the expansion eccentric at a later or earlier period, as the case may be, of the stroke of the piston.

The expansion valves are arranged, so as to be balanced, or in equilibrium, the steam being admitted to act equally on opposite sides thereof.

It will be seen, that by means of the arrangement herein-before described, the travel of the expansion slide-valves is derived from the expansion eccentric in the ordinary manner, and that the lap is increased or decreased automatically under the action of the governor, by a motion separate and distinct from that received from the expansion eccentric.

In this description, we have assumed, that an additional eccentric was necessary to work the expansion-valve. Though, this arrangement is recommended for new Engines of moderate power, this valve-gear allows itself to be applied to many kinds of existing engines where only one eccentric is used to work the ordinary slide-valves.

l. Thomas Robinson & Son, Engineers, of Rochdale.

Another constructive example of a Horizontal High-pressure Steam Engine belonging to the last named category, is the one illustrated in the annexed Fig. 161. It is one of a new series, designed by Messrs. Thomas Robinson & Son, of Rochdale, and constructed by them in various sizes, from 4 to 1000 indicated *HP*.

For the purpose of our present description, we select a 20 *HP* Engine. The bed, cast in one piece with the guide-bars, is bolted to its foundation by ten bolts, and has the cylinder bolted to it, by six bolts. The cylinder ports are 10″ × $1^1/_8$″, and the exhaust pipe is $5^1/_2$ in. diam. The cylinder, 16 ins. in diam. and of 30″, stroke is fitted with an improved metallic piston, turned truly to fit the cylinder, and bored to receive the piston-rod.

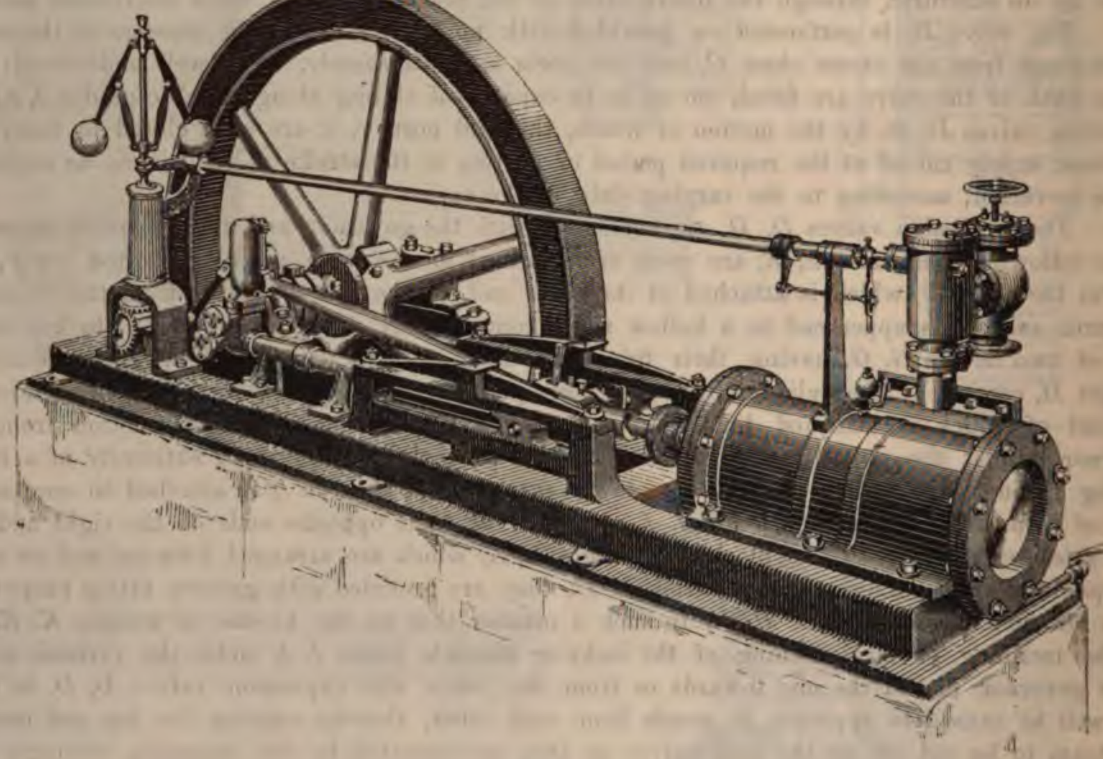


Fig. 161.

The main-slide is of cast iron, fitted with valve-spindle, turned to work through the stuffing box, and connected to and worked in the usual manner by separate eccentric off the crank-shaft. On the back of this main-valve, an expansion-valve is made to work, the main spindle of which is connected by a link to a variable expansion-lever, worked by an eccentric off the crankshaft, and so arranged as to easily alter the cut-off, whilst the engine is running, at points varying from $^1/_{10}$ to $^6/_{10}$ of the piston stroke. According to our engraving, this variable cut-off is not automatic, i. e. under the control of the governor, but the engine works under fixed expansion rates, which are rendered manually variable within the forementioned limits. The governor is however made to act on an equilibrium throttle-valve, in a manner sufficiently explained by Figs. 161 and 162 the latter of which shows the equilibrium valve in transverse section. A stop-valve is placed in front and in direct communication with the last mentioned valve. The piston-rod is of steel, $2^3/_4$ in. in diameter, truly turned, fitted to piston and cross-head and ground in and firmly cottered to the same. The joints of the valve-chest and cylinder are planed, and the cylinder in addition is fitted with 2 water discharge cocks, and lubricated by a brass lubricator placed on the top of the cylinder. The clearance space between the piston and cover at each end of the stroke amounts to $^1/_2$", and to lessen the loss resulting herefrom, the main-valve is set to cut off at $^2/_3$ stroke.

The cross-head is of wrought iron, and is polished all over, and bored to receive the piston-rod and cross-shaft, $2^3/_4$" diam. and 2 ft. $3^1/_2$ in. extreme length. The bottom slide-bars are cast, as already stated, with the engine bed, with the top slides bolted on. These slides are $4'' \times 9^1/_2''$, and are lubricated by a syphon pipe.

The connecting rod, is of wrought iron, 6 ft. 3 in. long between centres, and $3^7/_8$" diam. at its thickest portion; it is fitted at each end with gun-metal steps, wrought iron straps, gibs and cotters. The crank is of cast iron, and bored to receive the shaft and crank-pin, the radii of its two bosses being $2^1/_3$ times the diameters of crank-shaft and crank-pin respectively. The crank is set on its shaft in a hot state, and thus a very firm grip is secured.

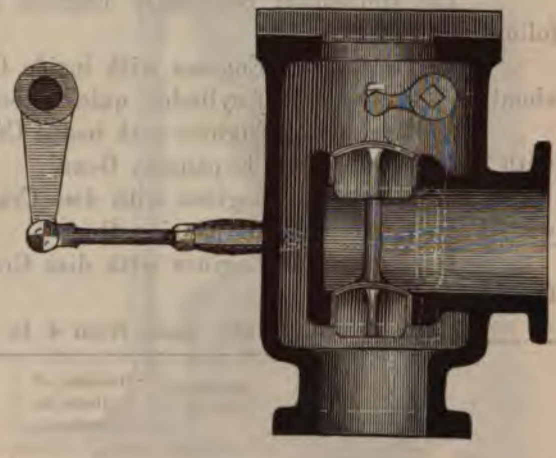


Fig. 162.

The crank-pin is of steel, $2^3/_4$ in. diam. and $4^1/_8$ in. long in the journals, truly ground into the crank and firmly cottered to the same. The crank-shaft, made of wrought iron, has a uniform thickness of $5^7/_8$". The crank-shaft is supported on two-cast-iron pedestals fitted with cast-iron caps, gun-metal steps, bored and turned to fit their respective necks. The cast-iron fly-wheel, 10′ 6" diameter and 7 in. on the face, weighs about 3 tons, and is cast in halves, and running at 65 revolutions per minute, it has a circumferential speed of $35^2/_3$ feet per sec.

The governor stands on column bolted to the engine frame. It is of the ordinary Watts-type, driven by bevel-gearing, from a link from the crank-pin. In conclusion, the Engine has a pump for supplying the boiler, attached in a separate casting to the engine-bed. With a 30 in. stroke, and working at 65 revs. per min. it is calculated to supply 500 gallons per hour to the boiler, and it is worked from the cross-head.

m. A. Rigg, Engineer, of London.

An Automatic Expansion gear working with two eccentrics, and with the expansion valve through-ported sliding on the back of the main-slide, has now become tolerably well known in England, owing to its appearance at the Smithfield Club Shows, as well as owing to the conspicuous place allotted to it in Rigg's Steam-engine treatise. The governor acts directly on the eccentric of an expansion valve, and regulates its stroke in order to vary the point at which steam is cut-off, and the slide valve is driven by its own eccentric in the usual manner. The governor proper, consists of a weighted frame so mounted as to slide radially, and placed against the expansion eccentric, the whole rotating with the main shaft of the engine. Inclines are attached to the frame, and corresponding projections to the eccentric, these fitting together so that any movement of the former, causes a change in the stroke of the latter. This governor is compact and simple, consisting of only three or four parts, instead of the numerous details of those ordinarily constructed. At a certain number of revolutions, determined by the strength of an adjustable spring, the governor weight flies outwards by the action of centrifugal force, and in so doing increases the eccentric stroke, cutting off steam earlier, until when the weight has finally reached its extreme position, there is only sufficient steam left to drive the engine unloaded.

n. Marshall, Sons, & Co., Lim. Gainsborough.

Messrs. Marshall, Sons, & Co., Lim. of Gainsborough have of recent years constructed Horizontal High-pressure and Condensing Engines fitted with Hartnell & Guthries, Variable Expansion apparatus.

The Horizontal Stationary Engines made by this firm, are now constructed in the four following types:

A—Horizontal Engines with inside Crank, and both bearings contained on frame, stroke about $1^1/_2$ times bore of cylinder, quick speed governors and equilibrium throttle valve.

B—Horizontal Engines with inside Crank, and both bearings contained on frame, and fitted with Patent Automatic Expansion Gear.

C—Horizontal Engines with disc Crank, stroke twice the diameter of cylinder, and fitted with Patent Automatic Expansion Gear.

D—Horizontal Engines with disc Crank, stroke and equipment as above, but fitted with Condenser.

Class *A* and *B* are made from 4 to 10 *HP.* inclusive, as follows:

HORSE POWER	Diameter of Cylinder in Inches.	Length of Stroke in Inches.	No. of Revolutions per Minute.	Diameter of Fly-Wheel.
4	$6^3/_4$	12	125	4′ 7″
6	$8^1/_2$	12	125	5′ 2″
8	$9^1/_2$	14	110	5′ 8″
10	$10^1/_2$	16	95	6′ 0″

Of classes *C* and *D*, we illustrate perspective views in Figs. 163 and 164, and as already observed, the last named class are of the same type as Class *C*, and are constructed in

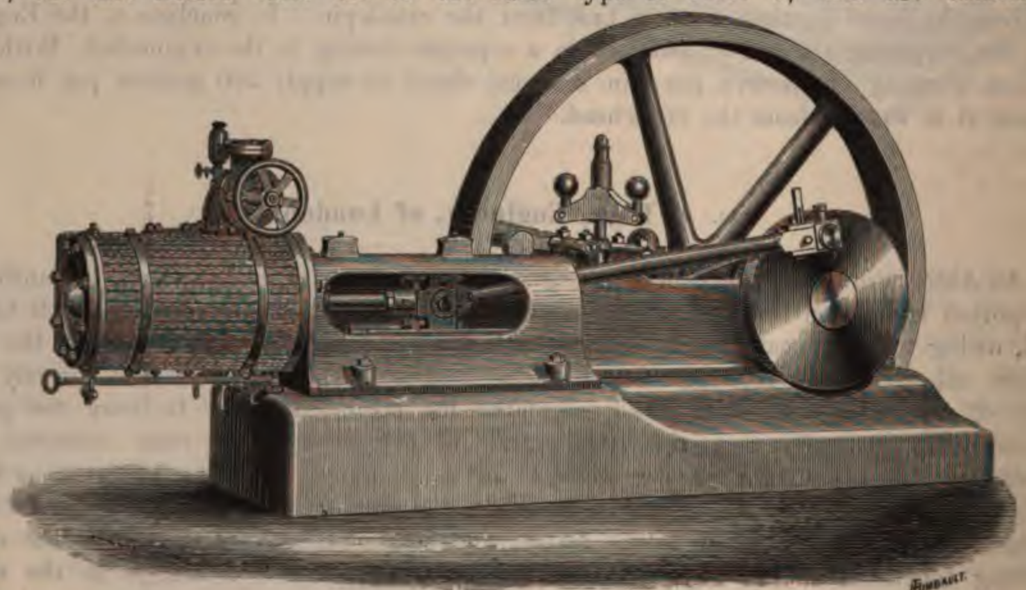


Fig. 163.

sizes, from 10—35 HP. The condenser in this class is adapted to quick speeds, the valve-seatings are of brass, with India-rubber valves. The Air-pump is connected to the tail end of the piston-rod, and a suitable distance piece is introduced between cylinder and condenser to ensure speedy and accurate relative adjustment of these parts, in erecting the engines. This arrangement of the condenser has been adopted with a view of reducing the necessary foundations to the simplest character.

Partly following the particulars given to the writer, we note that the cylinders are made of cold blast iron and steam jacketted with a separate liner forced in. The stroke is twice or more the diameter of the piston. The pipes, ports, and passages are large. The Expansion-valves are on the back of the main-valves. In engines having cylinders above 11" diameter short ports are introduced and double valves at each end. A Stop-valve is fixed to the cylinder with independent passage to the jacket; cylinder cocks, displacement lubricators, indicator bosses, etc., are provided.

The Crank-shaft Brasses are in four pieces, capable of horizontal and vertical adjustment. The guide blocks are adjustable. All the valve motion is deeply case-hardened.

The Automatic Regulator is powerful and sensitive; for it acts through a link and die, on to an expansion cut-off valve, working at the back of the main slide-valve. The ordinary throttle valve is dispensed with, and the speed of the Engine is controlled, by means of the expansion valve, which regulates the admission of steam into the cylinder, exactly in proportion to the duty performed by the Engine. In this manner, the Engine is controlled by the regulator by means of a simple expansion gear, so perfectly, that the whole load may be instantly removed with but slight variation in the speed. The cut-off extends to about $^5/_8$ the stroke. There are no inaccessible valve adjustments concealed in the steam chest.

The Fly-wheels, are turned to receive double belting, wide enough to transmit the full power of the Engine.

The Feed-Pumps are worked by a separate eccentric. They have brass valves and seatings, and an air-vessel.

The Engines may be reversed by taking off the eccentric sheaves, which are cast together in halves and turning them end for end.

The Engine Beds are made right or left, and planed on the under surface; all the other parts are similar or reversible.

A pair of Right and Left Engines may be coupled with the Fly-wheel between them.

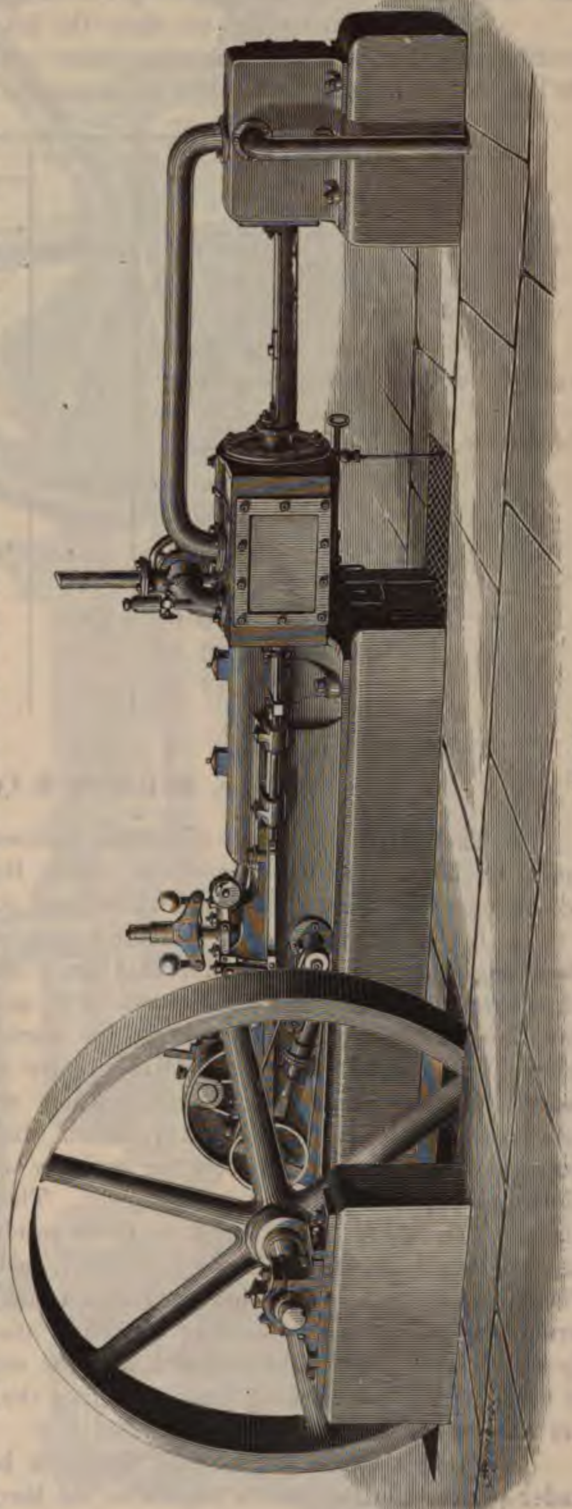


Fig. 164.

This arrangement, besides giving the power of readily starting in any position with extreme steadiness, will often be advantageous as a means of reducing cost, where one Engine can be laid down at first, and the second provided for, for future anticipated increase of power.

In the annexed table, we show the loads at which these Engines are proportioned to work continuously, i. e., with 40 lbs. mean pressure on the piston, this being about the maximum power with 60 lbs. boiler pressure, equivalent to expansion from about $^{3}/_{10}$ stroke with 80 lbs. boiler pressure.

DIMENSIONS OF ENGINE.			Revolutions per Minute.	POWER.				
Cylinder.		Fly Wheel.		Nominal.	Indicated			
					Most economical load.		Maximum.	
Diameter.	Stroke.	Diameter.			Boiler Pressure 60 lbs. (Cut off at 55 lbs.)	Boiler Pressure 80 lbs. (Cut off at 75 lbs.	Cut off half stroke at 55 lbs, (or $^{3}/_{10}$, stroke at 80 lbs.) Mean Pressure 40 lbs.	Cut off half stroke 75 lbs. Mean Pressure 56 lbs.
10"	20"	7 3'	105	**10**	26	30	33	46
11"	22"	8' 0"	96	**12**	31	36	40	56
12"	24"	8' 8"	88	**14**	37	43	48	67
13"	27"	9' 9"	78	**16**	43	51	56	79
14½"	30"	11' 0"	75	**20**	54	63	70	97
16"	33"	12' 0"	65	**25**	67	78	87	100
17½"	36"	13' 0"	60	**30**	81	94	106	146
19"	36"	13' 0"	60	**35**	93	108	121	169

o. Holborow & Co., Engineers, Stroud.

The annexed woodcut, (Fig. 165,) represents a type of Horizontal High-Pressure Engines, as made by Messrs. Holborow and Co., of the Dudbridge Iron Works, Stroud, and it is especially recommended by them, in all cases where large power is required with undeviating regularity in speed.

Engine makers have in their recent practice tried to arrange the constructive details of their engines in such a manner, that the working stress should pass through the frame or bed plate, and not over it, or on one side of it, and similarly, whilst very simple engine constructions have been introduced of late years, the various parts of the modern engine have been largely reduced in number. By these means greater stability and durability have been attained in the modern Steam-engine. The engine which we now refer to, certainly is no exception to the progress to which we have just referred. In this class of engine the frame is a massive box-casting, which directly connects the cylinder with crank-shaft bearing; the latter being with slide block-guides, cast with it in one piece. The cylinder is bolted firmly to the frame or engine plate, which has a recess bored in it to receive the front cylinder cover, and this last forms a kind of vowel between cylinder and frame, and renders any displacement between them impossible. The cylinder, with steam chest and steam jacket, is cast in one piece. The crank shaft is of best wrought iron, and ample bearing surface is allowed at the journals. To insure steady running the fly-wheel is of the weight required, and the connecting-rod is of best hammered iron, while steel is used for all the working pins, including the crank pin. Similarly, the piston and valve rods are also of steel, turned to gauge.

Porter's Patent High-Speed Governor has been adopted in these engines for keeping them under perfect control. With regard to the throttle valve for the smaller sizes, an improved wing valve is found sufficient, but with sizes above 12 horse-power, an improved equilibrium valve is applied. To superheat the steam after it has passed from the high-pressure cylinder, a simple arrangement is attached, so that the steam may enter the low-pressure cylinder for final expansion dry and hot. Especial care has been bestowed upon the question of obtaining the proper proportions of slide valve and cylinder ports and travel, so as to ensure the best distribution of steam and economy of fuel.

It will be noticed that the high and low-pressure cylinders are entirely separated, having quite distinct frames resting on separate foundations. The bedplates are somewhat of the Corliss type, with very large brackets under the shaft bearings. The shaft itself has two bearings only, one in each bedplate, and carries a fly-wheel and spur-wheel between them. Cast-iron discs are used for cranks. Both cylinders are fitted with expansion valves worked by separate eccentrics, that on the small cylinder cutting off very early, and having (as shown by the cards) a capitally sharp action. The Porter governor is placed on the high-pressure bed-plate, but this controls a throttle-valve only. Both cylinders are jacketted, steam being conveyed to the jackets by separate pipes. The two cylinders communicate simply by a pipe, and another pipe for the low-pressure cylinder connects it to the condenser. The condenser and air-pump are placed directly behind the low-pressure cylinder, the pump being worked by a prolongation of the piston rod through

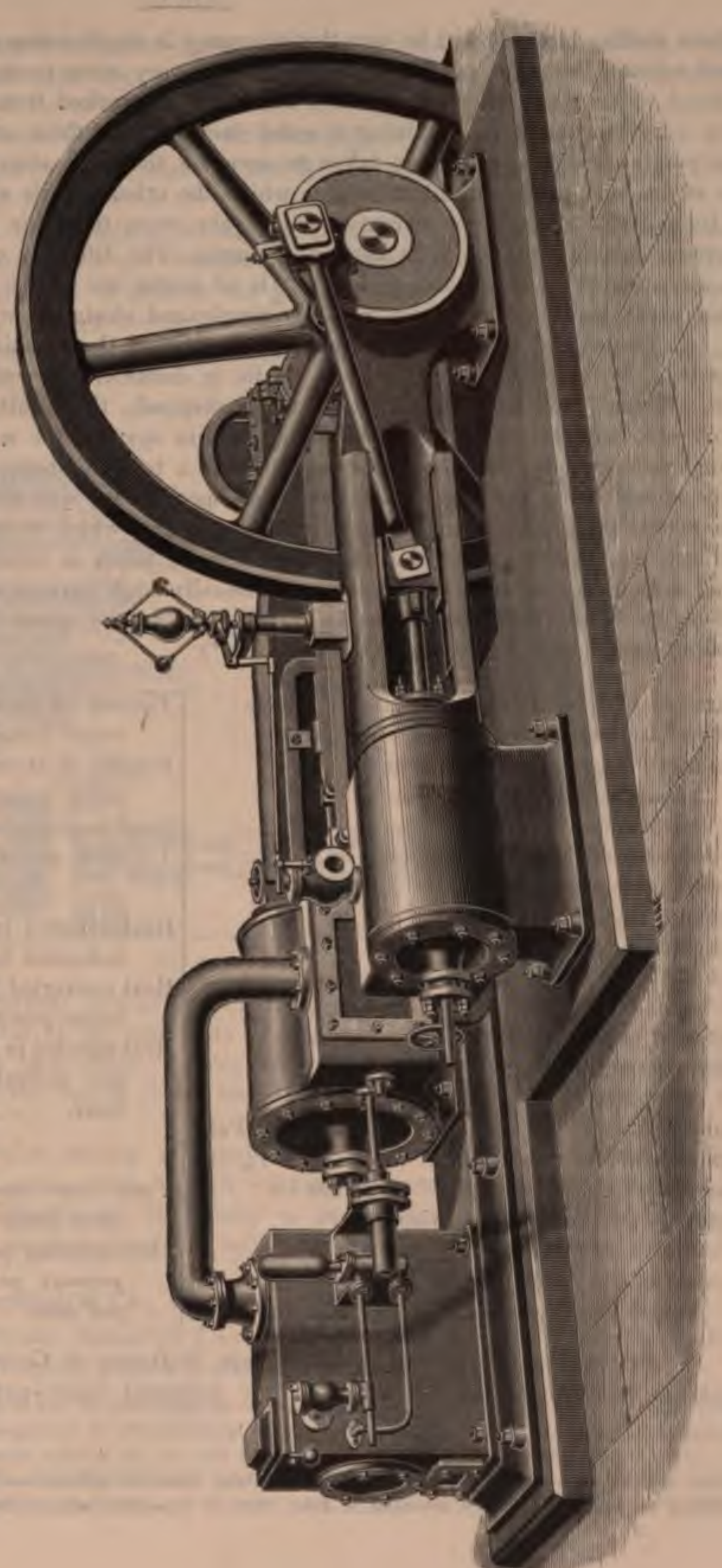


Fig. 165.

a back stuffing-box. It will be seen that the pump is single-acting and quite open in front, an arrangement which allows the condenser to be brought very close to the cylinder. The air-pump piston is fitted with a gland on its front side, which can be packed from outside. Messrs. Holborow have been very successful in obtaining a good vacuum with their arrangement of condenser, a result due partly to the special care taken to secure a thorough admixture of the injection water with the steam, and partly to the manner in which the other details are worked out. A steady vacuum of from 28 in. to 29 in. of mercury, which they seem to obtain generally, is certainly above the average vacuum obtained with horizontal pumps. The difficulty of obtaining a good vacuum with an air pump worked off the piston rod is of course one of the principal reasons for using some other arrangement of pump not quite so simple and straightforward.

The engine illustrated is employed in driving the machinery of a corn mill at Cam, near Dursley. Its cylinders are 14 in. and 24 in. in diameter respectively, and they have a stroke of 2 ft. Messrs. Holborow have placed at our disposal, the results of a trial which though a very short one, was carried out on the Farey-Donkin system, the water discharged by the air pump, being measured by being allowed to fall over a tumbling-bay, the work was kept uniform, (the same stones being running all the time) and special care was taken with it. Although, therefore, the results cannot be taken as having the authority, which they would have had, had they been deduced from a ten hours' trial, still they may be taken as substantially accurate: and taking the good action of the valves, and the exceptionally high vacuum obtained, into account, we see no reason to doubt that the engine is working with very great economy. The following are the leading particulars of the trial alluded to: —*)

Duration of trial.	1 hour
Sets of Indicator cards taken.	6
Observations of discharge from condensers (height and temperature).	6
Revolutions of Engine per minute.	68.5
Steam pressure in boiler. ...	53.0 lb.
Vacuum (mercurial gauge). ...	28.2 in.
Indicated horse power.	41
Cut off (real) (high pressure cylinder), about. ...	$\frac{1}{6.5}$
Ratio of expansion, (total). ...	19.5
Back pressure in large cylinder (absolute).	2.7
Temperature of injection. ...	54 deg. Fahr
Temperature of discharge. ...	89 „
Amount of discharge.	24.120 lb.
Amount of condensed steam drawn for jackets.	73 „
Pounds of condensing water per pound steam condensed. ...	30.6 lb.

Pounds of steam condensed per indicated horse power per hour. ...	18.6 lb.
Pounds of steam from jacket per indicated horse power per hour. ...	1.78 „
Total consumption of steam per indicated horse power per hour.	20.4 „
	ther. units.
Heat rejected in condensing water per indicated horse power per hour.	19,950
Heat converted into work per indicated horse power per hour.	2,565
Heat rejected in jacket water discharged per indicated horse power per hour.	358
Total heat accounted for per indicated horse power per hour.	22,873
Corresponding quantity of steam at boiler pressure per indicated horse power per hour.	20.6 lb.

In regard to these particulars, Messrs. Holborow & Co. observe, that this Engine did not consume more than 20.4 lbs. of steam per indicated horse-power per hour, and as an ordinary

*) In recording this trial, "Engineering" states that the calculations by which the forementioned figures were obtained, are similar to those it described in Febr. 1878, in connection with the South Metropolitan trials.

Cornish boiler will readily evaporate $10\frac{1}{2}$ lbs. of water per lbs. of fuel burnt, the amount of fuel consumed per indicated horse-power per hour will be represented by $\frac{20.4}{10.5} = 1.94$ lbs. which is certainly an economical result.*)

p. W. N. Dack, Patricroft.

Dack's Variable Expansion-valve, as made by Mr. Wm. Turner, Engineer of Salford, (Manchester) is illustrated in our Fig. 166.

In this arrangement, the main-slide *A* is through-ported. On its back, two expansion-valves *BB*, are made to slide, and these are worked from a separate eccentric-rod *H*, which is connected to a double-lever *D*, arranged to slide in the guide-block *G*. This lever *D*, is connected with the expansion-valve spindles through the links *CC*, and it is moreover under direct governor-control, through the adjustable rod *E*. It will thus be seen that the double-lever *D*, in addition to

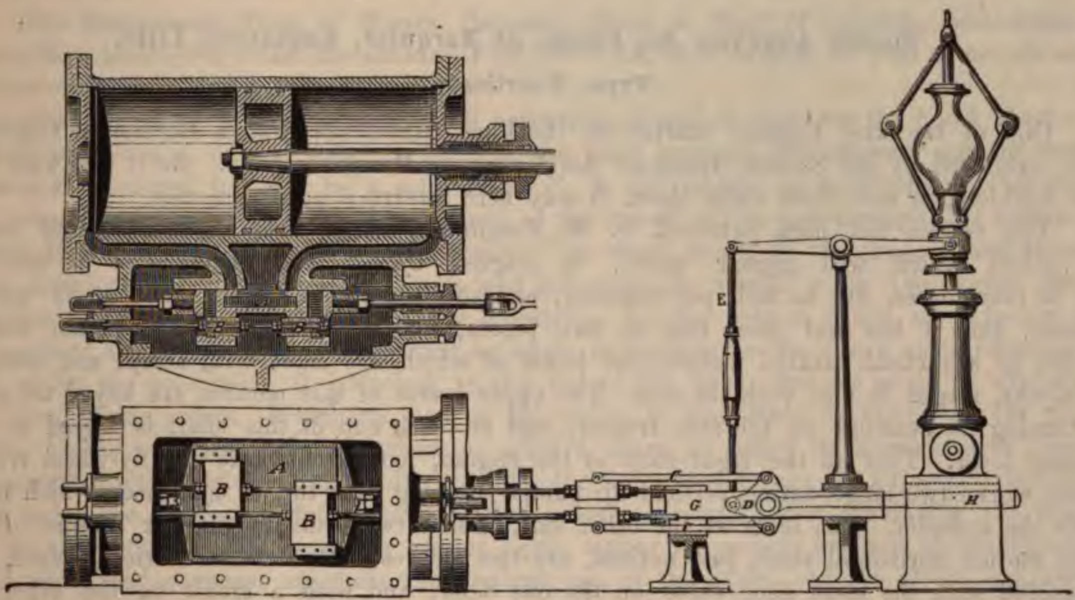


Fig. 166.

its reciprocating motion, has a vertical oscillation imparted to it by the governor, and that when the latter interferes with the travel of the expansion-valves, it has the effect of pulling these two valves further apart, or nearer to each other. In this manner the position of the expansion-valves *BB*, is altered, thereby varying the cut-off of the steam to the main-slide, and consequently also to the cylinder.

It is evident that this valve motion is equally applicable to steam-cylinders with long or divided main-slides and short steam-ways, though we have grouped it, in accordance with the cylinder construction herewith illustrated. Simplicity is unquestionably its great merit, and in this respect it will be found to compare favorably with the extreme complicatedness of many of its rivals.

q. Hempsted & Co., Engineers of Grantham.

For a number of years, Messrs. Hempsted & Co., Agricultural Engineers of Grantham, (England) have fitted their Portable Engines with a Variable Expansion and Cut-off valve.**)

*) A later improvement, brought to bear on these Engines, which we shall to illustrate in the Supplementary Volume announced on pg. 129, consists in an arrangement for disconnecting the high-pressure from the low-pressure cylinder, so that in case of a break down to either, the other cylinder can be used independently, and thus avoid a stoppage of work.

**) De Negri's valve gear published in The Engineer, 19 Dec. 1879, is another example of an Automatic variable Expansion arrangement to which the reader may also refer.

The main-slide valve spindle is worked through a guide for the purpose of taking up the oscillation of its rod, as well as for preventing the wear of the rod and gland. The main slide has an expansion-valve sliding over it, which is worked by link combination direct from the governor, and this expansion-valve is therefore, under direct governor control.

With a maximum load on, the expansion valve is arranged to cut off, at two thirds stroke, but as the governor rises, the expansion valve also rises, shutting off the main-valve ports, thereby cutting off at the power required, and vice versa. The expansion-valve spindle is worked through a stuffing box on the steam-chest cover, the removal of the latter affording accessibility to the whole of the valve.

This valve gear is also applied when required, to the Horizontal and Vertical Engines constructed by the same Firm.

r. Société Anonyme des Usines de Marquise, Engineers, Lille.

(Type: Fourlinnie.)

One of the first Engines started in the Paris Exhibition was a Horizontal Condensing Engine, exhibited by La Société Anonyme des Usines de Marquise, Lille. As it likewise works with a double-slide and short valve chest, it may here receive a passing notice.

This engine has been patented by M. Fourlinnie, manager of the works, and presents many points which will appear novel, in English eyes. The framing is of cast iron, really in four pieces, but so well put together, and so clean in the joints, that it is not easy to believe, that it has not been cast in two pieces, one at each side. The piston rod head is guided by a vertical parallel motion, the joints of which, are made with straps and cotters on solid blocks, forged in one, with the rods. The upper levers of this motion, are keyed on a cross shaft turning in bearings on the side frames, and on each end of this shaft is keyed a double horizontal lever. That on the right-hand of the engine, looking towards the fly-wheel from the cylinder, works two single-acting vertical air pumps drawing from the jet condenser, which is right beneath the cylinder. The lever at the other side, works two ordinary plunger pumps. On the parallel motion horizontal shaft, just noticed, are two sleeves; one of these carries a lever, which is connected with the main slide valve on the one hand, and with a crank on the other. The crank is made in a horizontal shaft, carried in bearings in two castings, one of which supports the governor. This crank shaft is driven by spur gearing from the main shaft.

Above the main-slide is a grid-iron expansion valve, actuated by an arm on a vertical shaft, at the side of the governor. On the lower end of the governor rod, is a sleeve fitted with two cams. This sleeve rises aud falls with the governor, the weight of which is partially balanced by two balls supported on arms. The position of the cam sleeve is controlled by the governor, and so determines the point of cut-off The cut-off valve is worked by a second lever and sleeve rocking on the horizontal parallel motion shaft.

The whole engine is self-contained in the sense, that little or no excavation is required; and abnormal as the engine appears, it is indisputable that it runs exceedingly well, and compares favourably with many other engines in the Exhibition. The workmanship is good, and the fly-wheel, was one of the finest in the Exhibition.

The admission of steam which corresponds with an effective duty of 100-horse power is stated to be one-tenth of the stroke of the piston. The principal dimensions are as follows: —

Diameter of cylinder.	23·6in.
Stroke of piston.	3ft. 8in.
Number of revolutions per minute.	46.
Diameter of air-pumps.	13·6in.
Length of stroke of buckets.	10·8in.

Proportion of steam cylinder to air-pump.	12 to 1.
Diameter of fly-wheel.	16ft. 9in.
Width of fly-wheel.	25·6in.

The width of the fly-wheel, is divided by a flange throughout its periphery and drives two belts. The working of the belts is very true. The engine reflects as much credit on the executive skill of the workshops at St. Maurice, as on the ingenuity and care displayed by M. Fourlinnie in the study and direction of his work.

The elevation and plan of this Engine may be found illustrated in "The Engineer" issues, dated 17th and 24th May 1878, whence the foregoing description has been borrowed.

s. Ransome, Sims & Head, Ipswich.

The Engineering Firm of Messrs. Ransome, Sims & Head of Ipswich, also construct a Variable Expansion gear, which the annexed Figs. 167—169, shew in plan, as well as in side and end elevations as attached to a Portable Engine.

The apparatus consists of two small eccentrics, *A* and *B*, fixed on the crank shaft *C*, and furnished with straps, *D*, and rods, *E*, fitted in the usual manner: the extreme ends of each pair of rods are connected together by a solid link, *F*, to the middle part of which,—between the ends of the eccentric rods,—is attached the rod of the cut-off valve; and through this hollow block the solid links are capable of sliding vertically. The weigh shaft, *H*, the arms, *I*, and supporting rod, *J*, form connection between the links and governor, *K*, which is on the Porter principle. The action of the whole is as follows:—The eccentrics, *A*,—the rods of which are attached to the lower ends of the links,—are fixed at such an angle in relation to the crank as to effect an early cut-off whilst the eccentrics, *B*, attached to the top of the links, are set so as to allow a late suppression of the steam. When the load on the engine is diminished or increased, the governor instantly begins to operate, and continues to revolve above or below its normal speed, until, by the rise or falling of its arms and balls, it shifts the links, and brings the adjustable valves more or less under the influence of the early or late cut-off eccentrics, thus regulating the supply of steam to the altered load, until the engine again makes its proper number of revolutions per minute; slides and governor are quite independent, one of the other, and the steam is always cut off in the cylinder at a fixed point, irrespective of any change which may take place whilst the engine is at work. When the load on the engine is diminished or taken off entirely, the same quantity of steam is admitted into the cylinder; but its ingress is checked by the action of the throttle valve.

By the action of the patent automatic governor, the exact quantity of steam is admitted into the cylinder, in the ratio required by the load on the engine, the induction port closing immediately the requisite amount of steam (required by the engine when it is performing a certain duty) has entered the cylinder.

The slide-valve is shewn in plan and section in Figs. 170 and 171. Side-view and Plan of double eccentrics, are appended in Figs. 172, and 173, with a view of explaining the method adopted, by the last mentioned firm, for adjusting the expansion-eccentric.

The slide-valves consist of one large 3-ported valve, which has a fixed travel over the whole lengths of the ports, and a second small grid-iron valve, which regulates the admission of steam into the cylinder, and cuts it off at any desired point of the stroke, up to about one half. The large slide, which has a lead of $^3/_{16}$ inch, and a lap of about $^1/_2$ inch, is moved by the inner eccentric, *A*, which is fixed to a disc on the crank-shaft; the small or cut-off slide is connected to the outside eccentric, *B*, which is loose on the shaft and kept in position by a bolt fixed to the inner sheave, and sliding in a slot in the outer sheave. When the load on the engine is increased or diminished, and it is required to admit the proper amount of steam

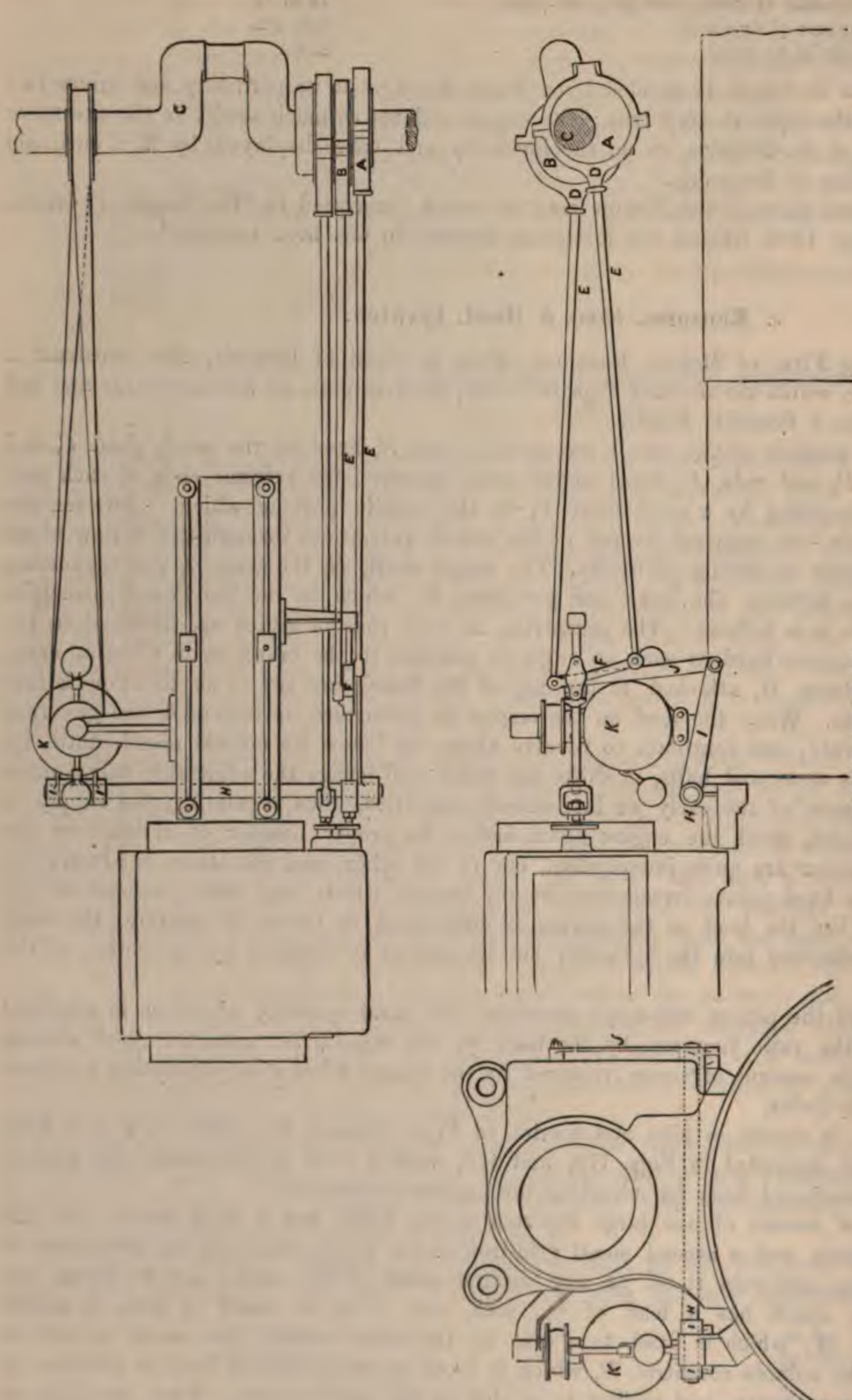
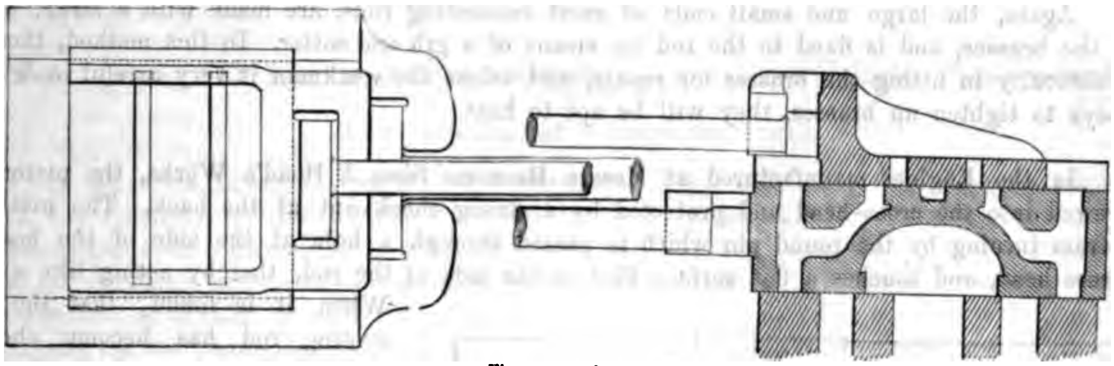


Fig. 167, 168 and 169.

to accomplish the work with the smallest consumption of fuel, the expansion sheave is shifted round so that the pointer is on the line with the marks on the sheave indicating the exact point at which the steam will be cut off in the cylinder, and consequently, the amount of expansion, to which it will be subjected. In order to set the eccentrics properly, and arrive at the exact relation between the load on the engine and the amount of steam required, it is advisable to test the engine with a fixed load when cutting off the steam at various parts of the stroke; and the most economical position of the slides will be determined when the engine is just able to keep up its normal number of revolutions without fluctuation, at a given pressure of steam.

As the guide bars, cross-head and connecting rod, deviate from the usual practice adopted in the construction of Portable engines, we illustrate in plan (fig. 174) the guide bars and attachment of the cross-head to the piston rod, and we also shew the large and small ends of the connecting-rod in Figs. 175 and 176.



Figs. 170 and 171.

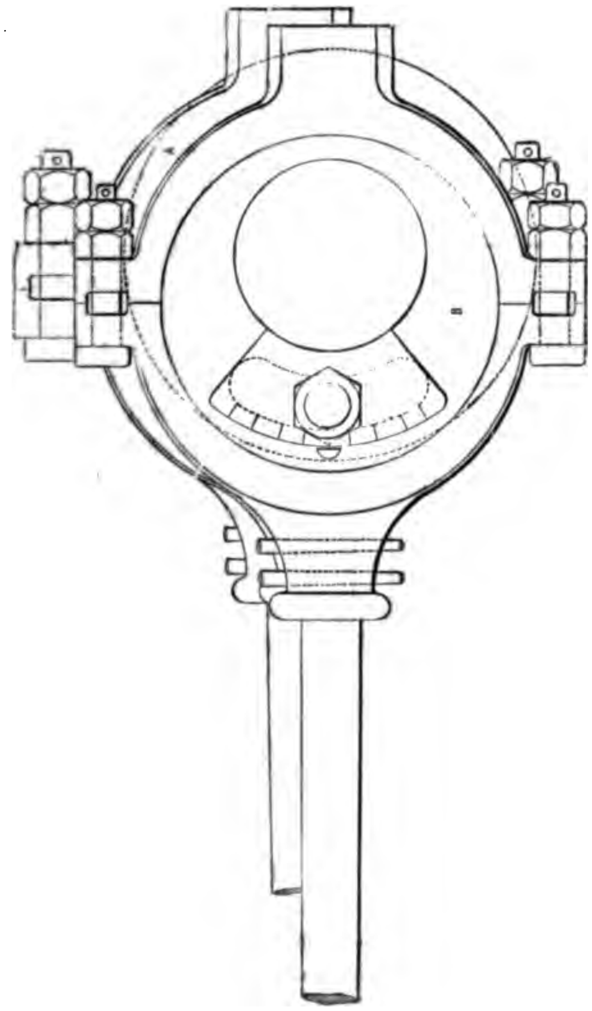


Fig. 172.

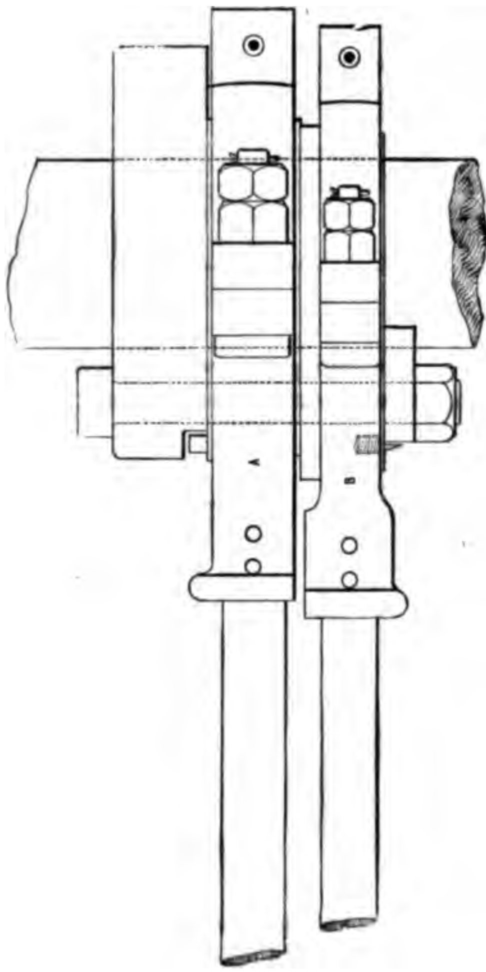


Fig. 173.

The usual way of fixing the cross-head to the piston-rod, is by keying it on the rod which is slightly tapered at the end; but in this plan, no compensation can be made, for the shortening of the connecting rod, through the wear of its brasses and consequent diminution, in the clearance of the piston, on one end of the cylinder.

Again, the large and small ends of most connecting rods, are made with a strap, which holds the brasses, and is fixed to the rod by means of a gib and cotter. In this method, there is some difficulty in fitting the brasses for repair, and unless the workman is very careful in driving the keys to tighten up brasses, they will be apt to heat.

In the Engines manufactured at Messrs. Ransome Sims & Head's Works, the piston-rod is screwed into the cross-head and protected by a strong check-nut at the back. The piston is kept from turning by the round pin which is passed through a hole at the side of the boss in the cross-head, and touches a flat surface filed in the side of the rod, thereby acting like a key. When it is found, that the connecting rod has become shorter, through the wear of the brasses, the guide bars are temporarily taken off, the pin is taken out, and the cross-head unscrewed, as many threads, as are equal to the diminished length of the connecting rod. The pin is then reinserted, and the distance between the piston and the crank shaft becomes, the same, as when the engine was new, and the clearance between the piston and the two cylinder covers, will be perfectly equal.

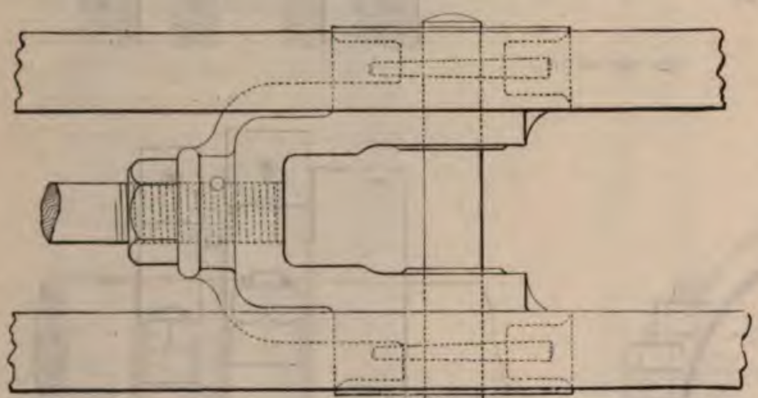
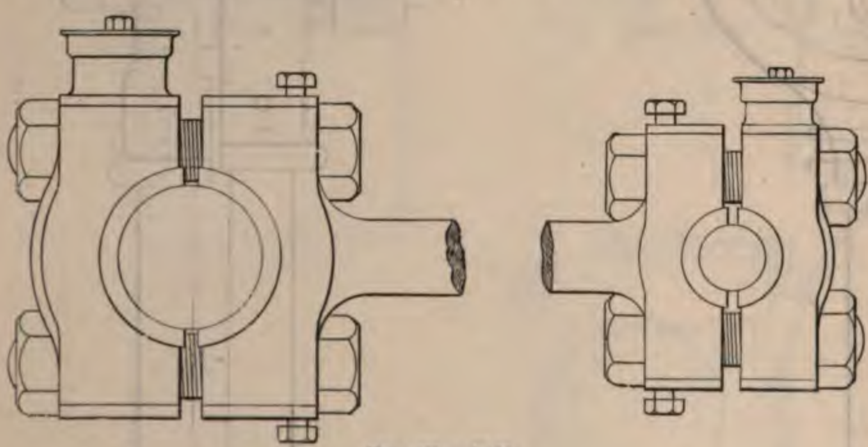


Fig. 174.

Continuing to avail ourselves of the particulars, kindly placed at our disposal by the same Firm, the connecting rods are forged out of one solid piece of iron, so that the greatest accuracy, can be ensured in the turning and shaping. The brasses are circular, both inside and out, and can be easily re-made in a common lathe, without any fitting. The brasses are kept in their place, by wrought-iron covers secured by strong bolts; and between the cap and the *T* end of the rod, a number of very thin steel washers are strung upon the bolts. When it is necessary to screw up the brasses, one or more of these washers are taken out, according to the wear which has taken place, and the cap is screwed up tightly against the washers, so that the brass bearing, only lightly touches against the crank pin, thereby avoiding the friction, which takes place, when the brass is tightly keyed up against the pin.



Figs. 175 and 176.

All the plummer-block brasses of the engine are made long in proportion to their diameter, and rest in circular beds, bored to a gauge, in the same manner, as in the connecting rods, so that in case of repair the new brasses can be inserted without any fitting whatsoever *).

2. Valve-gears, with long or divided Valve-chests, and short Cylinder Steam-passages.

a. A. T. Allcock, of Newark on Trent.

In Allcock's Expansion-gear, represented in our Figs. 177—180, the expansion-plates H and H_1 are rigidly connected together, and are driven by a separate eccentric E_1, to which they are attached in such a manner as to couple and uncouple. This is accomplished by the eccentric E, giving reciprocating motion to two parallel bars pp_1, which in their turn move the valve-rod F_1, when the bolt $(r\ o)$ falls into a corresponding slot of the bars pp_1. The main-slide G made extra long to shorten the steam-passages, is worked from the eccentric rod B, the eccentric E, and the valve spindle F. To obtain automatic variable expansion, the forked end of the main valve spindle F is attached to a rod b, the other extremity of which is articulated to a link AA, whose swing-centre is at Z. On referring to Fig. 177, we observe that the link sliding-block i, is under governor control,

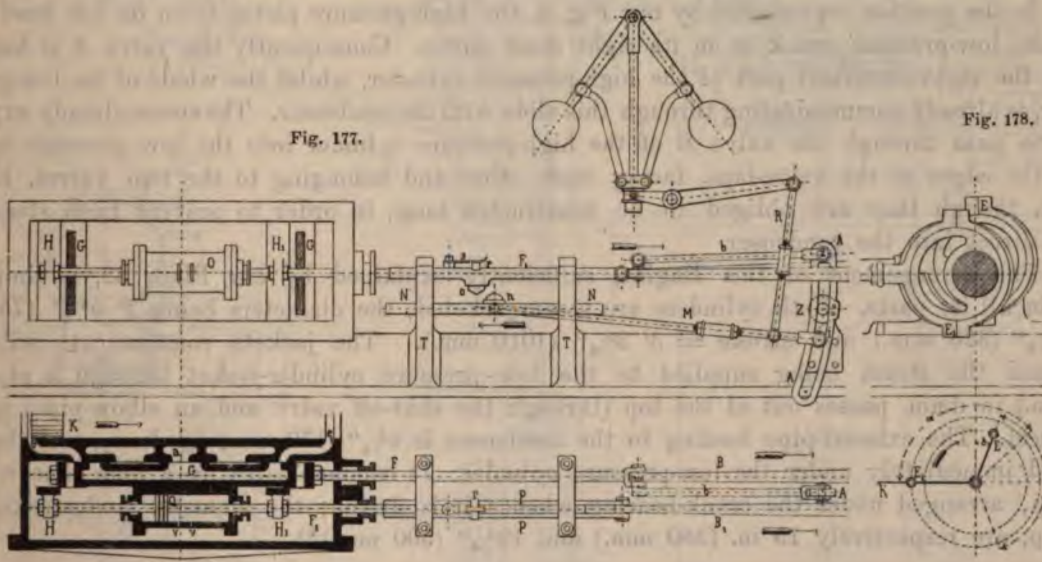


Fig. 177. Fig. 178.

Fig. 179. Fig. 180.

through the rod R. When this block i is below the swing-centre Z, then a slide-rod NN with fixed catch n, is moved in contrary direction to the eccentric rod B_1. The knocking of n against ro, raises this bolt, so disengaging or uncoupling the parallel rods pp_1 from the valve-spindle F_1. In order that the expansion-plates HH_1, may quickly shut-off, the back of the main-slide carries a cylinder or dash-pot O with piston Q. As the latter has openings vv_1, it follows that when disengagement ensues, the steam is at liberty to expand, so forcing the piston Q into its central position, which corresponds to a shutting off the expansion-ports through the plates HH_1. The lower the link slide-block i is in the link A, the smaller will the grade of expansion be, whilst cut-off will ensue all the later, the higher the block i is above the swing-centre Z. In Fig. 180, the graphical travel of the main-slide eccentric E from the beginning of the stroke to the closing of the corresponding port is shewn by the arc $\alpha = 0.85$ stroke. The automatic cut-off is, however,

*) Compare foot-note on pg. 165.

restricted to $^3/_4$ stroke, because later on, the catches *n* and *o* would not come in contact with each other.

b. Boudier Frères, Engineers of Rouen.

The Horizontal Compound Engine, represented on our Plate 32, is a type also constructed by Messrs. Boudier Frères, Engineers of Rouen.

In this arrangement, the high and low pressure cylinders are placed close together. Ordinary box slides are used, though their functions are somewhat different from the common class, owing to the three ports.

An ordinary eccentric is used to drive the valves, which are rigidly connected together, at each cylinder end. The top valves receive their motion, from an inclined eccentric and swing piece. They supply the high-pressure cylinder with steam, and effect the distribution of the steam between the two cylinders, as well as open out the exhaust-passage from low pressure cylinder to the condenser; on the other hand, a distinct expansion-valve is used for the steam cut-off, which is worked by similar mechanism, as that descibed in the same Firm's Beam engine (vide pg. 126).

Fig. 6 shews the forms and directions of rotation of the cams here introduced.

In the position represented by our Fig. 4, the high-pressure piston is on its left dead centre, whilst the low-pressure crank is on its right dead centre. Consequently the valve *A* is beginning to open the right (exterior) port of the high-pressure cylinder, whilst the whole of the low-pressure cylinder, is already communicating through this slide with the condenser. The steam already expanded, begins to pass through the valve *B* of the high-pressure cylinder into the low-pressure cylinder. Hence, the edges of the valve-laps, facing each other and belonging to the two valves, have no function, though they are obliged to be constructed long, in order to prevent fresh steam from passing direct into the condenser.

The arrangement of this Engine, sufficiently explained by our Plate 32, is simple and strong in all its parts. Both cylinders are steam-jacketed, the diameters being 2' 5$^1/_2$" (750 mm.) and 12$^1/_2$" (320 mm.) and stroke = 3' 3$^3/_4$" (1010 mm.). The jackets communicate with each other, and the steam being supplied to the low-pressure cylinder-jacket through a pipe 4 in. (100 mm.) in diam. passes out at the top (through the shut-off valve and an elbow-pipe) into the valve-chest. The exhaust-pipe leading to the condenser is 6$^3/_4$" (170 mm.) in diam., and the latter is placed immediately under the low-pressure cylinder. It communicates by a long pipe with the air-pump, arranged under the crank-bearing whence it is driven; the diameter and stroke of the air-pump, are respectively 15 in. (380 mm.) and 19$^3/_4$" (500 mm.)*).

c. Wm. & John Yates, Canal Foundry, Blackburn.

Messrs. Wm. and John Yates, Engineers of the Canal Foundry Blackburn, recently constructed a fine pair of Compound Horizontal Engines for a Cotton mill at Lodz, (Russian-Poland); it is these Engines which we represent in elevation in Fig. 181, in semi-plan-section in Fig. 182 and in transverse section in Fig. 183.

They belong to the group now under discussion, and are fitted with self-acting variable expansion motion applied to each high-pressure cylinder, with the fly-wheel arranged for two driving-belts, each two feet six inches wide. The Scale of Figs. 181—183, as here drawn is $^1/_4$ inch = 1 foot, while the enlarged details (Figs. 184—186) are represented to a Scale of $^3/_4$ inch = 1 foot.

*) We may here conveniently refer the reader to the Horizontal Engine, constructed by M. A. A. Duvergier, Engineer of Lyons, as offering another carefully designed type of engine, working with long valve-chest, short steam-passages and double slide valves. It is fully described in Engineering issue d. 31 May 1878 pg. 428.

Fig. 183.

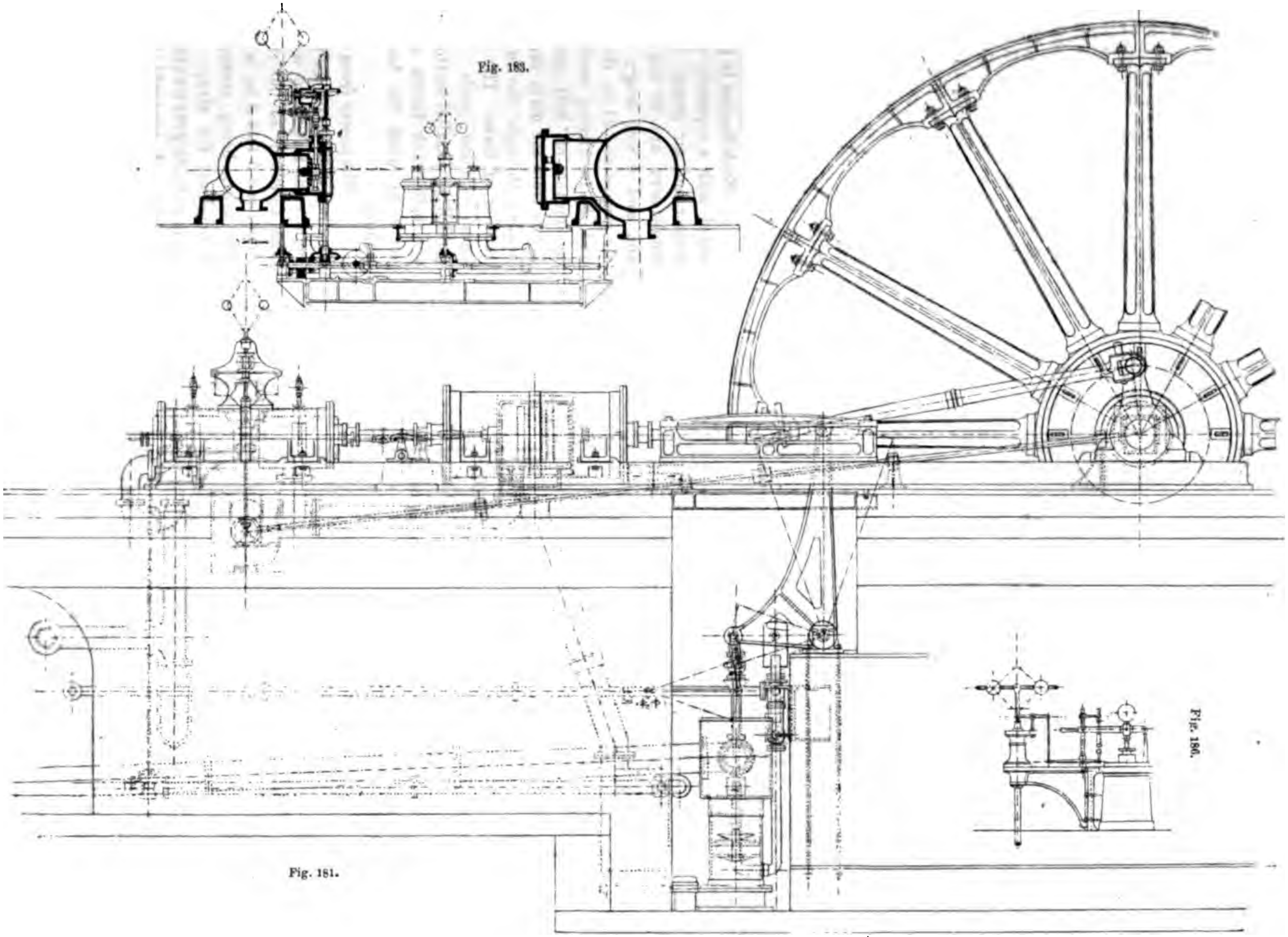


Fig. 186.

Fig. 181.

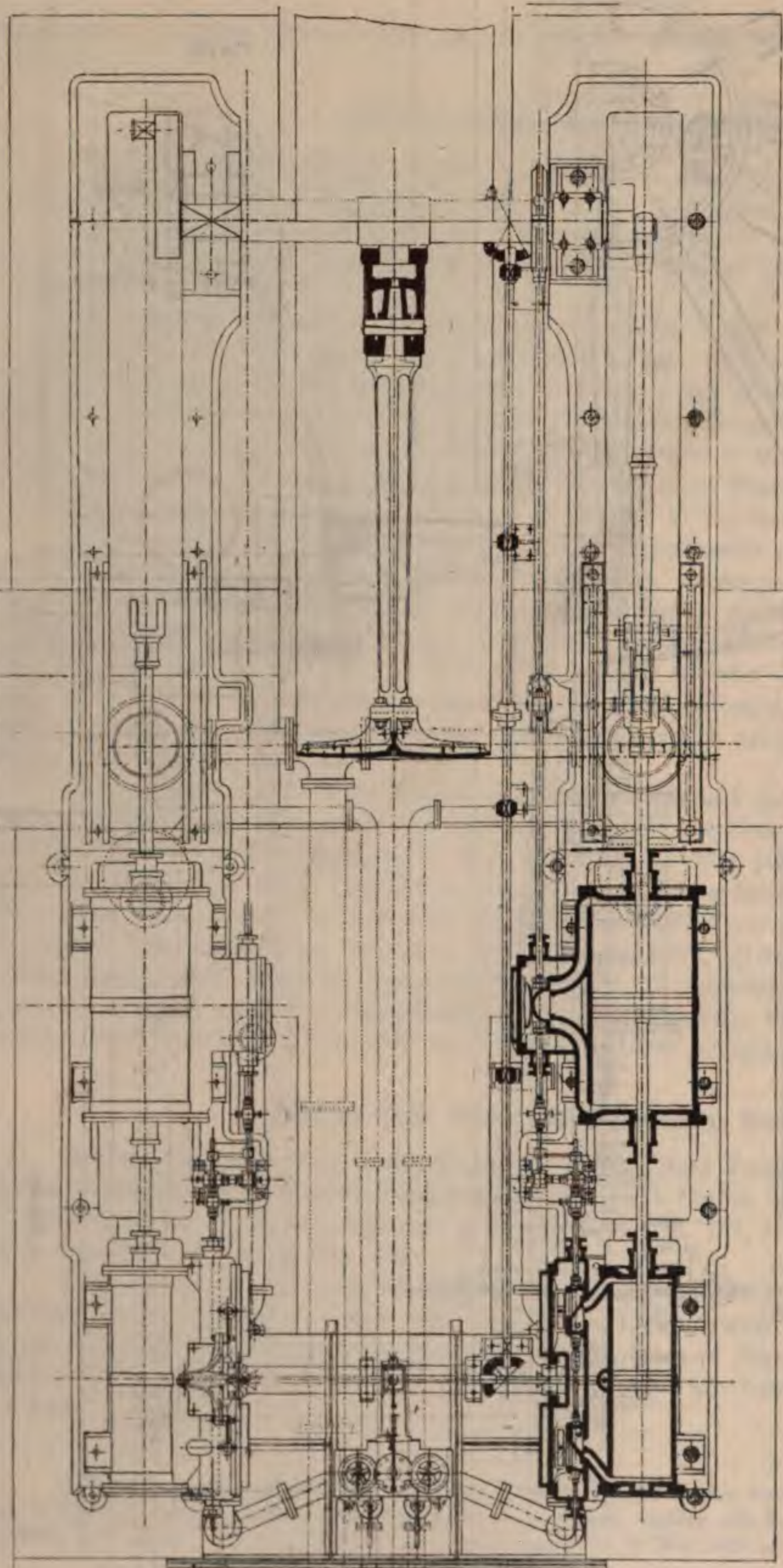


Fig. 182.

The Engines are of the tandem type, constructed to develop a power of 650 horses indicated, having each a high pressure cylinder 20 in. diam. and a low pressure cylinder of 34 in. diam. The stroke of the Engines is 5 feet, running at 42 revolutions per minute. The high pressure cylinders, are each fitted with slide valves at each end, with expansion valves worked from the governor, as more fully described hereafter. The low pressure cylinders are fitted with the ordinary slide-valve.

Each Engine is provided with a separate condenser and air pump. The condensers are 28 ins diam. and 4 feet long; the air pumps are 21 in. diam. and 26 in. stroke, worked by means of bell crank levers from the main crossheads, through the intervention of links. The air pump bucket rods are guided by parallel motions; the bell crank levers also serve to work the boiler pumps.

The power from the Engines is taken off by two belts each 2 ft. 6 in. wide. The flywheel is 30 feet diam. and 5 feet 9 in. wide. The mill, being arranged throughout for strap driving, no tooth-gear whatever is used. A separate bay is reserved, wherein the whole of the belts, driving the various line-shafts are contained; suitable gangways and stairs afford easy access to the whole of the belts, pulleys, and bearings.

The Engines have been specially designed for working with economy of fuel and steadiness of running: the simplicity, of the design, promises to avoid costly and expensive repairs. The Engines have now been at work for about twelve months, and have given the utmost satisfaction.

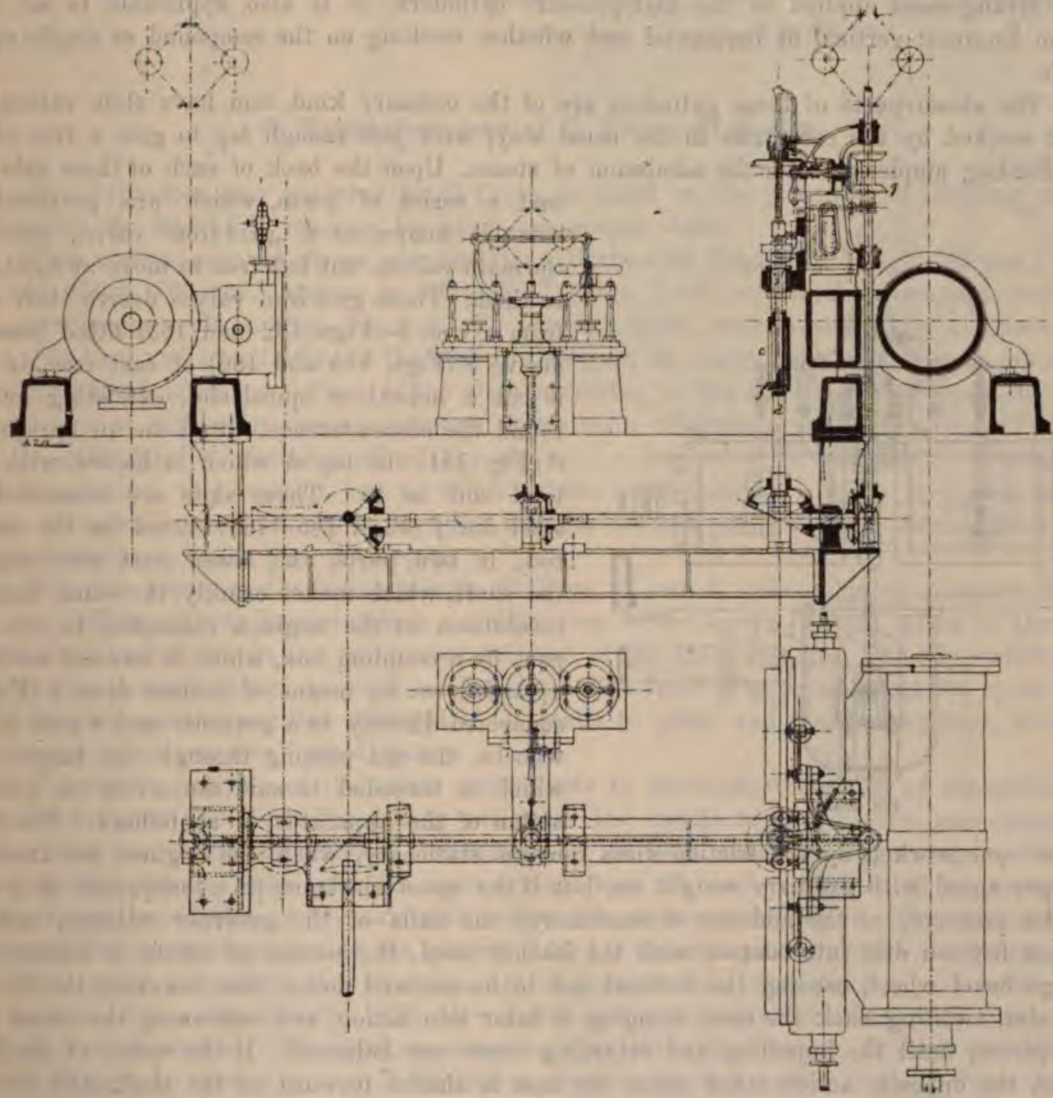


Fig. 184.

They are certainly of substantial design, the principal dimensions being as follows:

High pressure cylinders 20 in. diam.; steam ports 14" × 2".
Low pressure cylinders 34 in. diam.; steam ports 24" × 3".
Stroke 5 feet.
High pressure piston rods $3^3/_4$" diam. Steel.
Low pressure piston rods $4^1/_2$" diam. Steel.
Crosshead pin-necks 5" × $6^3/_4$" Steel.
Crank pin-necks $5^1/_4$" × 7" Steel.
Connecting rods 13 feet 6 ins long.
Cranks $8^1/_2$" thick. Wrought iron.
Crank shaft-necks 11" × 20" Steel.

Crank shaft-largest diar.	16".	Boiler pump	4 in. diam.
Frames	12 in. deep.	Boiler pump stroke	14 in.
Air pumps	21 in. dia.	Fly pulley	30 feet diam., 5 feet 9 in. wide. Weight 38 Tons.
Air pumps stroke	26 in.		
Condenser	28 in. diam. 4 ft. long.		

Though the details of the cut-off motion, represented in Fig. 184 to Fig. 186 shew the expansion arrangement applied to the high-pressure cylinders, it is also applicable to all classes of Steam Engines: vertical or horizontal and whether working on the compound or single cylinder principle.

The steam-ports of these cylinders are of the ordinary kind, and have slide valves (GG_1) Fig. 182 worked by the eccentrics in the usual way, with just enough lap to give a free exhaust, while affording ample space for the admission of steam. Upon the back of each of these valves, are cast a series of ports, which are provided with what is known as a „grid-iron" valve, carried by the main valves, but left free to move at right angles to them. These grid-iron valves derive their motion from a cam *b* (Figs. 182 and 183) fitted loose on a sleeve *c* (Figs. 185 and 186) of cast iron, in which is cut a helical or spiral slot, extending half way round the circumference, fitted on an upright shaft *d* (Fig. 184) the top of which is hollow with a vertical slot in it. These slots are connected by a steel die *f* (Figs. 185—186) fitted on the end of a rod, in two parts, the lower part revolving with the shaft, which makes exactly the same number of revolutions as the engines, connected to the upper part by a coupling box, which is screwed and moved up and down by means of friction discs *g* (Fig. 184) connected directly to a governor and a pair of bevel wheels, the rod passing through the larger wheel which is threaded to suit the screw on rod. The action of the apparatus is as follows: The leather wheel or cone worked by the friction discs remains stationary, when the engines are running at the proper speed with ordinary weight on, but if the speed slackens, (in consequence of a fall in the boiler pressure, or the addition of machinery) the balls of the governor collapse, and bring the upper friction disc into contact with the leather bowl, the motion of which is transmitted to the large bevel wheel, causing the vertical rod to be screwed down, thus lowering the die in the helical slot, twisting back the cam, bringing it later into action, and continuing the steam longer on the piston, until the impelling and retarding forces are balanced. If the speed of the Engine quickens, the opposite action takes place, the cam is shifted forward on the shaft, and the steam „cut-off" sooner.

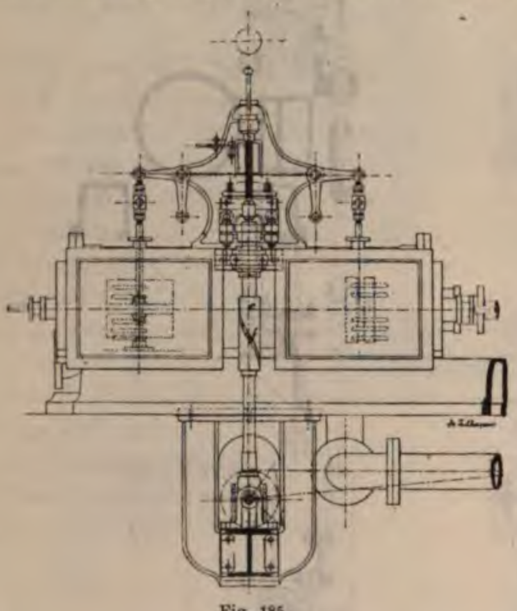


Fig. 185.

It will be seen from this description, that the apparatus is calculated, closely to meet, the requirements of perfect expansion, combined with steadiness of motion. The ports being wide, open and afford unrestricted admission to the steam till cut-off ensues, and a pressure is obtained on the piston, almost equal to that in the boilers. The travel of the expansion valve being short, and the action of the cam rapid, the steam is almost instantaneously cut-off. The governor, regulating the grades of expansion, being driven at a quick speed is peculiarly sensitive, while the short distance, it is arranged to travel, makes its action at once felt upon the engine, and preserves uniform speed.

In Figs. 187—190 we illustrate a set of Indicator diagrams, taken from one of these Compound Engines, which diagrams, certainly bear out the preceding remarks.

Figs. 187—190.

d. Expansion-gear of C. Prött, of Berlin.

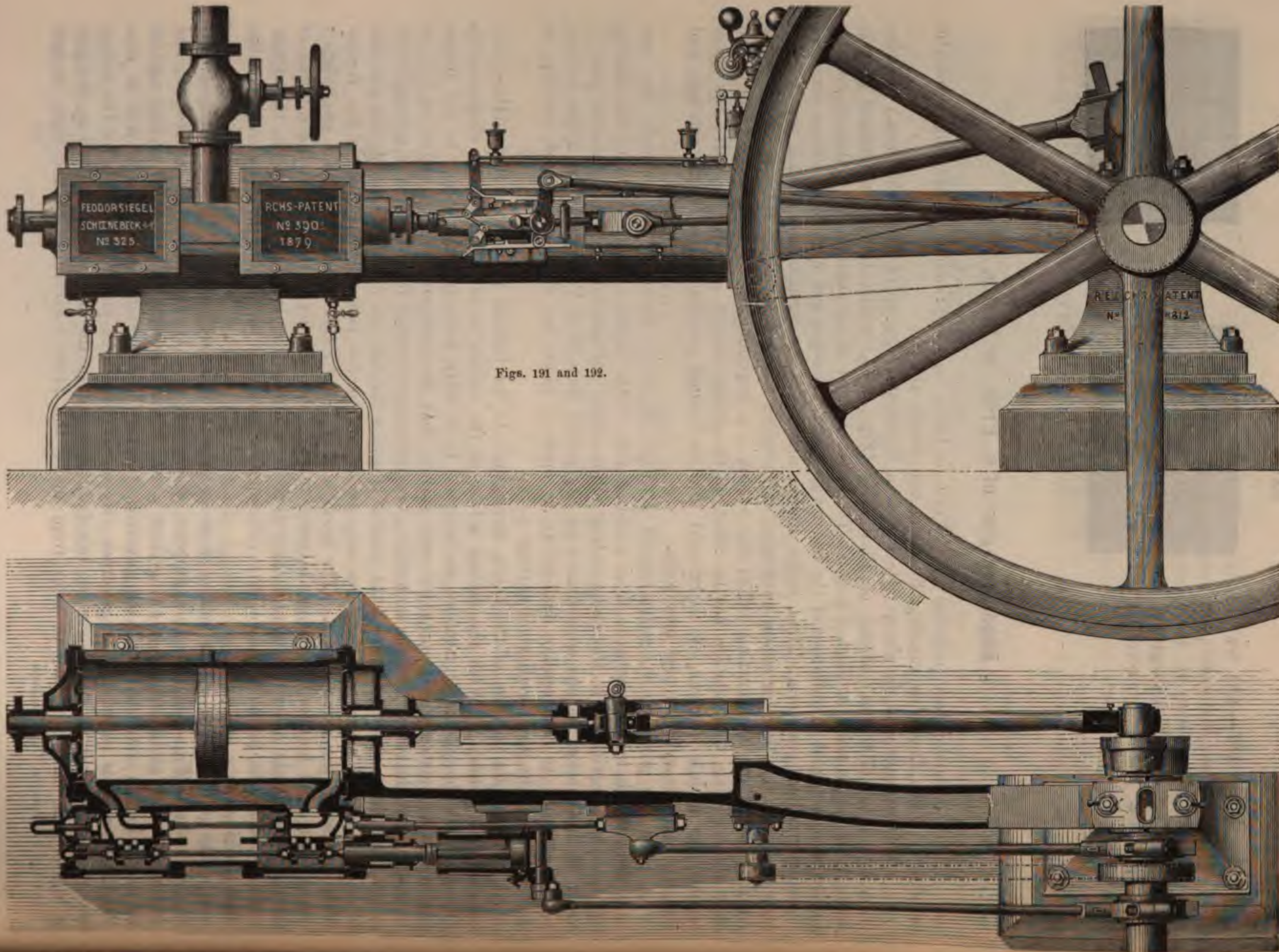
The Expansion-gear patented by C. Prött, is based on the principle, of effecting automatic cut-off whilst the Engine is running, by using one simple slide.

This arrangement, is shewn attached to a Horizontal Engine of $13^3/_4$" (350 mm.) cylinder diam. and $27^1/_2$" (700 mm.) stroke on Plate XXI (Figs. 1—4,) whilst the disengagement gear is drawn to a larger scale in Figs. 5 and 6. To obtain a short steam-passage, the balanced slide is divided into two, and in imitation of the Rider valve-gear, its edges and cylinder ports are arranged in slanting helical positions. Thus, if the slide is moving in the direction of its axis, the cylinder ports are opened, either for steam admission or emission, whereas a sudden rotation of the valve round its axis, implies shutting off of the steam, *i. e.* beginning of expansion. Owing to the large slide-opening, this rotation has no effect on the steam-exhaust. When the valve has again assumed its middle position, it is brought into its normal position by a return rotation, and then the opposite cylinder port may open.

For this purpose, the valve-spindle F (Figs. 5 and 6) driven by an eccentric, has two levers $a\,a_1$, which take up between them a sliding ring b; the levers $c\,c_1$, are let in to this sliding ring and they participate in the reciprocating action of the valve-spindle. The top saddle piece e, owing to this motion, swings as indicated by the dotted lines (Fig. 5). Against its upper surface, a pin f attached to the peculiar dash-pot O, is made to glide, and these two pieces, are kept in gliding contact, by two small steel springs s.

The middle position of the valve, corresponds to the highest position of the saddle-piece e and dash-pot piston Q. With the falling action of the saddle to either side, one steam-port is opened whilst the piston Q remains stationary. It is only subsequently, owing to the steam-pressure on the piston y (also provided with spring) that the dash-pot piston Q begins to fall, so bringing about the rotation of the main-slide; expansion consequently begins. This is accomplished, by coupling the connecting-piece of the pistons Q and y through pin h and the two levers $g\,g$, and rods $k\,k$, in such a manner to the lever $a\,a_1$, as to prevent the latter taking part in the reciprocating motion of the valve-spindle. The lower end of the rod k is furnished with a steel-plate l resting on a steel bolt m. Therefore, in order to close the cylinder port, through the rotation of the valve, it is only necessary to pull the bolt m from under the plate l, because then, the steam-pressure forces the piston Q down, the valve-spindle receiving the desired rotation owing to the lever combination a and g.

The pulling back of the bolt m is under governor control, the latter being arranged over the crank-shaft. (Fig. 2.) For this purpose, a cam-disc r is keyed fast on the crank-shaft, and its circumference glides against a swing-piece q, which as it is pressed outwards, presses against the wedge link p connected with the governor. Owing to the wedge form of p, it will be seen that the more it is raised by the governor, the sooner will it be pressed outwards by the swing-piece q, and vice versa. Moreover as this link is linked to the bolt m, by the rod n, the bolt m will become drawn sooner or later from under the plate l according to the high or low



Figs. 191 and 192.

position of the wedge link p. The spring v placed behind the bolt, lands the latter again under the plate l the moment the dash-pot piston is in its highest position.

We may add that we are informed that at the Works of Mr. Freund of Charlottenburg near Berlin, Prött's Expansion valve-gear was substituted, in place of the Meyer valve-gear attached to the Engine. The result was a very marked economy in the consumption of power, and the regularity of speed of the Engine so refitted, has been pronounced to be blameless, even under the most variable loads.

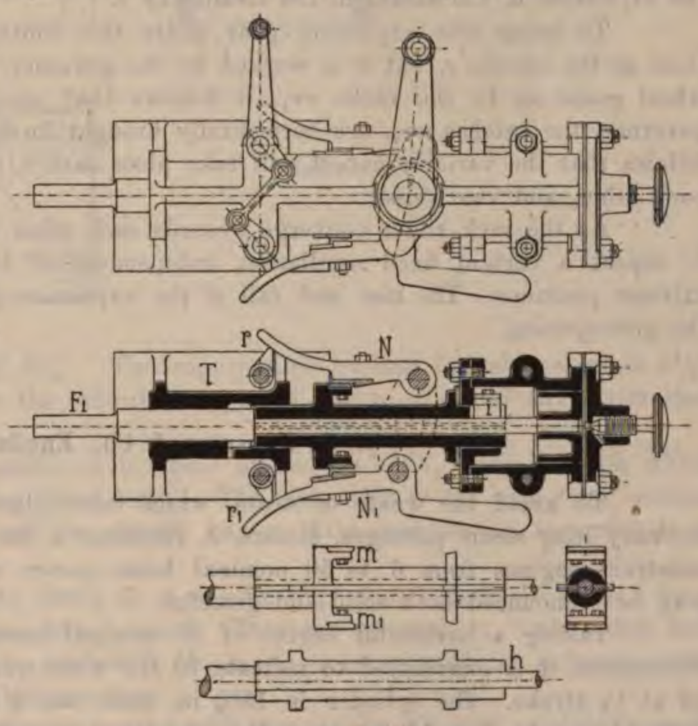
e. Feodor Siegel, of Schönebeck on Elbe.

(Type: F. A. Schulz.)

On pg. 120, we described Schulz' valve-gear, and we may now add that it is constructed in a modified style by the Engineering Works of Mr. Feodor Siegel, at Schönebeck. We represent this modified arrangement, in side-elevation and plan-section in Figs. 191 and 192, as attached to a Horizontal Engine.

The alteration made in this valve-gear, chiefly consists in the application of a divided valve. On the other hand, the through-ported rigid plate between expansion valve and main slide, has been retained. With each stroke, the expansion-plates are jointly pushed to the left, so opening the steam-way of the intervening plate. As the motion of these expansion-valves, is obtained from a second eccentric, the range of cut-off lies between 0,0 and 0,75 stroke. The steam pressure on the thickened valve-rod, effects the prompt return-travel of the expansion-plate.

The former somewhat complicated external valve-gear, has also been simplified, as may be seen on referring to the annexed Fig. 193—197. In this arrangement the gearing of the trigger NN_1 on to the valve-spindle F_1 is not direct, but is effected by a coupling-clutch mm_1 catching behind a collar-piece of the spindle F_1. This coupling arrangement is introduced, with a view of obtaining higher grades of cut-offs, with only one expansion-eccentric.



Figs. 193—197.

We may further draw attention, to the crank-shaft bearing, patented by Feodor Siegel, and illustrated in our Figs. 198—200. The construction is at once explained by our woodcuts, its object being the prevention of undue strains on the crank-shaft, so that we will only add that the last mentioned Firm, construct these High-pressure Engines fitted with the Schulz Automatic Variable-expansion Valve-gear in sizes from 10 *HP.* upwards, calculating these for a steam-pressure of 6 atm. and a normal cut-off at $^1/_5$ stroke.

f. J. Fish, of Summit, (U. S. A.).

The double slide-valve gear represented in our Figs. 201 and 202 was designed by J. Fish of Summit (U. S. A.) The expansion arrangement is worked from a separate eccentric, and for reason of its great simplicity this valve-gear, requires little attention in working it. For securing short steam-passages, a separate valve is used for each cylinder end, though these two valves GG_1 are rigidly connected together, so that the motion of the eccentric rod E may be equally transferred to the latter. As aforesaid, motion is imparted to the expansion gear, by a separate eccentric rod E_1 permitting cut-offs between 0.0 and 0.7 to take place, under the control of the governor.

Two expansion plates HH_1 are fitted to the working lever shewn in Fig. 201, and resting at times on the main-slide GG_1 they effect the variable shut-off. In this illustration, the piston K is at half-stroke, and as the port e is open, whilst the port e_1, is in communication with the exhaust, this piston is moving in the direction of the inscribed arrow. Our drawing shows that the main-slide can slide under the temporary motionless rocking lever. To obtain the rocking movement of the latter, its centre-pin Z carries outside the valve box, the peculiarly formed lever N (vide Fig. 202). The latter is furnished with two racks rr_1, fitted with catches nn_1, these racks being made so as to slide in the bracket N as shewn by the dotted lines. These catches gear alternately on to similar catches oo_1 arranged on the slide rod A moved by the eccentric-rod E_1. Assuming the latter to move in the direction of the inscribed arrow, corresponding to the position drawn in Fig. 201 the catches n and o come into gear with each other, and as A is not able to disengage itself, the lever N along with centre-pin Z is turned; in other words, the plate H is brought steam-tight on to the main-slide G, owing to the steam-pressure in the valve-chest, and the expansion of the steam in the steam-way e.

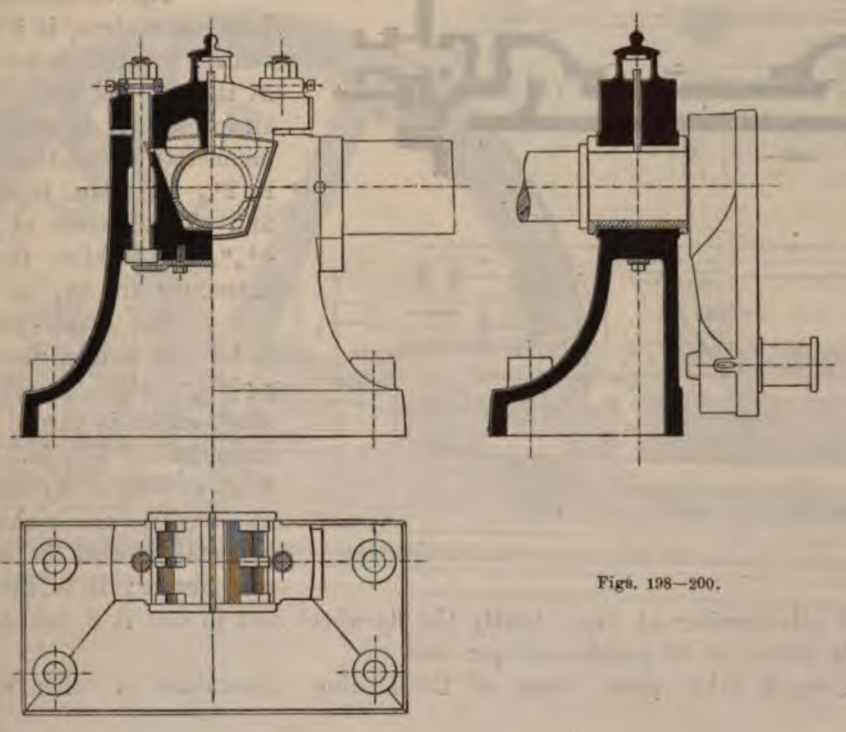
To bring this expansion-gear under the control of the governor, a toothed wheel sits loose on the spindle z, but it is worked by the governor, through the lever R and rod M. As this wheel gears on to the racks rr_1, it follows that according as the lever R is actuated by the governor, the catches nn_1, are horizontally brought further apart from or nearer to each other. It follows that the variable cut-off will take place earlier, the nearer the catches nn_1, are brought to each other, and vice versa.

As the rack-slides converge towards each other at the bracket-end, the lever N is forced to repeat a certain fixed oscillation, independent of the catches nn_1, being in their middle or extreme positions. The rise and fall of the expansion plates need not exceed half the width of the port-opening.

g. A. Ransome & Co., Engineers, London.

To avoid the waste of steam, which takes place at each stroke with engines having the ordinary long steam passages, Messrs. A. Ransome & Co. of the Stanley Works, Chelsea (London) construct engines from 6 to 50 nominal horse power with short steam-ways, to a design which may be pronounced both solid and graceful.

Taking a horizontal engine of 20 nominal horse power, for the purpose of our present description, it is guaranteed to indicate 70 *HP* when working with steam of 60 lbs. and cutting off at $^1/_2$ stroke. The cylinder is $13^1/_2$ in. diam. and 2 ft. 3 in. stroke, and it is bolted to the engine-frame by four $1^3/_8$" bolts. Its cylindrical surface is steam-jacketted. The external diameter of the internal shell is $14^3/_4$ in.; the steam film in jacket $^3/_4$ in., and the external diameter of external shell is $18^1/_2$ in. The latter is next covered with felt and then lagged with strips of polished mahogany, and this felting and lagging is continued over the entire valve-chest excepting its two covers and steam-supply pipe. The steam-jacket is in direct communication with the valve-chest and is drained off at the bottom. The exhaust chamber is 2′ 6″ long, and its inner vertical side is $12^1/_2$ in. distant from cylinder centre; the exhaust ports each $1^1/_4$ in. wide, are arranged at each end of the exhaust space which communicates with the exhaust pipe ($4^1/_2$ in. internal diameter). They are separated from the cylinder steam ports ($^7/_8$ in. wide) by metal-sides $^3/_4$ in thick. The internal distance between cylinder-covers being $32^3/_4$ in. the piston 5″ thick, and the stroke being 27 in., it follows that the clearance space at each end is $^3/_8$ in. The centre line of main-valve-spindle is $15^5/_8$ in., off the cylinder axis, and that of the expansion valve 1′ $7^3/_8$″, and the distance between valve-chest vertical side (internal) and cylinder-centre is $21^1/_8$ in., whilst the



Figs. 198—200.

internal length of valve-box measures 3′ $8^1/_2$″. The supply pipe leading to valve chest is $3^1/_2$″ diam. The openings from the cylinder to the exhaust are placed low to drain off any water that may be formed in the cylinder.

The main-slides are fitted on a spindle (1 in. diam.) bushed by a $1^3/_4$″ tube, through which they are kept 23 in. apart, this tube being 23 in. long. — The main-slide is set with $^{11}/_{16}$″ outside lap, $^1/_8$ in. inside lap, and $^1/_{32}$ in. lead, and its spindle has a three inch stroke imparted to it from its corresponding eccentric.

The expansion-slides are similarly fitted on a spindle ($^3/_4$″ diam.) similarly bushed by a $1^3/_8$″ tube, through which they are kept is $30^1/_2$″ apart. They are set with $^9/_{16}$″ minus lap, and are each $2^1/_2$ in. long, having a variable stroke of $1^5/_8$ in. to 4 in. effected by eccentric with changeable positions, directly controlled by governor.

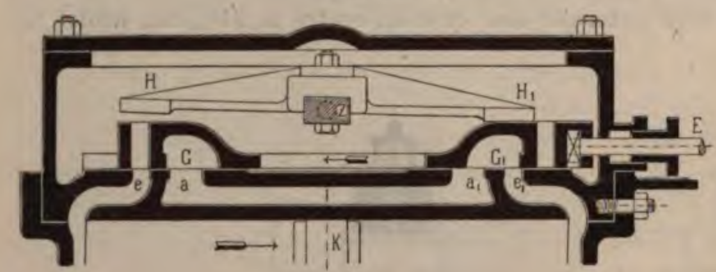
Both valve-spindles have their left ends bushed with brass-tubing allowed to slide through stuffing-boxes in the hind valve-cover; their fore-ends are guided by a bracket-support bolted to the engine bed.

The feed pump is similarly bolted to the engine frame, and is worked from a third eccentric mounted between the crank-shaft wheels, with a 4 in. stroke; its suction end is $2^{1}/_{2}$ in. diameter and its delivery end $1^{1}/_{2}$ in. diam. The tail-end of this eccentric is attached to a hollow piston-plunger.

The piston rod $2^{1}/_{8}$ in. diam. is tapered at each end to receive piston and cross-head.

The double slide-bars are $4' \, ^{3}/_{4}''$ between bolt-centres; the bottom slide with end-uprights are cast in one with the engine bed.

Fig. 201.



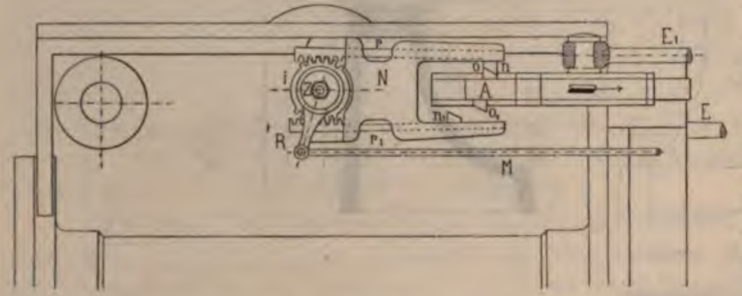


Fig. 202.

The top slide-surface is $2^{7}/_{8}$ in. from piston centre line, and the latter is $3^{3}/_{8}$ in. from bottom slide. The top-slide has oil-receptacle in centre.

The connecting-rod 6 ft. long between centres, is $3^{1}/_{2}'' \times 2^{5}/_{8}''$ at its centre, tapered down to $2^{1}/_{4}'' \times 2^{1}/_{4}''$ at its butt-end and $2^{3}/_{4}'' \times 2^{5}/_{8}''$ at its strap end. It is attached in the usual manner to the motion-block pin, which is $2^{3}/_{8}$ in. diam. tapered towards its nut. The brasses at its butt-end are $4^{1}/_{4}''$ wide, whilst those at its other extremity are $3^{3}/_{4}$ in. wide.

The crank-pin $2^{7}/_{8}$ in. diam. is let into a cast disc ($2' \, 8^{1}/_{2}''$ diam. $\times \, 3^{1}/_{2}''$ wide) keyed on the crank-shaft which is turned to one uniform diameter of $5^{1}/_{4}$ in. but reduced to $4^{1}/_{2}''$ outside of fly-wheel.

The crank-shaft ($7^{3}/_{4}$ in. wide) pedestal is cast in one with the engine frame; it is fitted with brasses 9 in. wide, and oil-chamber at top. Lastly the fly-wheel cast in one is 8 ft. diam. by 11 in. on the face, and is driven at 80 revolutions per min.

The annexed table gives some of the leading dimensions of other sized Engines of this type:

Nominal Horse Power.	Diameter of Cylinder.	Length of Stroke.	Revolutions per Minute.	Diameter of Fly-wheel.	Width of Fly-wheel.
6	7 in.	14 in.	170	4 ft.	7 in.
8	8	16	145	$4^{1}/_{2}$	$7^{1}/_{2}$
10	9	18	120	5	8
12	10	20	110	6	9
16	12	24	90	7	10
25	15	30	70	9	12
30	$16^{1}/_{2}$	33	65	$10^{1}/_{2}$	13
40	18	36	58	12	15
50	21	42	50	14	17

h. W. Benson, Engineer, Nottingham.

In Figs. 203 and 204 we give two side views of a Horizontal High Pressure Expansion Engine, constructed by Mr. W. Benson, Engineer of Nottingham. It belongs to the engine-type now under discussion, and in the construction of this Engine the bearings for carrying the crank shaft

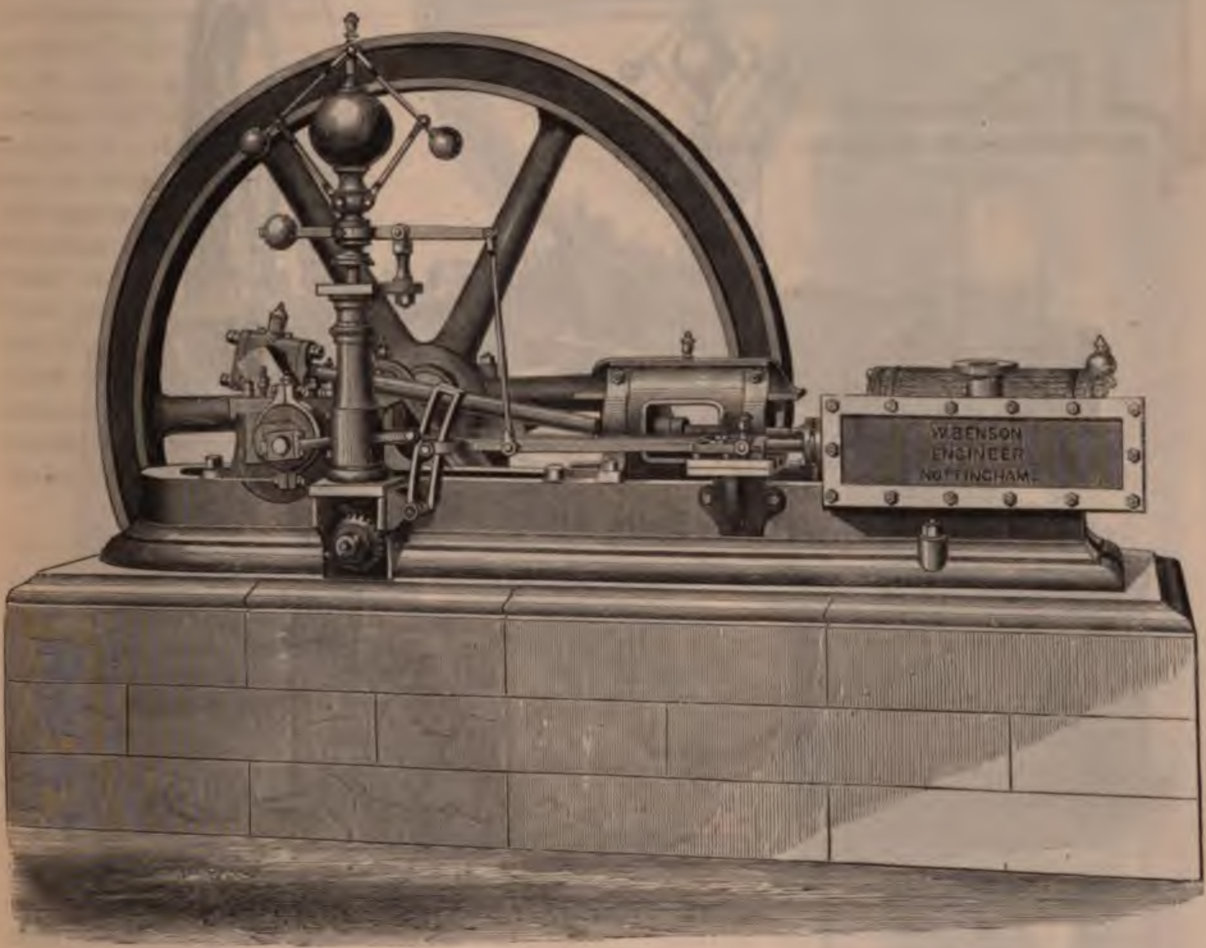


Fig. 203.

are cast on the Engine Bed: they support the crank close up to the web. The bearing brasses are in 4 parts, and can be closed up horizontally by a wedge, having the wide side at the top. This wedge, acts on the side brass and is forced down by a hollow screw of large diameter, fitting in a hole chased in the pedestal cap. Another bolt, passes through both the wedge and the hollow screw, with the head on the under side or narrow edge of the wedge; by these means, the wedge is forced down parallel, by the turned end of the hollow screw and is locked fast by the bolt drawing up the wedge.

The slide bars are both capable of adjustment; the bottom one is bolted to a vertical rib cast in the recess in centre of Engine bed. The slides are fitted with a setting-up screw, at each end. The top slide bar is clipped between the 2 castings covering the cross head, and it can be lowered as required. The cylinder has a long steam chest cast on, and is arranged with short steam passages at both ends. The valve-gear consists of 2 long valves, one working on the back of the other,

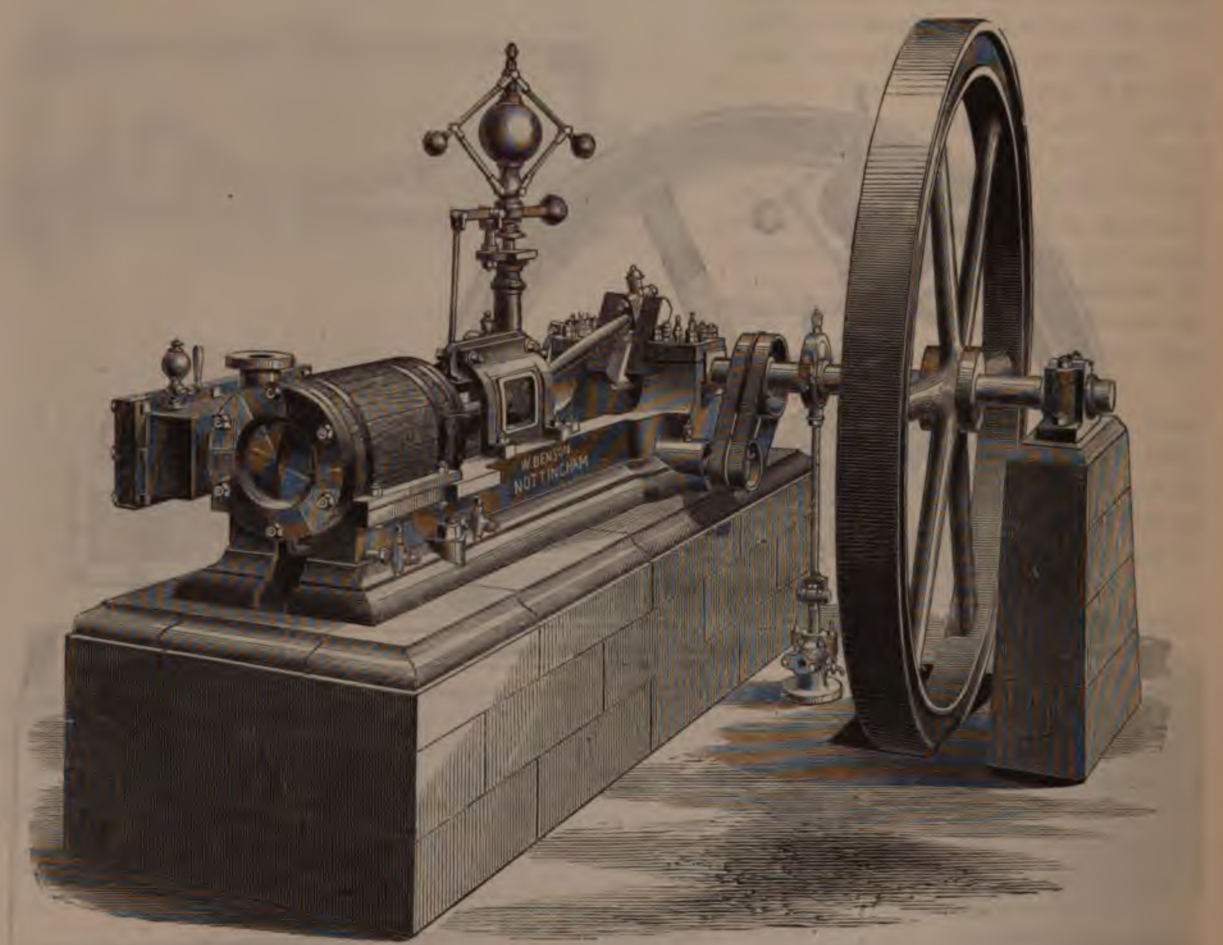


Fig. 204.

the main valve receives its motion from an eccentric on short end of crank shaft. The expansion or cut off valve is worked from a small crank, also on the outer end of the same shaft; a fork connecting rod from this crank gives motion to the link, through which a variable rate of expansion is effected. By the governor raising, or lowering the valve rod in the slotted link, the travel and point of cut off is accordingly varied. The cross-heads, to which the slide valve spindles and rods are attached, have large bottom surfaces; they are of wrought iron and are fitted with brasses and screw adjustment and work in a long slide carried by a bracket, screwed to the side of the bed. The governors are of the high speed type; they are carried by a polished column fixed to the engine bed, and are worked by a shaft, passing through the bed, at the end of which, is a double pulley, driven by 2 belts from a similar pulley or crank shaft, either of which is capable of properly driving them. It is thus sought to reduce the objection to belt-driving to a minimum. The governors and governor motion are arranged, to be in the same line as the valve rod; the governor spindle revolves between the fork connecting rod that gives motion to the link. The large sizes of these Engines have wrought cranks keyed on, with the valve gear driven by a fly-crank.

Fig. 205.

i. Friedrich Wannieck of Brünn.

In 1874, a new expansion valve-gear was constructed, by the Engineering Firm of Friedrich Wannieck of Brünn, which has been since patented in almost all European Countries, as well as in North America. The builders (Messrs. Wannieck & Köppner) here abandoned their rather complicated Corliss-gear modification, and substituted a far simpler trip-gear, working with slide-valves. In this arrangement the main-slide and expansion-slide, sliding on each other, are arranged in separate valve-chests, one eccentric-rod being only used. These valve-chests, are placed at the side of the cylinder, parallel to its longitudinal axis.

Front and back elevations of this elegant Engine, are shewn in the annexed Figs. 205 and 206. We have grouped, the external valve-gear, together with longitudinal section through cylinder, and the relative positions of the main and expansion-slides to each other during various positions of the crank in our Figs. 207—217.

The slides are worked from one eccentric only, the latter driving direct the main-slides $a a_1$ arranged at each cylinder end, and working the expansion-valves $c c_1$ by

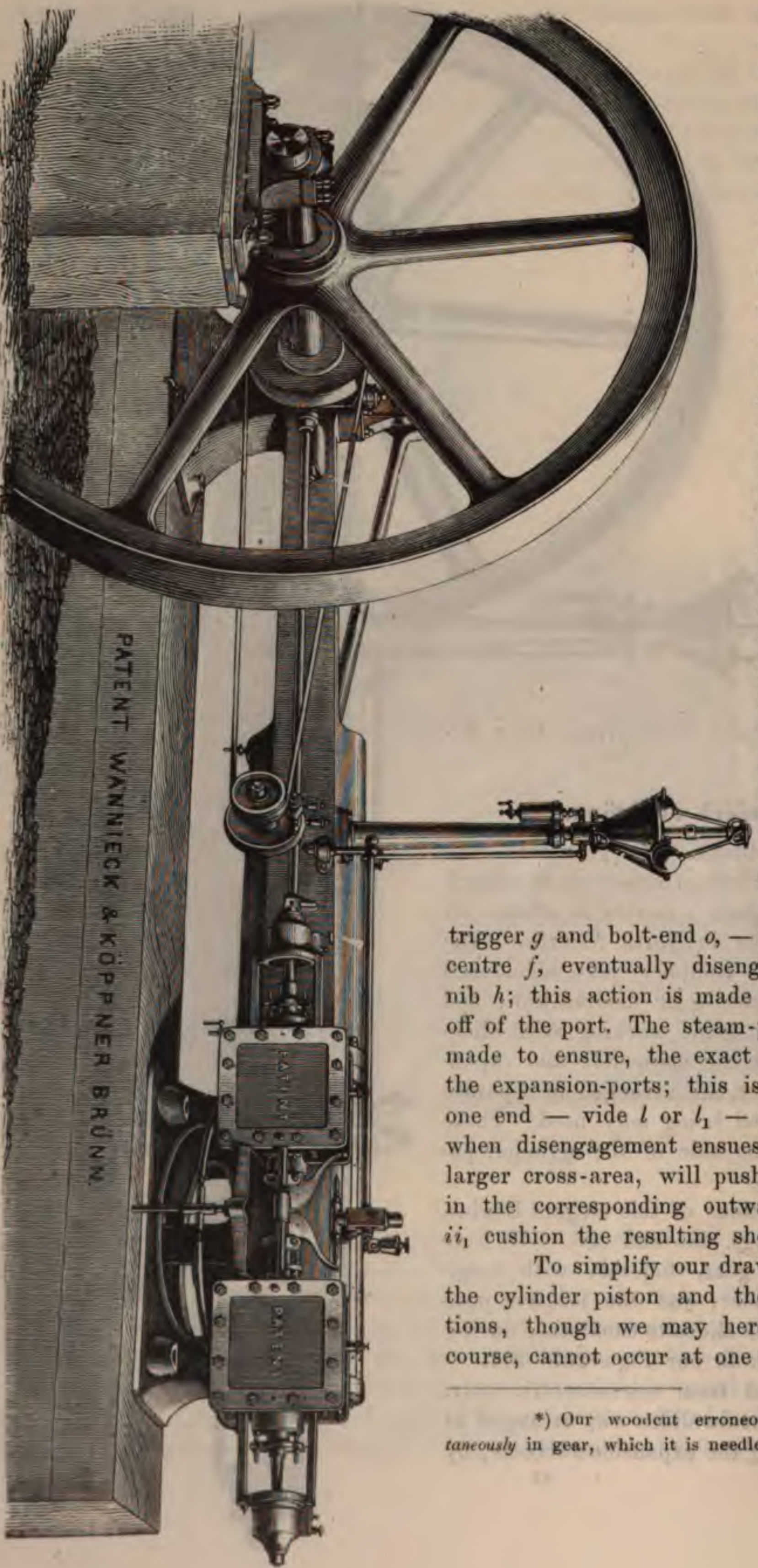


Fig. 206.

the intervention of a trip-gear arrangement. Hence it follows, that the range of automatic cut-off is limited, in the same degree as the simple Corliss-engine, whereas a full supply of steam during the entire stroke ensues, when no disengagement takes place. The main-slides aa_1 are connected together by the rod b, carrying a bracket d which forms the slide of the valve-spindles ee_1 fitted with steel nibs hh_1. This bracket is also furnished, with steel trigger catches gg_1 arranged on the hinges or pivots ff_1 which alternately *) come into gear with the nibs hh_1 of the valve-spindles ee_1, so regulating the opening or shutting off of the expansion-ports. The motion imparted to this trigger-bracket, causes one of its triggers g or g_1 to come sooner or later into contact with a sliding bolt oo_1 which is under governor control as shewn in Fig. 209. After contact has taken place, — between say trigger g and bolt-end o, — the former will swivel on its centre f, eventually disengaging the catch g from the nib h; this action is made to correspond to a shutting-off of the port. The steam-pressure in the valve-chest, is made to ensure, the exact instantaneous shutting-off of the expansion-ports; this is accomplished by thickening one end — vide l or l_1 — of the valve-spindles, so that when disengagement ensues, the steam-pressure on the larger cross-area, will push the expansion valve-spindle in the corresponding outward directions; the dash-pots ii_1 cushion the resulting shocks.

To simplify our drawing Fig. 208, we have drawn the cylinder piston and the valves in their middle positions, though we may here again observe, that this, of course, cannot occur at one and the same time. For this

*) Our woodcut erroneously shews both catches $g\,g_1$ simul*taneously* in gear, which it is needless to add could *never* occur!

reason, the travel of the main and expansion valves, is not to be inferred from this illustration; yet in order to represent graphically, the relative positions of these valves, we reproduce the latter in Figs. 210—217. In Figs. 210 and 211, the piston is moving to the left, since the left end of the cylinder, is in free communication with the exhaust through its valve a, whilst

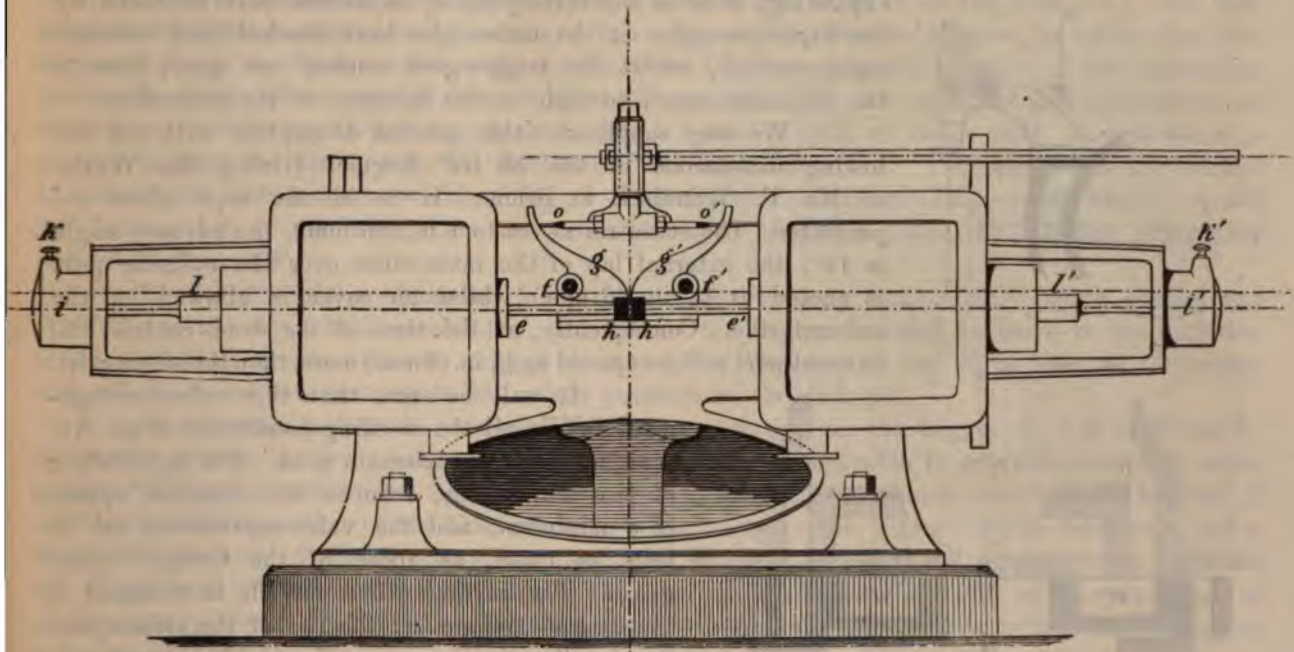


Fig. 207.

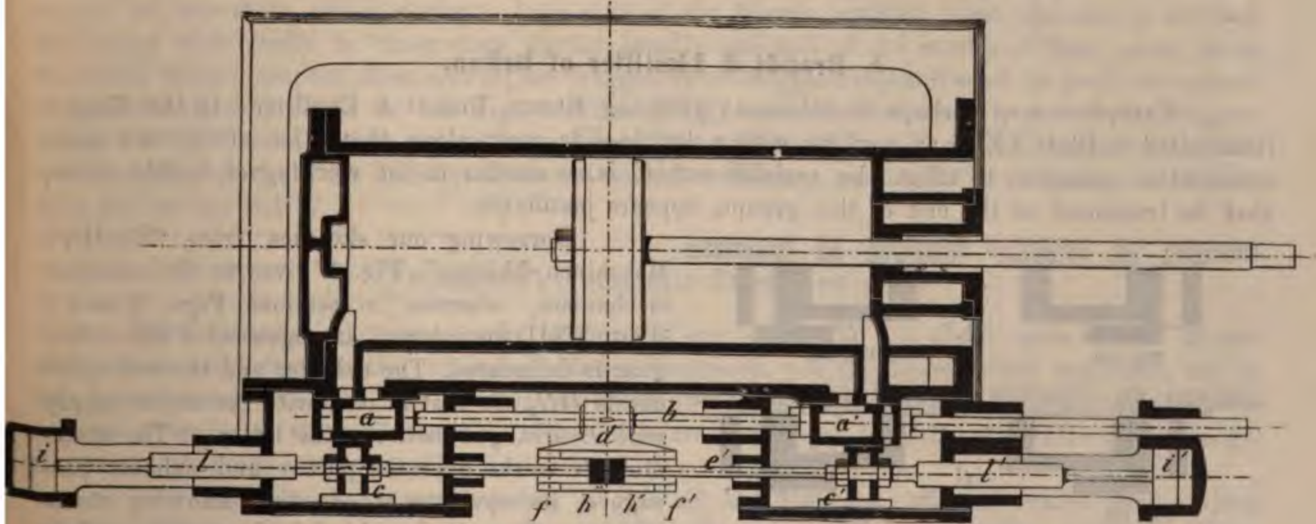


Fig. 208.

expansion is taking place in the right end, inasmuch as the expansion valve port, is closed by the plate c_1. The valves a a_1 have assumed their extreme left travel, the trigger g is about getting into gear, and the expansion-valve c and main slide a are on the point of moving uniformly to the right. As soon as the crank is on its left dead centre, the position of the valves will be, as shewn by Figs. 212 and 213. The unequal lineal lead of the two working edges is apparent from these woodcuts. In Fig. 215 the right hand cylinder port is fully exhausting, whilst in Fig. 214, the left hand cylinder-port is still open with the left expansion-valve c_1, still remaining in its extreme right-position. Fig. 216 and 217 are analogous to the Figs. 210 and 211. The steam in the left cylinder portion is expanding, because the corresponding expansion port is closed by the expansion-valve c; the main-slides have reached their extreme right position, whilst the trigger-gear coming into gear, permits the expansion-valve, to slide in the direction of the main-slide.

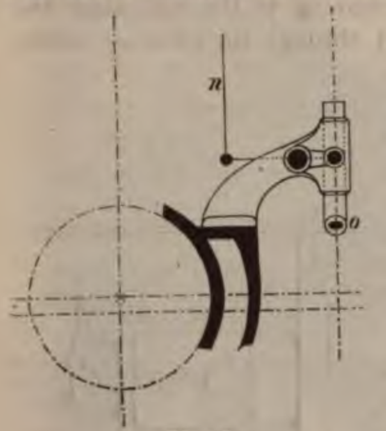


Fig. 209.

We may supplement this general description with the following dimensions of the 30 *HP* Engine, driving the Works of Mr. F. Wannieck at Brünn: It is of the type above represented. The eccentric is set to 1 in. (26 mm.), the advance angle is 12°; the external lap of the main-slide over the cylinder port is quoted at $^1/_8$ in. (3 mm.) whilst no cover is allowed on the exhaust side. Consequently, at the time of the dead-centres, the exhaust port will be opened by $^1/_8$ in. (3 mm.) more, than the steam-port.

Fig. 210.

A

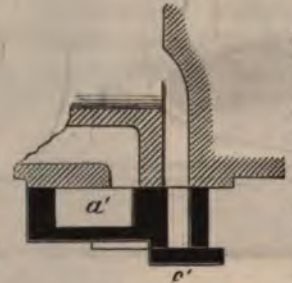


Fig. 211.

It will be seen, that this valve-arrangement fulfills all the working conditions of an Automatic variable expansion gear. The application of two main-slides, reduces the clearance spaces to a minimum, and the valve-movements are at least as rapid, as those of the Corliss valve-gears. The instantaneous cut-off, is obtained in the easiest manner by the use of the steam-pressure, and lastly the range of variable expansion is equal to that of simple Corliss-engines.

k. Brandt & Lhuillier of Brünn.

Exception may perhaps be taken, at grouping Messrs. Brandt & Lhuillier's 12 *HP* Engine (illustrated on Plate XXII) as working with a double-slide gear; alone, the action of the two separate slides, arranged to effect the variable cut-off, is so similar to the working of double slides, that its treatment at the end of this groupe, appears justifiable.


Fig. 212.

B


Fig. 213.


Fig. 214.

C


Fig. 215.


Fig. 216.

D


Fig. 217.

Borrowing our sketches from "Riedler's Maschinen-Skizzen", Fig. 1 gives us the external mechanism, whereas in sections Figs. 2 and 3 (Plate XXII) the internal arrangement of this valve-gear is delineated. The cylinder and the two valve chests HH_1 are cast in one, with the steam supply pipe E arranged between the latter. The main-slide G works over the port e and exhaust passage a, its cavity g at one time allowing steam to enter the cylinder through the port e, and at another time placing the latter, in direct communication with the exhaust a. By means of a suitable external mechanism, described lower down, the main-slide G — shewn in its central position in Fig. 3 (Plate XXII) — in moving to the right, admits steam to the cylinder, whereas it returns to its central position during the expansion-periods, when the steam-supply to the cylinder is cut off. With the succeeding stroke, the main-slide G travels gradually to the left, and then returns again to its central position. To accomplish this reciprocating motion, a single eccentric is used, which is connected through the eccentric rod B to an oscillating lever A arranged at the cylinder-side. The oscillations of this lever, may be varied, by setting the set-screw C accordingly. This lever gives motion to the trigger-bracket EE_1 arranged to slide on the rods KK_1. The last-mentioned bracket forms the swing-centres of two triggers NN_1 the steel nibs nn_1 of which, gear into the catch-plates oo_1 fitted on the valve spindle lever LL_1 owing to the pressure of the springs ss_1 forcing down the other arms of these triggers. These rods KK_1 are much reduced in diameter at their ends — vide kk_1 — and a piston is fitted loose on each of these ends, though steam is always pushing the piston k in the direction of the inscribed arrow. The main-slides are worked by wheel and rack motions — vide f Fig. 3 — off the external levers LL_1 — vide Fig. 1 —, and the bottom ends of the latter, have a square-opening to receive a pin ii_1 let into and protruding out of the rods KK_1.

To describe the working of this arrangement, we may conveniently again confine our attention to the right-hand mechanism and assume the trigger-bracket to move in the direction of the inscribed arrow. As the trigger N is in gear, the lever L, rod K, as well as the piston and valve, are moved contrary to the steam pressure in the dash-pot.

At a certain point, the vertical bolt r always resting on the trigger N, will be lifted by the latter against the wedge-formed bracket MM_1 which though able to move horizontally under governor-control, is otherwise rigid. It is apparent, that the continued travel of the bracket E and the unyielding action of the bracket MM_1, will disengage the trip-connection between n and o, when the pressure of the steam against the piston in the dash-pot O will rapidly force back the rod K and with it the lever L and consequently also the main-slide G; it will be observed that as an air-cushion forms in the dash-pot against the steam-pressure, the severity of this return motion is thereby deadened. As soon as the trigger-bracket, has resumed its middle position it becomes its duty to move the main-slide to the left, and for this purpose, the rods KK_1 have each a second pin zz_1 let into them, which works in long slots of the trigger bracket; these pins are so set that they may slide freely in these slots during exactly one half of the stroke of these parts, when the return takes place; but these pins zz_1 are dragged by the trigger-bracket E when the port e is required to exhaust into a. Thus in our Fig. 1 (Plate XXII) with the assumed travel of the trigger-bracket EE_1, it would drag the pin z_1, whereas the trigger N_1 would remain in gear whilst the corresponding piston of the dash-pot O_1 would remain stationary, on account of its being also loosely mounted on the rod K.

l. Sturgeon's Automatic Expansion-gear.

This arrangement, also works with only one slide, and one short valve chest. It certainly does not belong to the valve-group under discussion, yet the desire before expressed, not to admit too many sub-divisions in this work, coupled with its similar function, of regulating the ingress of steam to the cylinder, may allow us to treat this and the following valve gear arrangements under the present category.

The High-speed Air-compressing Engine of Mr. Sturgeon, offers a valve-gear, which adjusts with a remarkable nicety and simplicity, the supply of steam to the driving cylinder, according as the pressure of the compressed air in the receiver falls below or above the desired pressure, also eventually automatically stopping the Engine when a certain excessive pressure has been obtained. We give in Figs. 218 and 219 side-elevation and part plan section of this Air-compressing Engine, simultaneously shewing the automatic cut-off gear above alluded to. We shall confine our attention to the latter, as the other machine parts do not, at present, concern us. This regulating arrangement is effected in the following manner: An eccentric k, placed on the shaft d, acts on a

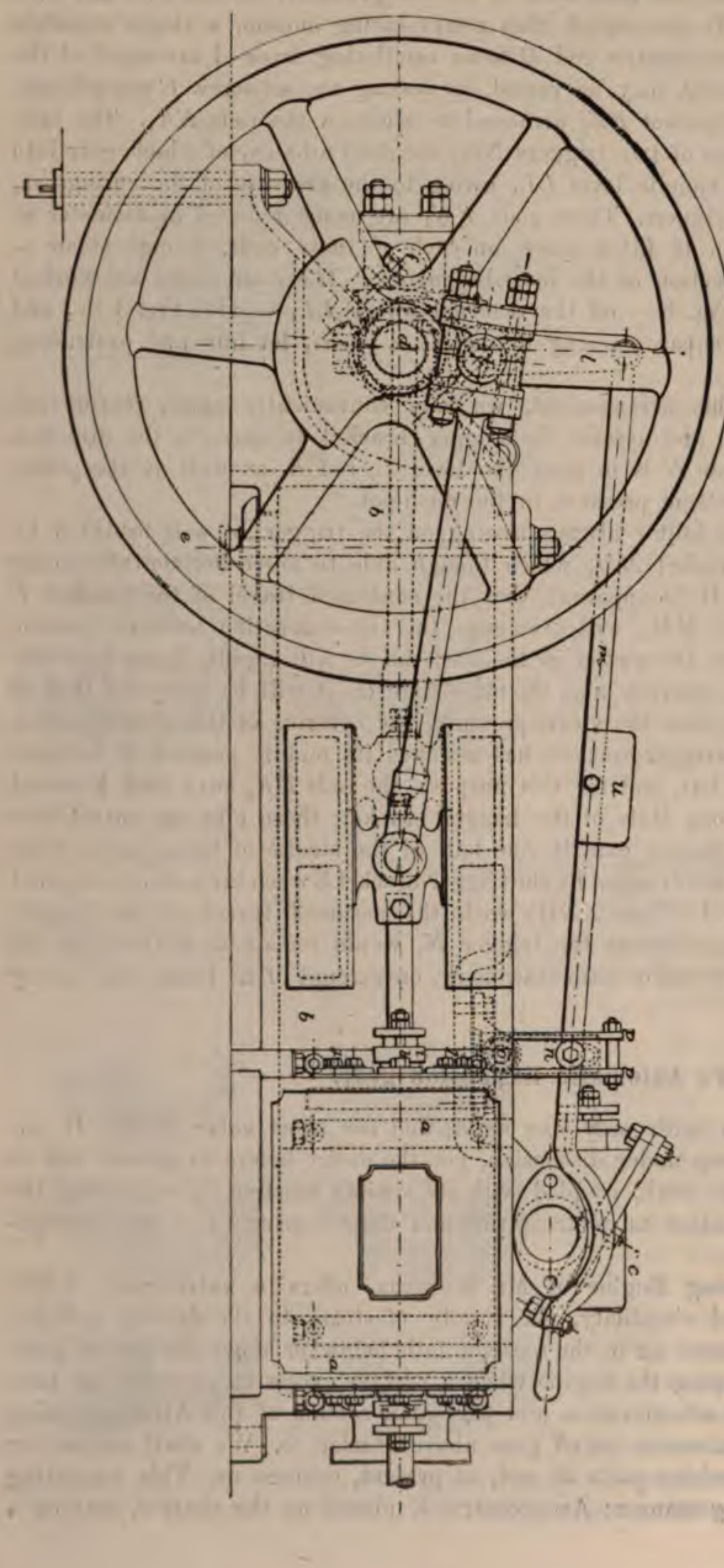


Fig. 218.

lever and rod *l m*, and gives a reciprocating motion to another lever *n*, from its centre *o*; the latter *o* being connected to a plunger, *q*, in the receiver, and sliding in the guides *pp*, becomes either raised or lowered in its position according as the pressure in the receiver *b* either increases or diminishes, that is, raises or lowers the punger *q*. A projecting pin *r* on the valve levers *s*, working from the fixed fulcrum *t*, gears into a groove in the whole length of the lever *n*. From this description, it is evident, that the more the centre *o* rises (which is caused as aforementioned by the air pressure in the receiver *b* increasing on the plunger *q*) the more will the stroke of the valve lever *s*, and consequently of the valve itself, be shortened, since the lever *s* owes its action to the lever *n*; this shortening of the valve-travel, means less steam to the cylinder, or in other words a slackening of speed. If, on the other hand, the required pressure in the receiver falls below the mark, then the plunger *q* falls in a corresponding degree, carrying with it the centre *o*, making the stroke of the lever *s* or of the steam engine cylinder-valve longer, consequently allowing more steam to enter, that is, increasing the speed of the engine. The engine is brought to a standstill, when the centre of the lever *n* comes opposite the pin *r* of the lever *s*, thus causing the movement of the latter to be entirely stopped, which materially also applies to the steam cylinder-valve. A sliding weight, *u*, is further carried by the lever *m*, which may be set, so as to take effect at any required ssure. Messrs. Clayton Howlett & Veuablès of London, now make this self-acting arrangement th a simple throttle-valve, worked either by hand lever, or this lever being directly attached to plunger-rod weighted to any desired amount with loose weights, closes or opens the throttle-

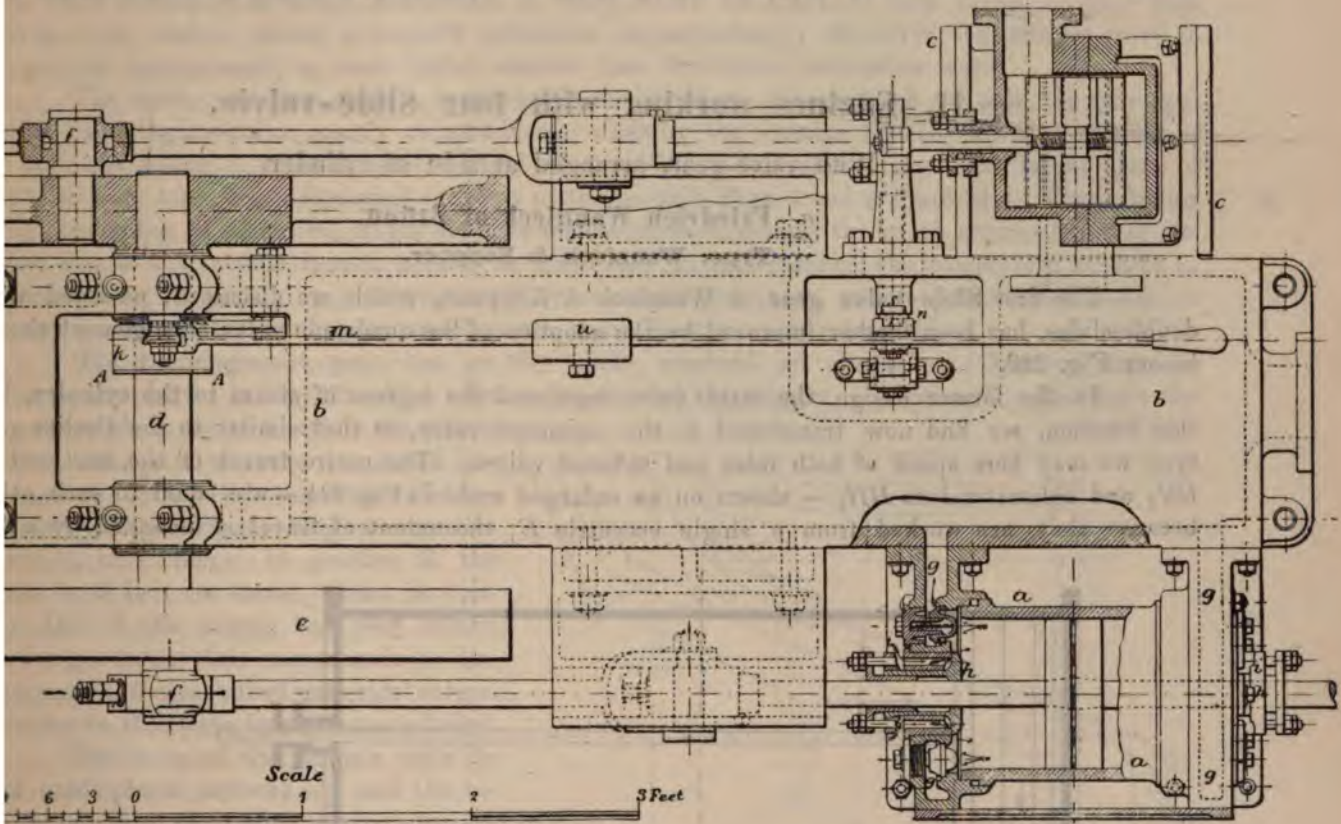


Fig. 219.

ve, according as the air-pressure, in the receiver, rises above or falls below, the desired working ssure. It is claimed that this arrangement acts almost without friction, and is consequently re sensitive, being also less complicated than the first-named method.

m. Halpin's Automatic Expansion Gear.

In this Automatic Expansion-gear Mr. Druitt Halpin has but one slide valve, and he ects all the desired changes of cut-off with this single valve without varying the lead or the nt of release. The valve used is of a very peculiar form, and it has two distinct motions given it, the one being a to and fro motion of the ordinary kind, and the other a movement of rtial rotation on an axis coinciding with the centre of the exhaust cavity, the extent of this t mentioned movement being controlled by the governor. No practical trials have as yet peared of this valve-gear, so that we refer those who may take an interest in this arrangement Engineering issue d. 6. June 1879 pg. 481, and we merely add that Messrs. Manlove, Alliott yer & Co. Engineers of Nottingham have undertaken the construction of Engines fitted with this ve-gear*), though apparently not with great success.

*) With a view of rendering the present Work as complete as possible and notwithstanding the many additions e in this Edition — Fig. 220 corresponding to Fig. 156 in the original issue — a Supplement will be found appended at the of this Volume for the purpose of including such valve-gears as may have been omitted from these pages, or which have been introduced during the compilation of this Edition. Compare also the Supplementary Volume referred to on pg. 129.

II. Engines working with four Slide-valves.

1. With valve-gear, arranged at side of cylinder.

a. Friedrich Wannieck of Brünn.

Type: Wannieck & Köppner.

The first Slide-valve gear of Wannieck & Köppner, which we discussed, as fitted with double-slides, has been further improved by the adoption of the quadruple valve arrangement shewn in our Fig. 220.

In the former design, the main-valve regulated the ingress of steam to the cylinder, but this function, we find now transferred to the expansion valve, so that similar to the Corliss-gear type we may here speak of both inlet and exhaust valves. The entire travel of the inlet valves GG_1 and exhaust-valves HH_1 — shewn on an enlarged scale in Fig. 221 — are equal to each other because they are worked from a single eccentric E; the extent of travel is indicated by *ae* in

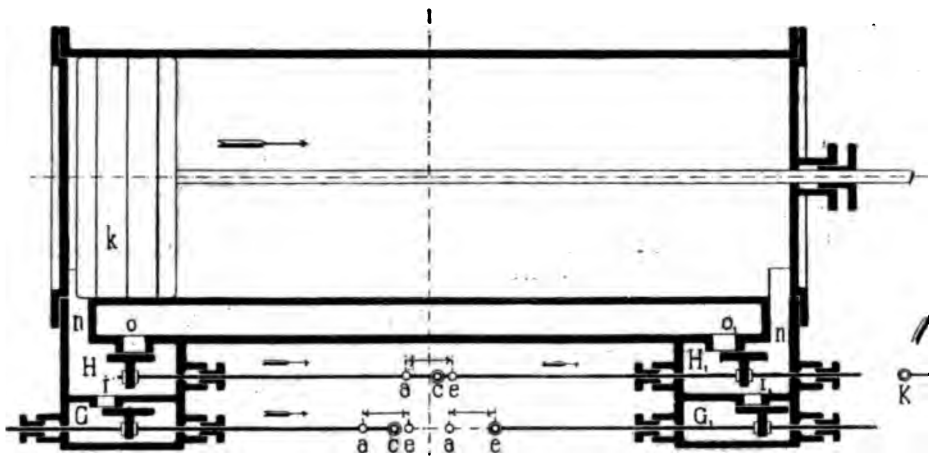


Fig. 220.

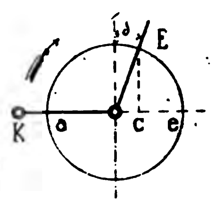


Fig. 221.

Fig. 220. According to the position represented by our woodcuts, the crank K is on its dead centre a and with the eccentric E set to the advance-angle δ, the latter has already performed the travel *ac*. Similarly, the valves are in the corresponding positions, the inlet valve G allowing the ingress of steam through port i, and the exhaust-valve H_1 simultaneously placing the port n_1 in communication with the exhaust passage o_1. Owing to the trip-gear arrangement, described lower down, the inlet valve G remains in its position e. On the other hand the exhaust-valve H takes part in the oscillating motion, without however having any effect.

On Plates 33 and 34 we show this valve-gear attached to a pair of Engines. Fig. 1 Plate 33) shews elevation, Fig. 2 plan of one of these engines, whereas in Figs. 3 and 4 we have plan and end-view of the coupled-engines. Plate 34 explains all the constructive features of the entire construction. The difference between the present and the forementioned type, will be seen to consist in the expansion valve no longer sliding on the back of the inlet valve, but in its having an independent seating of its own. Consequently, the valve required, is merely made flat instead of the former *D*-slide shape, shewn in our Fig. 208. It is true that this arrangement, somewhat enlargens the clearance spaces, alone the sliding of the slides on each other is obviated; such valve-sliding is specially detrimental in cases, where the travel of each varies, because then uneven wear occurs, which eventually occasions steam-leakage. Moreover the exhaust-valve in the present arrangement, is made rather smaller than the former main-slide was.

The dash-pots too, show a considerable modification, inasmuch as we find, the principal of the VIth Corliss-valve gear*) re-introduced, whereby the vacuum formed behind a portion of the dash-pot piston is utilised, for the rapid shutting off, of the inlet-valves. The larger area, of what we may term the differential dash-pot piston — vide Figs. 1 and 2 Plate 34 —, draws in air at the beginning of its stroke, which air becomes compressed, during the rapid return-stroke of the piston due to the vacuum formed behind its small end. In this manner, the compressed air acts as an air-cushion; its efficacy may be regulated by a suitable air-valve, and to prevent concussion at the termination of the stroke, the small piston has a leather washer inserted.

The disengagement-gear, has on the whole, received no alteration. Some of its main positions are drawn in Fig. 222. The extreme position of the trigger — position I — indicates the play required, in order to effect the timely getting into gear, whereby we should observe, that the whole distance travelled by the fall of the trigger only amounts to about 1/8 in. (3 mm.). In position II, the valve is at half its travel, whilst in positions III—V the trigger has been turned by the governor; this corresponds to disengagement, the inscribed numerical values, referring to the piston-travels accomplished.

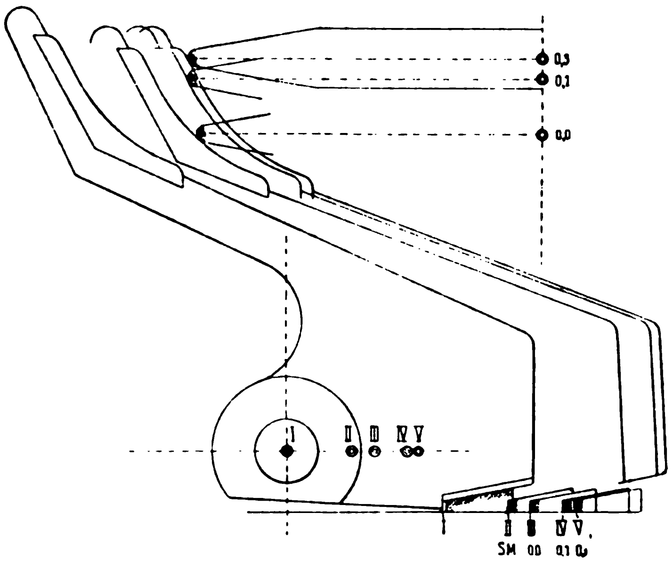


Fig. 222.

The form of the trigger with its steel catch-plates screwed on, and the india-rubber liner, preventing jarring when engagement takes place, may be seen from Fig. 9 (Plate 34).

Owing to the inlet and exhaust valves being worked by the same eccentric (set with an eccentricity 1 in. (26 mm.) and a lead angle of about 20° the range of automatic cut-off lies between 0.0 and 0.32 of the piston-stroke. Should the release of the trip-gear not take place, the connection between the two valve-spindles remains intact, and the admission of steam continues up to 0.92 stroke. The valves are so set, that just at the opening of the inlet-valves, the exhaust valves are closed by 1/16 in. (2 mm.) lap; the lineal lead of the inlet valve equals 3/16 in. (5 mm.) that of the exhaust valve with a negative lap of 1/16 in. (2 mm.) equals 3/8" (11 mm.).

It was under these conditions that the diagrams herewith drawn in Figs. 223 and 224, were obtained for the inlet and exhaust valves respectively. If the two be compared together, the negative and positive laps of the valves will be seen from the position marked with *SM* — i. e. slide-midway. — The double shaded portion of the diagramm, indicates the range of automatic cut-off.

The pair of Engines already alluded to, had 12½ in. (316 mm.) cylinder-diameter, and 2' 7" (790 mm.) stroke. Running at 54 revolutions per min. the mean piston speed calculates itself

*) See pg. 20 and 21.

at 4 ft. 7 in. (1.4 m.) per sec. The steam supply and exhaust pipes being respectively $3^1/_2$" and $4^3/_4$" (92 mm. and 118 mm.) in. diameter, they each stand in the ratios of $^1/_{11\cdot 8}$ and $^1/_7$ to the cylinder-cross-area. The steam-port is $^7/_8$ in. × $10^7/_8$" (22 × 276 mm.) and the exhaust-port 1 in. × $10^7/_8$ in. (25 × 276 m m.); they each correspond therefore to $^1/_{13}$th. and $^1/_{11\cdot 3}$th. of the cylinder cross-area.

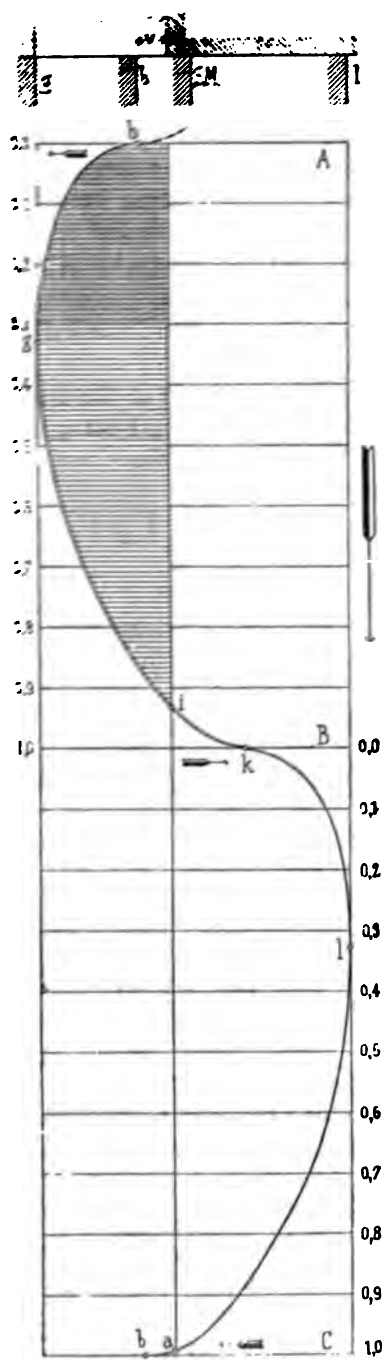


Fig. 223.

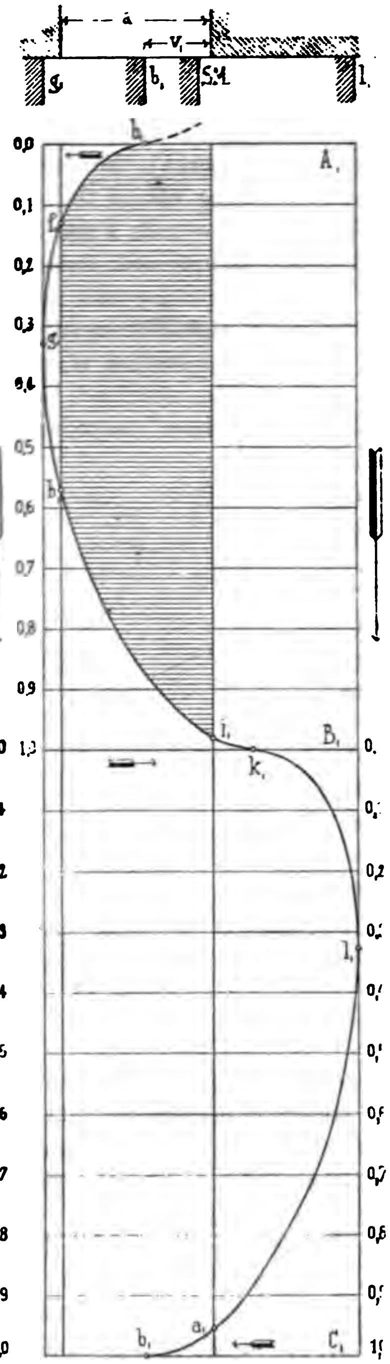


Fig. 224.

The construction of the piston will be seen from Fig. 2 (Plate 34). Fastened in the usual way to the piston rod (2 in. = 49 m m. diam.), a steam-tight contact is obtained by open cast rings, two of which are externally placed side by side, whilst a third broad ring is placed underneath them, and pressed outwards by four steel springs. The Corliss cross-head, slides in double slides. The connecting-rod, five crank-lengths long, and about 3 in. (72 mm.) diam. at its centre, has closed ends. The cross-head pin is $3^3/_8$" and $2^1/_4$ in. diam. (86 × 59 mm.); the crank pin is 4 in. long (99 mm.) and 3 in. (72 mm.) diam. The crank-shaft bearing, both horizontally and vertically adjustable, is of 5 in. (125 mm.) bore and $9^{13}/_{16}$ in. (250 m m.) width. Between each engine, the fly-wheel, 11 ft. 5" (3470 m m.) in. diam. is mounted, midway on the crank shaft; the diameter of the latter is $7^7/_8$" (200 mm.). The rim of the fly-wheel, $13^1/_4$ in. (335 mm.) is furnished with five rope-races. The Porter-governor, driven by belting at 95 revs. per min. has a collar-slide of 3 in. (78 mm.) corresponding to $1^1/_4$ in. (33 mm.) travel of the releasing bolt. We may add, that the resulting shocks from disengagement are taken up by an oil-brake and do not react on the governor, so that the entire work, devolving on the latter, consists in moving the releasing bolt, to and fro.

b. Prager Maschinenbau Actiengesellschaft of Prague.

Type: Iwan Dautzenberg.

At the Vienna International Exhibition, the Prague Machine-Works Co. Lim. — formerly Messrs. Ruston & Co. — exhibited a Horizontal Engine fitted with a valve-gear mechanism, patented by Iwan Dautzenberg. On account of the peculiar arrangement of its four valves, and the absence of any springs whatever, this machine was discussed and favorably criticized in many Engineering journals, and as it is thus more or less generally known, we have confined our illustration to the sketch shewn on Plate XXII in Figs. 4 and 5.

Two double-slide chests are arranged at the side of the cylinder; the upper part of the former is taken up by the main-slides GG_1, whereas the expansion-valves HH_1 are fitted in the lower portion. These valves are rigidly connected, through the rods ff_1 with the oscillating cast iron lever A, attached by lever C to the eccentric rod B; by the alternate motion thus imparted to the exhaust valves HH_1, the exhaust ports — shewn dotted — are opened and shut in turns, though they are never allowed to cover the steam-ports ee_1. Consequently, the pressure of the steam in the cylinder will always be exerted on the exhaust-valves HH_1. The work of supplying and cutting off the steam, to and from the cylinder, devolves entirely on the main-valves GG_1. They are also worked from the lever A through the intervention of a suitable trip-gear. To prevent any throttling of the fresh steam during the gradual opening of the valve — assume for an example the valve G_1 — it can pass by the edge 1 or the edge 2 through the valve-space.

On a cross-piece b attached to the lever A, are firmly fixed the catch-plates oo_1, which, with each extreme position of the lever, gear on to the trigger-rods NN_1 simply coupled to the valve-spindles FF_1. Thus full steam-pressure is exerted on these thickened spindles, of 1½ in. (40 mm) diameter, in contrary direction to the port-opening valve motion. For the variable disengagement of this trip-gear, a frame M supports the trigger rods NN_1, and hangs on inclined surfaces rr_1 on the governor rod. The trigger-rods are thus kept in a certain position by the governor, answering to their being in or out of gear, with the lever A. When disengaged, the steam-pressure on the cross-area of the valve rod, will shut off steam, violent concussions being avoided, by the intervention of the dash-pot piston Q in the dash-pot O.

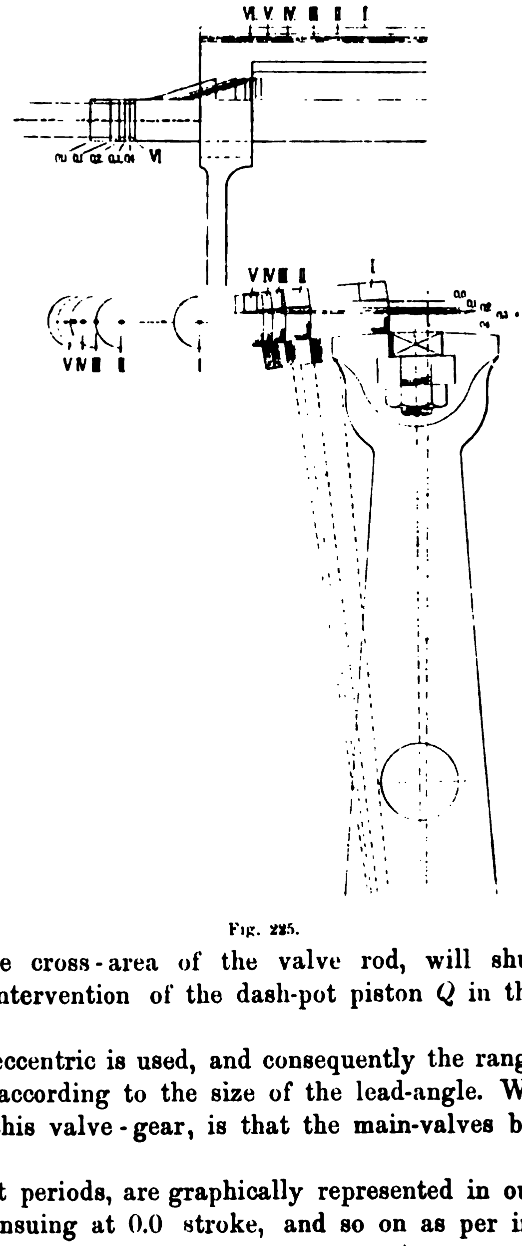


Fig. 225.

Similar to the simple Corliss-engine, only one eccentric is used, and consequently the range of automatic cut-off is limited up to about 0.4 stroke according to the size of the lead-angle. We should observe, that a special advantage claimed for this valve-gear, is that the main-valves become balanced, immediately the port begins to open.

The positions of the trip-gear at disengagement periods, are graphically represented in our Fig. 225. Position I, corresponds to disengagement ensuing at 0.0 stroke, and so on as per inscribed numerical values till in position V, the limit of automatic cut-off under the action of the governor is reached; this corresponds to a cut-off at 0.4 stroke. Should steam be supplied during the entire stroke, the trip-gear will be in position VI.

c. Goldie & Mc. Culloch, Galt-Ontario Canada.

An improved arrangement of the valve-gear of Messrs. Goldie & Mc. Culloch of Galt already described*) is sketched on Plate XX Figs. 5—9. The four valves are set in separate valve-chests arranged at the side of the cylinder, though in order to secure as small steam-passages as possible, the exhaust and inlet valves, are set in pairs close together. Grid-iron valves are used for securing a small travel. The valve-spindles, are carried out at the bottom side of the valve chests, and are raised and lowered by suitable cam motion; the cam-forms are so chosen as to ensure a rapid shutting and opening of the valves.

From the transverse section shewn in Fig. 6, we notice the motion of the inlet-valve. The shaft w rotating at equal speed with the crank-shaft, drives by spur-gear zz_1 another shaft v at half its speed. This shaft v carries the cams KK_1 — vide Fig. 8 — which raise, the peculiarly formed levers NN_1; the latter are under governor adjustment through lever M. Simultaneously the valve rod F is also raised, because it has a projection n always resting on the top surface of the rod N, owing to the weight of the valve itself, and of the steam pressure on the spindle-end. With the rotation of the shaft v in the direction of the inscribed arrow, the edge o of the lever N will slip off the projection of the cam K, and will suddenly fall; this down-ward movement, is naturally also imparted to the valve G, whereby the steam port becomes closed. This slipping off and port-closing action ensues all the sooner, the more the lever N is pushed outwards by the governor, just, as it takes place all the later, the more the lever N is dragged inwards. The main slide G is lifted twice for every revolution of the shaft v, corresponding to a double stroke of the piston. The dash-pot piston Q is fitted to the prolongation of the valve-spindle for cushioning purposes. As seen by Fig. 7, the motion of the exhaust-valve is far simpler, and is effected by the cams R or R_1 (Fig. 9) keyed on the shaft w. The rotation of the latter causes the frame T to rise, so causing the slide H to open the port. During the steam-cylinder piston stroke, the slide remains stationary, so that steam may pass out freely, offering no back-pressure on the piston. Before the completion of the stroke, the slide falls rapidly. On account of the steam trying to lift the valve H off its seat, the latter is made to slide between two fixed grids. Referring to our sketches, EE denote the supply-orifice of the inlet-valve chest; AA on the other hand are the exhaust openings.

d. W. & J. Galloway & Sons, Manchester.

The 300 horse-power Compound-engine illustrated on Plate 35 in plan and elevation was constructed by Messrs. W. & J. Galloway & Sons, of Manchester, and supplied to the British Royal Commissioners of the late Paris International Exhibition, for the purpose of driving the whole of the machinery in the English section. In Figs. 6 and 7 of the same Plate, we represent the valve-gear motion of the high-pressure cylinder.

High and low-pressure cylinders are placed close together, and as the cranks are set opposite each other, the exhaust of the high-pressure cylinder is passed direct into the low pressure cylinder; this arrangement renders the steam-passages exceedingly short. The inlet-valve to the high pressure cylinder has its lead or point at which steam is admitted, constant under all variations of load.

The expansion-slides are worked from a separate eccentric. The admission valves are simple flat plates, for reason that they require no cavities for the exhaust; they are therefore of

*) See pg. 124.

small dimensions, so reducing friction to a minimum. The admission valves, independent of each other are under the direct control of the governor.

As the valve-spindles are made of larger diameter in the stuffing-boxes, the pressure of the steam has a tendency of forcing them outwards — to the right in our drawing —; these valve-spindles are connected with an ordinary dash-pot piston Q at the opposite end of the valve-chest. The square end of the valve-spindle fitted with a common steel catch-plate o, is taken up by a guide T, and within the fork of an eccentric B, which is also guided in T. The movable trigger N is arranged over the straight moving part E of the eccentric rod, and its horizontal arm is fitted with a steel nib n, which gears into o with the extreme position of the trigger. A rod L connects the vertical arm of the trigger N with one arm of the bell-cranked lever $r r_1$; the swing centre of the latter is a stud R of the governor-lever M and the other arm r of this bell-cranked lever, is connected with the head of the eccentric rod B by the rod l.

Variable cut-off is obtained by a shifting of the oscillatiug centre R of the bell-crank lever $r r_1$, the cut-off ensuing later, when R is shifted to the left, in the moving direction of the eccentric rod, and vice versa. The centre R is fixed on the bell-crank lever MM_1 which receives its motion direct from the governor collar slide, the movements of the latter being steadied by the cataract cylinder s. The steam-pressure exerted on the swelled ends of the valve-spindles F effects the closing of the steam-ports. If, from some cause or other, the valve-plate should not close rapidly, then the valve-spindle F is nevertheless taken back by a pin z sliding freely in a slot of the eccentric rod E, so closing the valve.

The patentees of this valve gear (Mr. C. J. Galloway and Mr. J. A. Beckwith) describe their arrangement in the following words: „The high-pressure cylinder has separate induction ports each governed by a slide. Each of the slide rods E and E_1 has its end fitted to work in guides T and within the fork of a crank or eccentric rod which is also guided in T. On each slide rod head is fixed a plate of steel o and o_1, and on each of the spindle rods is mounted a bell-crank trigger lever N and N_1, one arm of which has a steel plate n fixed upon it, so that when the edge of the plate n engages with that of o the movement of the crank or eccentric rod towards the left, causes the slide rod to move also towards the left along with it. The slide rods are made with swells, fitted to work as plungers through packing at the end of the slide jacket, so that the pressure of the steam within the jacket tends to push the slides towards the right, and thus if either of the trigger levers N or N_1 be moved so as to disengage its plate n or n_1 from the plate o or o_1 on the slide rod, the slide rod so disengaged will be forced by the steam pressure towards the right, and the slide attached to it, will close the port. Also, when the crank or eccentric rod retreats, towards the right, the steam pressure, acting on the plunger swell causes the slide rod to follow it, the plates n and o or n_1 and o_1 still remaining engaged with each other. Pins z working in slotted holes, in the slide rod heads, limit their movements relatively to those of the crank or eccentric rods. The trigger levers N and N_1 are connected by adjustable rods L and L_1 passing through sliding sockets and having exterior collars with other bell-crank levers r and r_1, which are worked by the cranks or eccentrics on the main shaft, that move the crank or eccentric rods. The bell-crank levers rr_1, are pivotted on a stud R on the vertical arm of a counterbalanced lever M which is worked by the governor, the movements thereof being steadied by a dash pot or cataract cylinder S. From this construction it follows, that supposing the lever M to be stationary at a certain part of each stroke of the engine, as determined by the position of the fulcrum R, the bell-crank levers rr_1, are moved, so that by acting on the collars of the rods L, L_1, they move the triggers so as to disengage the edges of the plates n and o and n_1 and o_1, and thereby to leave the slides free to be moved back by the steam pressure acting on the plungers FF_1 and to close the admission ports, thus effecting a rapid cut off of the steam supply to the cylinder. When, owing to increase or decrease of the engine-speed, the lever M is moved by the governor so as to remove the fulcrum R of the lever rr_1, towards the right or left, as the

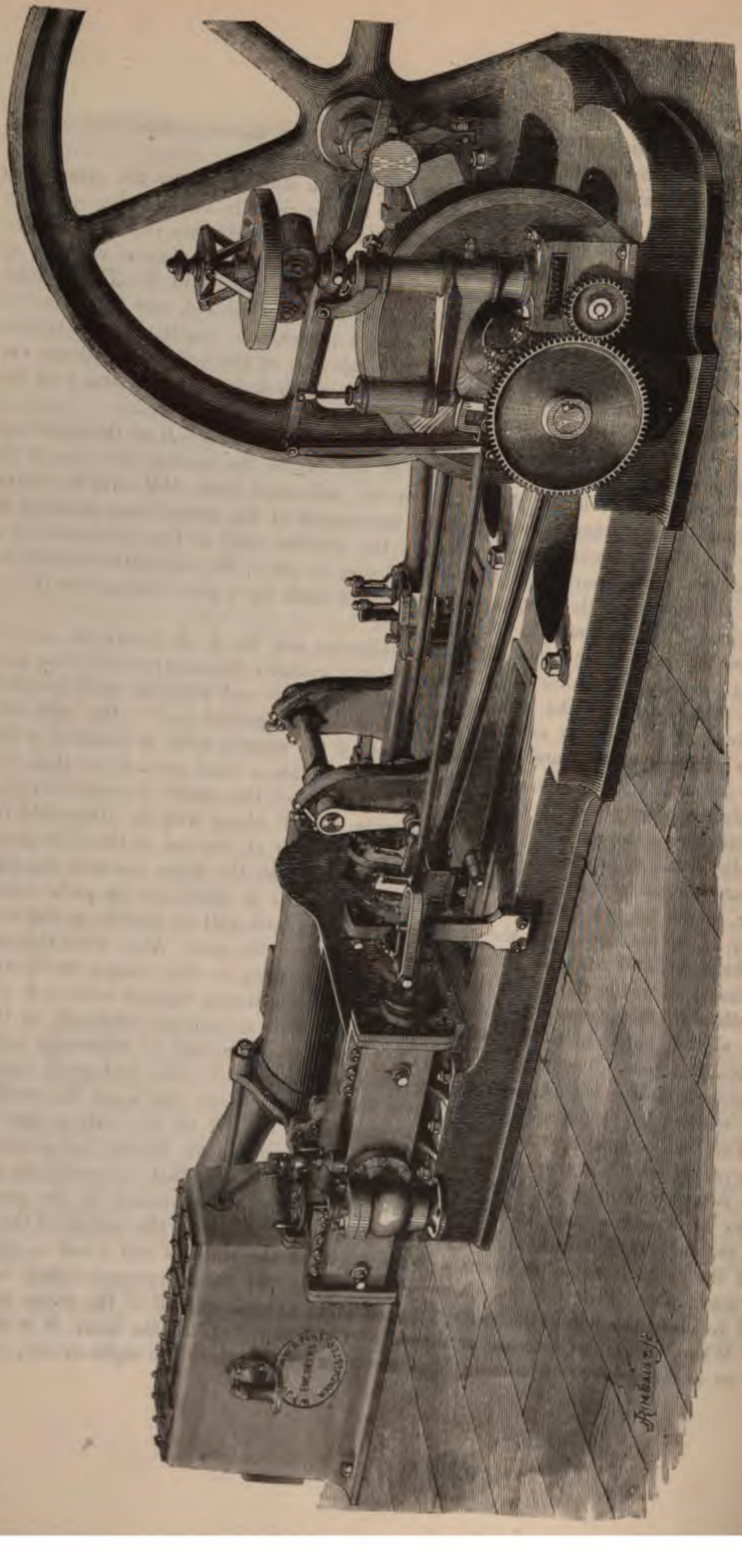


Fig. 226.

case may be, then the triggers N and N^1 are caused at an earlier or later period of the stroke to release the slides, whereby the steam is cut off sooner or later, according as the speed of the engine has increased or decreased."

According to diagrams taken off this compound Condensing Engine, the latter indicated 300 *HP*; the diameters of high and low pressure cylinders were respectively 20 in. and 34 in. with a stroke of 3 ft. The crank revolving at 60 revolutions per minute gives a mean piston-speed of 6 ft. per sec. All the engine parts are securely bolted to the bed-plate, so rendering the engine self-contained. The cross-head, slides in slipper-guides. The fly-wheel (18 ft. diam. and 3 ft. 2 in. on the face) is arranged as belt-pulley; its driving strap measures 100 ft. 8 in. long, 36 in. wide and weighs about 800 lbs. The prolonged piston rod of the low-pressure cylinder drives the horizontal air-pump, which is 11 in. in bore, and arranged inside the condenser-casting. As the entire apparatus, is placed above the floor-line, all the valves can be readily seen to.

The characteristic features of this Engine may be summarised as follows: Cylinders side by side with pistons nearly at opposite ends at the same moment; steam-passages reduced between the two cylinders to the shortest possible dimensions; valves on the plain flat principle, without exhaust cavity.

A perspective view of a similar Engine-construction is given in our Fig. 226 with this difference that it is not fitted with Galloway & Beckwith's expansion-gear, but nevertheless the steam admission-valve is so arranged, as to be in direct communication with the governor, cutting off automatically and instantaneously. It is of the same power and dimensions as the preceding, and the Engine is provided with a special motion for stopping automatically, in the event of any accident occurring to the governor-wheels.

The consumption of fuel in these Engines, when working in connection with Galloway Boilers and suitable Condensers, is stated not to exceed 2 lbs of coal per indicated horse-power per hour.

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2. With Inlet-valves, arranged at side and Exhaust-valves fitted on top of the Steam-cylinder.

a. C. H. Brown & Co., of Fitchburg (U. S. A.).

At the Centennial-Exhibition, great regard was paid to an Engine constructed by Messrs. C. H. Brown & Co. of Fitchburg, for reason of its facile and elegant design, its simple valve-gear and its capital working commanding general attention. This Engine, we illustrate on Plate 36, Figs. 1—4.

It is apparent, that the plain flat inlet and exhaust slides are separated, the former, *G*, being arranged at the side of, while the emission valves *H* are placed underneath the cylinder; the travel of the inlet valves is therefore in a vertical plane, whilst that of the exhaust-valves runs horizontal, as shewn in our Fig. 227.

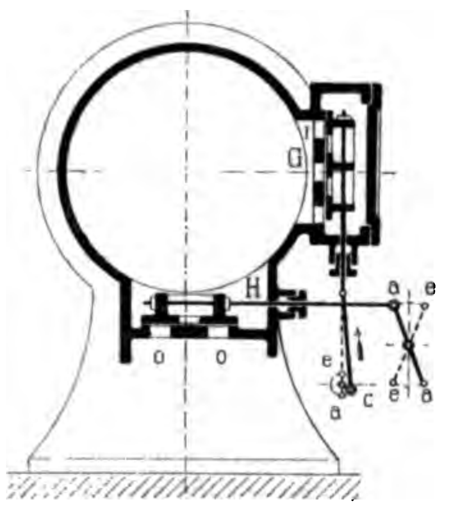

Fig. 227.

Motion to the inlet and exhaust valves *G* and *H* is imparted by two distinct mechanisms mounted on the gear-shaft. In our sketch we assumed the piston to be at its stroke-end, and consequently the inlet-valves *G* have begun to open steam-passages *i*, whilst the exhaust valve *H* remains stationary in its position *a*. The inlet valves receive their vertical travel from a weigh-shaft *w* which is made to revolve at equal speeds with the crank-shaft —vide Fig. 2 Plate 36—. The end of the trigger *N* with fast swing-centre *f*, is made to catch the steel projecting nib *o* arranged in a slot of the valve spindle *F*. The eccentric *A* continues to lift up the trigger *N*, which similarly lifts the valve-spindle *F* and slide *G* till disengagement ensues; this occurs when the trip *o* is pushed out of gear of the trigger *N*. The moment disengagement takes place, occurs the valve *G* will fall rapidly, partly owing to its own weight and partly owing to the steam-pressure acting on the swelled valve-spindle *F*. This falling motion, corresponds to a shutting off of the steam-ports; in its drop, the valve-spindle *F* is suitably air-cushioned by the dash-pot *O*.

Disengagement ensues, at the bidding of the governor. The governor imparts a slight rotary movement to the rod *w* attached to the crank lever *r* carrying a stud at its end, which stud is made to press at the proper time, against the tail-end of the trip *o*. Presuming contact between the two to take place, then with the continued upward motion of the valve-spindle *F*, it is evident that at a certain moment, the trip *o* will be pressed out of gear with *N* by the crank-stud *r*, when as fore-explained the valve will rapidly shut-off steam. It is self-evident that disengagement — i. e. cut-off — will ensue all the sooner, the more the crank-lever *r* has approached the trip *o* at the beginning of the stroke. With this arrangement, the point at which steam is admitted or the lineal lead remains constant under all variations of load, and as each eccentric is solely used for lifting its own valve, the range of steam-admission can take place up to almost full-stroke.

The exhaust-valves *H* are also worked from the forementioned shaft *v*, by means of slotted cam-discs *B* imparting motion to levers *L*.

The governor worked from the shaft *v* lying low, is enclosed in a cast-casing. The main dimensions of this Engine are as follows: Cylinder diam. $15^3/_4$ in.*) (400 mm.), and stroke 3 ft. 2 in. (965 mm.). In conclusion we may add, the Engine working with 60 lbs. steam-pressure, and running at 65 revolutions, is stated to be of 65 nominal horse-powers.

b. Wm. Wright & Co. Newburgh (U. S. A.).

Both on account of the general design, as well as of the valve-gear mechanism, the Engine constructed by Messrs. Wm. Wright & Co. of Newburgh, and drawn in Figs. 5 to 9 Plate 36 — deserves the attention of the Engineering profession.

The fixing of the four valves appears very rationally arranged. The bottom side of the cylinder carries the exhaust-slides, so effectually draining the cylinder, and the grid-iron inlet-valves work at the side in a valve-chest cast with the cylinder. The external valve-gear could thus be laid low, and partly hidden from view. An intermedieate lever, enabling the eccentric-rod to be brought close up to the cylinder, transfers the motion of the single eccentric on to the four valves. This is done in the following manner: The eccentric-rod *B* grasps the upper stud *c* of a three-armed lever *A*, keyed on a transverse shaft, placed underneath the cylinder, and thus the lever *A* with its shaft are caused to oscillate. The lower studs dd_1, of the same lever, each work to and fro one of the hollow rods zz_1, whose other extremities raises the inlet-valves. This lifting action is accomplished by a sliding steel-bolt *n*, or *n* placed with a varying protruding length transversely across it. This bolt *n* — confining ourselves to the one side is made to gear at the proper time, on to a free swivelling catch-plate *o* fitted in a slot of the valve-spindle *F*. In this manner this bolt *n*, lifts up the spindle *F* and its valve *G* higher, when the bolt *n* protrudes more out of its rod *z* than when it protrudes less; it devolves on the governor to shift this bolt *n* more or less out of its socket according to requirements. Referring to our Fig. 6, the governor slightly turns the rod *r* placed lengthways under the Engine, which in its turn causes the inner rod of the hollow shaft *z* to slide lengthways. This last motion, is obtained by the crank *p* and intermediate link *m*. The toothed projection simultaneously holds the bolt *n* and causes him to slide owing to the wedge-action.

As soon as the bolt-end becomes disengaged from the vertical lifting catch-plate *o*, the latter ceases to rise, the valve-spindle falls rapidly, and steam is cut-off instantaneously partly owing to the valve weight and partly owing to the action af the long spring-blades *SS*. A dash-pot *OO* is used in the ordinary manner for regulating preventing violent concussions. The catch-plate oo_1 is weighted as shewn.

The two exhaust-valves at the bottom of the cylinder, receive their motion from the hollow shaft *z*; a crank *K* is keyed midway on the latter, and it gives motion by the intermediate

*) According to Prof. Radinger only 318 mm. = $12^1/_2$ in.

link *e* to a slide *b* connected with the exhaust-spindle *f*. The form of the massive engine-bed may be seen from Figs. 8 and 9.

The cylinder of the engine exhibited was 12 in. (305 mm.). With a stroke of 2 ft. 3 in. (686 mm.), and running at 100 revs. per min. we obtain a mean piston-speed of $7^1/_2$ ft. (2.3 m.) per sec. Working at 80 lbs. pressure, the engine gave off 39.5 *HP.* The fly-wheel diam. is 9 ft. (2.74 m.) and its face 1 ft. 8 in. (508 mm.) wide: weight of ditto: 1 ton 6 cwt. (1350 kg.).

c. Machine-works of the Imperial Hungarian State Railways, Buda-Pesth.

Type: Zimmermann-Waldmann.

On Plate 37 we reproduce the design of an engine shewn in motion at the Paris Exhibition of 1878 by the K. Ung. Staats-Eisenbahnen of Buda-Pesth. It works with four slides, with the inlet-valves arranged at the side of, and the exhaust-valves placed beneath the cylinder.

The admission-valves fastened to bushes, receive their motion from an eccentric on the crank-shaft by the valve rods passing through these guides. The latter are so connected together by a frame, as to permit the governor-spindle — placed perpendicularly over the valve-spindles, — to rotate freely within this frame. This frame is guided in a slide attached to the cylinder, and serves to carry the two triggers. The bushes, of unequal diameters in their opposite stuffing-boxes, are furnished with a steel catch-plate on that portion of their top-side which always remains outside the stuffing-boxes; these catch-plates are made to gear on to a corresponding trigger, with the commencement of each stroke. As a result, the spindle-bushes and the slides take part in the eccentric-motion, so effecting the alternate opening and shutting of the valves.

To obtain Automatic Variable cut-off, the governor-collar is connected to a bracket, which moves the governor-spindle up and down, according to the rise or fall of the governor-collar; this bracket has the upper ends of the triggers inside it, so that when disengagement is required, it presses the triggers out of gear from the catch-plates on the valve-spindle bushes. In consequence of the equal steam-pressure exerted on the unequal end-areas of the swelled valve-spindles, the latter are rapidly forced back, so closing the corresponding-valve. The dash-pot piston arranged at the smaller end of the bush, prevents in the usual manner, the occurrence of any violent concussions. Air-pressure is substituted in place of steam-pressure, for closing the valves in all engines exceeding 100 *HP.* This is done, by making the bush, which passes through both stuffing-boxes of one uniform diameter, and fitting it up at its outer end with a piston moving air-tight in a corresponding cylinder: the resulting vacuum is utilised in this manner for the rapid drawing back of the valve-spindle.

As the forementioned eccentric merely regulates the steam-supply, the eccentric could be set at an angle of 127° behind the crank. Automatic cut-off may therefore take place, during the travel of the eccentric over this angle, and the range of automatic expansion lies between 0.0 and 0.8 stroke. The exhaust takes place in separate grid-iron valves, arranged under the cylinder. These exhaust-valves are worked by cams fastened on a shaft driven by screw-gear.

The Condensing Engine illustrated on our Plate 37, has a stroke of 4 ft. 1 in. (1250 mm.) with cylinder-diameter of 22 in. (560 mm.). The cylinder is steam-jacketed, and this remark also extends to the front cover, cast in one piece with the cylinder; the hind cover is placed in communication with the jacket through several perforations. The steam-pipe of 5 in. (130 mm.) bore, corresponding to $^1/_{18}$th the cylinder cross-area, is attached to a vertical pipe, the lower end of which is fitted with stop-valve. The steam circulates from here into the steam-jacket, so as to pass subsequently through the stop-valve into the valve-chests. The cylinder legs give the spent steam into an exhaust-pipe of $6^1/_4$ in. (160 mm.) bore (= $^1/_{12}$th the piston area) which in its turn yields it up to the condenser arranged vertically under the cylinder. The forementioned vertical steam-pipe is fitted with injection valve, which delivers water to the condenser connected by horizontal pipe to the air-pump; the latter is fixed at the side of the crank-bearing casting and is driven by separate crank.

The engine bed is of peculiar design, as our drawings shew. The connecting-rod is five times the length of the crank-radius. The crank-shaft bearings are $8^3/_4$ in. (220 mm.) bore by $12^1/_2$ in. (320 mm.) wide. The mortise-wheel keyed on a crank-shaft neck of $10^3/_4$ in. (270 mm.) is 15 ft. (4600 mm.) in diam. and 9 in. (225 mm.) on its face with $3^1/_8$ in. (80 mm.) pitch. It is cast in two halves, and transfers its power to a smaller spur-wheel placed below it; the pitch-line diam. of the latter is 4 ft. 11 in. (1500 mm.)

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3. With Inlet-valves arranged at top, and Exhaust-valves fitted at bottom of Cylinder.

A. Slide working parallel to the piston-rod.

a. L. Nemelka, Engineer, of Simmering nr Vienna.

The Engineering Firm of L. Nemelka of Simmering nr Vienna has patented the Slide-valve gear represented by Figs. 1—3, Plate XXII. From the side elevation — Fig. 1 — of the cylinder we observe, that the third Corliss valve-gear has been here retained in the external arrangement, with the simple difference that the dash-pots are placed horizontally as in the Spencer and Inglis gear. The longitudinal cylinder section shewn in Fig. 2, gives the internal valve-motion. In the Corliss gear the cock-valve fitted on the valve spindle effects the distribution of the steam; in the present case however a flat slide is added and worked by rack, off a toothed roller fitted on the valve-spindle. Owing to this complication the advantage of the flat-slide, may well appear to have been too dearly obtained.

According to Prof. Riedler's „Excursionsberichte", the silent working of this valve-gear is very noticeable.

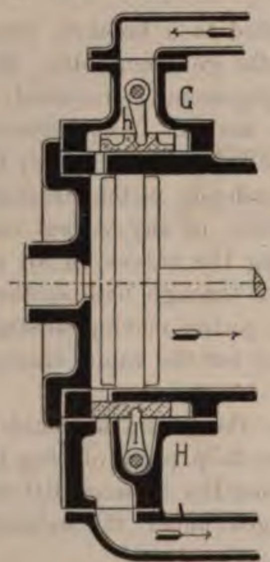


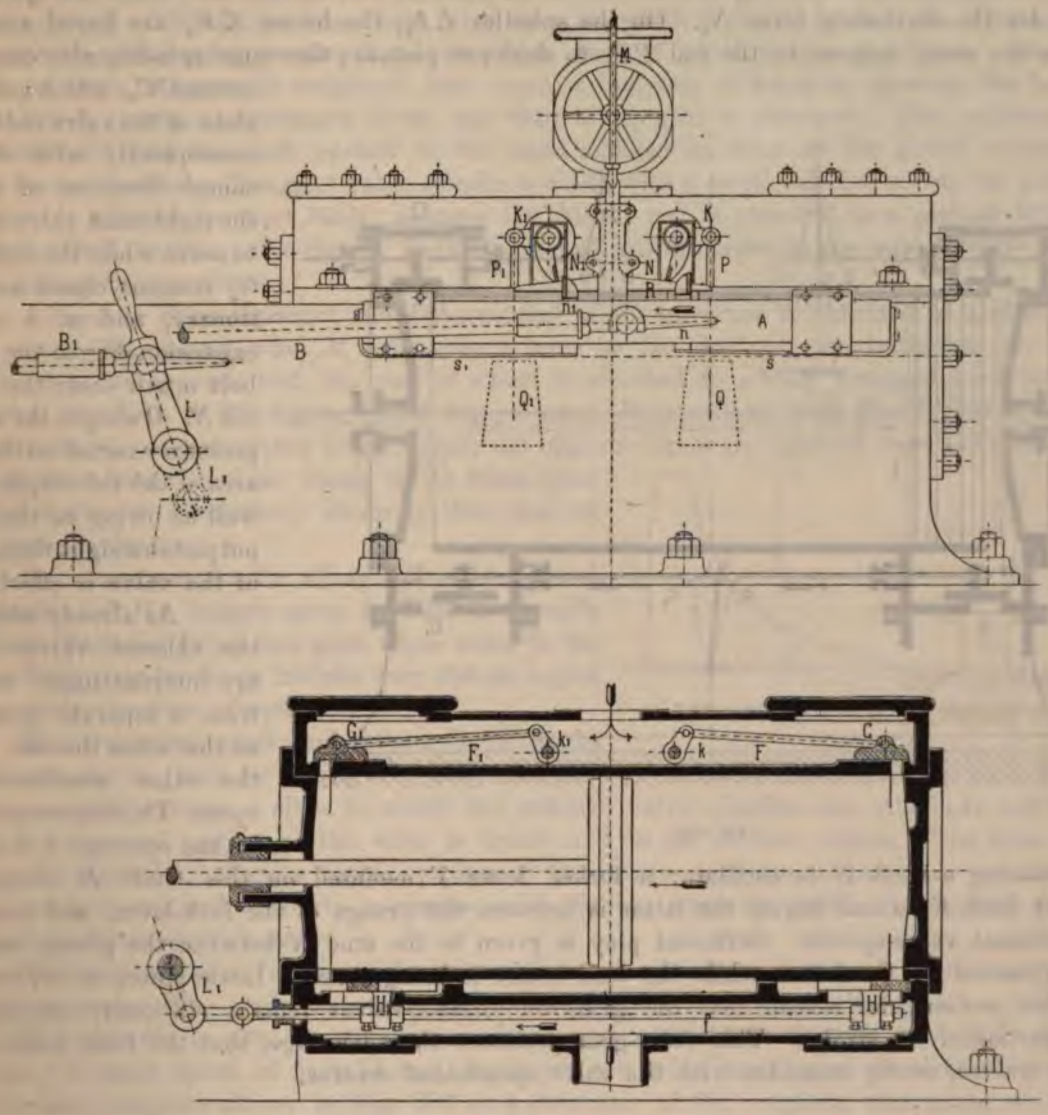
Fig. 228.

b. Philip Allen & Sons, of Print Works, U. S.

Allen's Quadruple slide gear, as shewn attached to one cylinder end in the annexed Fig. 228 is almost as old as the first Corliss valve-gear, described at the beginning of this Work. The external gear presents nothing novel, as it is arranged on the third Corliss valve-gear principle. Instead of cock-valves, plain flat slides are used, *G* and *H* in our figure referring respectively to the inlet and exhaust-valves. In other respects our woodcut explains itself.

c. Noble T. Greene, of Providence, U. S.

Greene's Expansion-valve gear was already patented and constructed by the Steam-engine Building Co. of Providence in 1869. A side elevation of the external valve-gear is shewn by the annexed Fig. 229, Fig. 230 giving a longitudinal section through the cylinder. Two eccentrics are used, the tail rods (B and B_1) of which, are respectively connected with the inlet and exhaust valves. The eccentric rod B is attached to the slide A, which is furnished with catch-bolts $n\,n_1$ resting on the springs $s\,s_1$. The alternate rectilinear motion of the slide A, and consequently also of these catch-bolts $n n_1$ force the latter to push the steel nibbed levers $N N_1$ as soon as they come in contact with them; by this lever motion the weights $Q Q_1$ are raised, and this corresponds to the opening of the steam ports. According as the catch-bolts $n n_1$ are held high or low, by the governor action on the cross-rail R and rod M, the longer or shorter will they be in gear with the lever ends $N N_1$: or what amounts to the same thing, the more will the cut-off be retarded or hastened. A continuous reci-



Figs. 229 and 230.

procating motion is imparted to the exhaust-valves by the eccentric rod B_1, which causes the double lever $L L_1$ to oscillate; the latter is coupled by link to the spindle f on which the two exhaust valves $H H_1$ are firmly fitted.

We shew Greene's Improved Valve-gear on Plate XXII Figs. 4—6 and refer the reader to the annexed wood-cut Fig. 231 for the purpose of explaining the principle of the valve-gear. The piston k being at the termination of its stroke, steam is passing into the main-slide chest G through the port i behind the piston; on the other hand, the exhaust-slide H_1 has opened the exhaust port o_1, while the emission slide H is not working and the other inlet-valve G is at rest. As the travel of the inlet and exhaust valves is controlled by two eccentrics, the variable range of expansion lies between 0.0 and 0.75 stroke. The eccentric-rod B imparts reciprocating horizontal travel to the slide A, in which the catch-bolts $n\, n_1$ adjust themselves vertically as before. When the slide A works in the direction of the inscribed arrow, the catch-bolt n pushes the lever-nib N before it, whilst the catch-bolt n_1 (on account of its inclined end surface and the weak spring s_1) slides under the stationary lever N_1. On the spindles $L\,L_1$, the levers $K\,K_1$ are keyed and connected in the usual manner to the rod $P\,P_1$ to dash-pot pistons; the same spindles also carry the levers $C\,C_1$, which gear into slots of the valve rods $F\,F_1$, consequently with the assumed direction of travel, the right-hand valve begins to move while the left slide G_1 remains closed and stationary, and at a certain expansion-degree the catch-bolt n will clear the lever-nib N. Owing to the steam-pressure exerted on the end-area of the valve-spindle as well as owing to the dash-pot piston weight, the closing of the valve is effected.

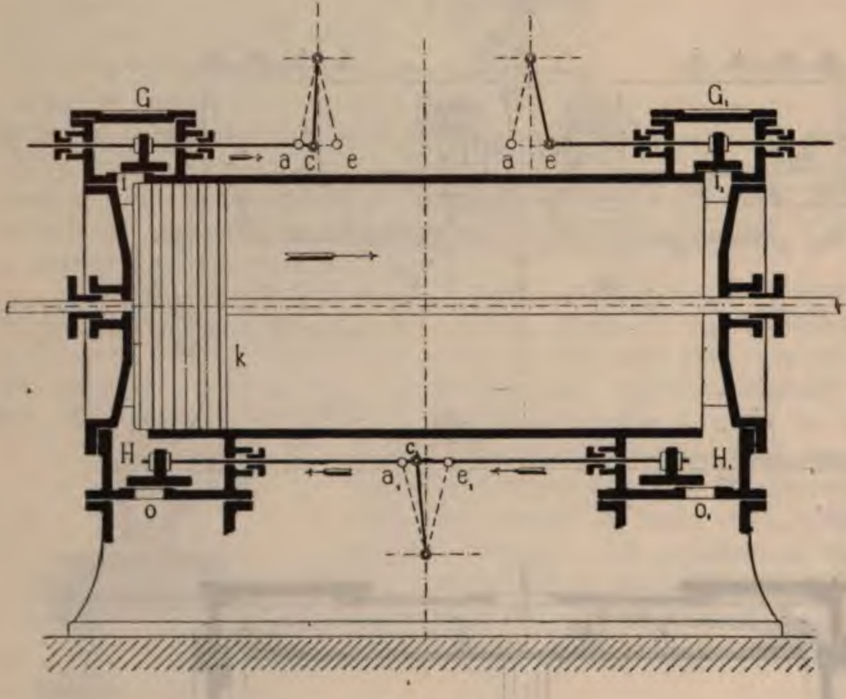


Fig 231.

As already observed the exhaust valves $H\,H_1$ are intermittingly worked from a separate eccentric, so that when the one closes the other simultaneously opens. This is accomplished, by the eccentric rod B and lever I causing a shaft E to oscillate; a forked lever T mounted on this shaft E, alternately works the stud K to and fro, as the latter is between the prongs of the fork-lever, and mounted on the exhaust valve-spindle. Sufficient play is given to the stud K between the prongs, so that it is only moved by the latter, while the dead centre is being passed. Little power is required to ensure this motion, for reason that the grid-iron exhaust-valves remain stationary during the greater portion of the stroke. This valve-gear possesses the advantage, that the force required to work the valves, nearly coincides with the valve spindle-rod centres.

d. B. Lebrun & Co., Nimy nr Mons, Belgium.

Type: B. Lebrun.

The Valve-gear mechanism illustrated on our Plate 38 has been constructed for a number of years by the Engineering firm of Messrs. B. Lebrun & Co. of Nimy (formerly Ateliers de Construction de E. Mauroy & Lebrun). The internal arrangement is shewn in Fig. 2, transverse section and end-view of cylinder are drawn in Figs. 3 and 4 of the same Plate.

The trip-gear bears great similarity to the Bède & Farcot gear, though the working of the same could not be arranged as simply as in the former mechanism, on account of the slides lying over the cylinder, which necessitated the use of an extra horizontal lay-shaft driven by bevel-gear, both for the inlet and exhaust valves.

Motion is imparted to the valve-gear, by a lay-shaft driven by equal bevel wheels and arranged parallel to the cylinder-axis. The same shaft also drives by bevel gear the governor spindle placed at the side of the cylinder. This shaft revolving at the same speed as the crank-shaft, imparts equal speed to the lay-shafts placed transversely over and under the steam-cylinder. The upper shaft of these two, has a cam fitted upon it, which is shewn by Fig. 10. This cam gives a reciprocating horizontal movement to two slides, each of which carries a trigger. As one end of each of these triggers is weighted, they have a tendency of pressing against the horizontal valve-spindles arranged underneath them, and thus a trip-gear is obtained. The valve-spindle is pushed forward and the port opened in the usual manner as soon as the piston returns on its former stroke direction. The inlet valve spindle is made with a swell, against which, the pressure of the steam is allowed to exert itself, whereas its thinner end is attached to a piston, fitting in a dash-pot bolted to the valve-chests; both steam and piston press in opposite directions to the corresponding trigger-thrust.

Automatic disengagement under the control of the governor is obtained in a rather round-about way. The governor-rod *M* articulates a lever on the shaft *m*; the latter has an eccentric disc keyed at its opposite end, the ring of which is attached to a slide arranged with vertical up and down travel on to the non-weighted trigger-arms. It is evident from Fig. 2, that if this slide presses down the non-weighted trigger-arms, the opposite arms are released from the valve-spindle, which is then forced to close, owing to the steam-pressure and dash-pot connection; steam is thus shut-off and expansion begins.

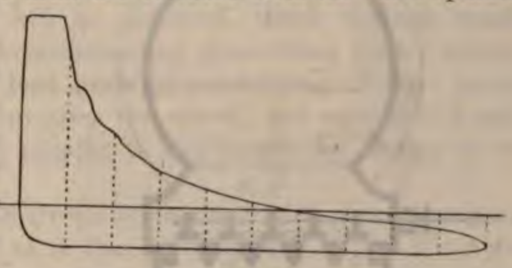


Fig. 232.

As a contrast to the advantageous form and arrangement of the trigger arms in Bède & Farcot's Automatic Variable Expansion gear, these arms in the Lebrun design are made to include very obtuse angles against their direction of motion.

The transverse shaft under the cylinder works the exhaust-valves, also by means of a cam, the form of which is shewn in Fig. 11. This cam likewise rotates between a slide to which the exhaust valve spindles are attached; and thus the alternate horizontal motion of the slide is transferred to the exhaust valves. The form of this cam is determined to afford a rapid opening of the slides, and to ensure their remaining stationary when open, and similarly to ensure quick closing when required. A catch-oil receptacle is placed underneath the cam.

The exhaust-steam, as in the Inglis and Spencer valve-gear is passed off through the two cylinder-supports. The guide-bars, bed-plate etc. are copied from the Corliss-type.

The cylinder is $15^3/_4$ in. (400 mm.) in diam. and of 2' $11^1/_2$" (900 mm.) stroke, its piston developing a mean speed of 5 ft. 11 in. (1.8 m.) per sec. when running at 60 revolutions per min. The indicator diagram shewn in Fig. 232 as a facsimile of the original, was taken with 72 lbs. boiler-pressure, and gives an effective power of 70 per cent.

This engine has a condenser attached. The horizontal air-pump $6^1/_2$ in. (165 mm.) in diam. is driven direct from the piston-rod which is prolonged for this purpose, through the hind cylinder cover; the ratio between air-pump and cylinder piston is therefore as 1 : 6. The steam-supply pipe is 4 in. (100 mm.) in diam., or $^1/_{16}$ the cylinder-cross-area. The fly-wheel cast in one, is 13 ft. $1^1/_2$ in. (4 m.) in diam. and 7 in. (180 mm.) on the face. The connecting-rod, is five times the crank length.

e. C. Virck, Engineer of Kirch Mulson, Mecklenburg.

The Virck Automatic Expansion gear, has four separate slides, the inlet and exhaust valves of which, are respectively placed separately on the top and bottom sides of the cylinder. The steam valves are closed rapidly by an independent small steam-cylinder, and are under the control of the governor. The motion of the exhaust-valves is not depending on the inlet valve travel, and the adoption of a peculiar flat-slide arrangement, reduces the clearance spaces to a minimum. A full illustrated description of this Valve-gear will be found in Engineering issue, dated 5th Sept. 1879, pg. 187 and 190.

B. With Valves working perpendicularly to the cylinder-piston.

a. Babcock & Wilcox, of New-York.

The majority of Four slide Automatic Variable Valve gears, have the slides placed cross-wise over or under the cylinder, as represented in the annexed Fig. 233. Grid-iron valves are mostly used, as they ensure a very small slide-travel. A great variety of mechanisms have been introduced for the purpose of working horizontally such flat-slides as shewn by G and H in Fig. 233. Thus, they have at times been arranged independently of each other, as we notice with the valve-gears of Smrczka, Theis & Berchtold, whereby wider grades of automatic cut-off are ensured, and at other times we find these valves set dependent on each other as in the Wannieck type. In this case the cut-off under the control of the governor is mostly limited to $^2/_5$ ths stroke, though Mr. Kuchenbecker's extremely simple valve-gear*) forms an exception hereto by permitting automatic cut-offs up to $^9/_{10}$ ths stroke.

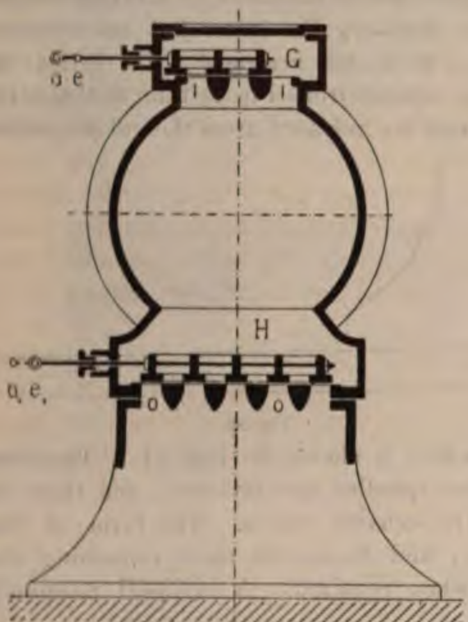


Fig. 233.

One of the oldest and most renowned Works of North America, under the management of Messrs. Babcock & Wilcox and known as the Hope Ironworks has constructed a four slide Expansion valve-arrangement in connection with its Engines, which already appeared in 1869 in "Engineering". We leave the reader to refer to this account, contenting ourselves by describing their latest improved construction as illustrated on our Plate XXIV.

Although six slides are used it nevertheless belongs to the group of quadruple slides: thus, we find two inlet-valves working transversely on the cylinder top with two corresponding expansion plates working on the back of the former under governor-control, and lastly the two exhaust valves complete the six-valve arrangement.

Only one eccentric is used, which is shewn in Figs. 3 and 4 (Plate XXIV) to articulate a double lever A, which in its turn imparts an alternate horizontal movement to the rods EE_1. The latter are furnished with inclined grooves NN_1, and on referring to the plan (Fig. 4) it will be at once apparent that an intermittent transverse motion must be given to the valve-spindles FF_1 since perpendicular pins (firmly secured to the latter) pass into these slots.

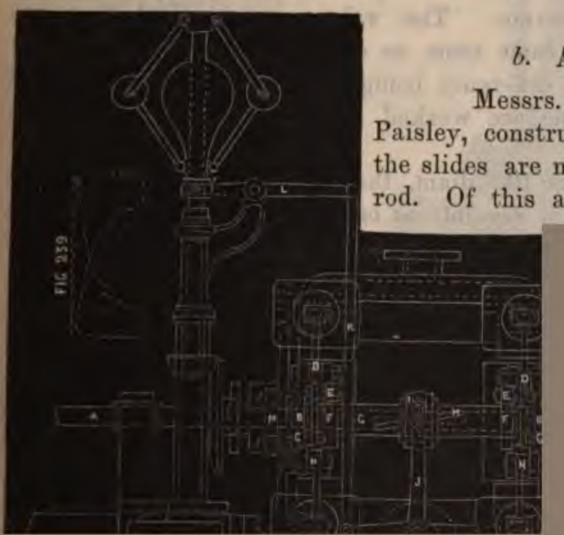
The movement of the inlet-valves is similarly imparted to the expansion plates ee_1 which are rigidly connected together by the rod f. At the moment that steam is cut-off, the expansion-

*) see pg. 193.

plates are moved laterally over the inlet valves — i. e. parallel to the cylinder-axis — by the following mechanism: The expansion-rod *f* has a piston *k* attached at one end, which fits in a small cylinder *h* (Fig. 8) bolted to the cylinder. This piston receives fresh steam alternately on each side through a regulating piston-slide *o*, whereby its corresponding opposite sides are similarly alternately connected with the exhaust; these exhaust passages are however not set exactly at the ends of this cylinder, but they are arranged somewhat inwards so that a steam-cushion may be formed to prevent violent concussions. Thus, to ensure cut-off at a certain position of the stroke, all that is necessary to do, is to shift the regulating piston slide *o*, as this will cause the expansion-plates to rapidly change their position and shut-off steam. For this purpose, the governor spindle is allowed a vertical sliding motion (regulated by the ball-velocity) which causes a double lever *m* to oscillate; this lever *m* is moreover connected with the slide piston *o* through the rod *p*.

The peculiar construction of the governor as shewn in Fig. 5, may well deserve our further attention. The arms *M* carrying the balls *P*, are made twice as long as the links *N N* connected to the hollow spindle *L* giving rotation to the governor-balls. On the other hand, the arms *M* are fixed to the vertical sliding spindle *R* revolving inside the other spindle L_1. Owing to this arrangement, the governor-balls will rotate in a horizontal plane, their centrifugal action being impeded by a counter-weight *Q* hanging from the opposite end of the lever *m* which forms the support of the sliding governor-spindle. When these two acting forces are in equilibrium, the governor balls naturally remain in one swing-circle, but if one force becomes greater than the other, a corresponding effect on the movable governor-spindle will be produced, which becomes transferred on to the expansion-plates. The engine-speed, notwithstanding diminishing loads, always remains the same, because each increase or decrease of load gives preponderating effective power to the balls or to the counter weight, which in their turn alter the cut-off, and so ensure a uniformity of speed. Consequently the engine may be set running to any speed, by adding or reducing the weight of the counteracting weight *Q*.

The high range of automatic cut-off of 0.0 to 0.8 stroke is obtained with this valve-gear. An additional advantage which should not be lost sight of in this gear, is that in case the automatic cut-off mechanism should by some accident or other become deranged, the expansion plates may be bodily removed, when the ordinary inlet valves take up the supply and shutting off of the steam, though it is true, then giving steam up to nearly full stroke.



b. A. F. Craig & Co., Engineers of Paisley.

Messrs. A. F. Craig & Co., of the Caledonia Engine Works, Paisley, construct an Automatic Variable Expansion Gear, in which the slides are made to work in a plane at right angles to the piston-rod. Of this arrangement, presumed to be fitted to an Horizontal Engine, the annexed Figs. 234 and 235 give a side elevation and plan, while an end-view is afforded by Fig. 236, for the purpose of shewing the arrangement of the slides; Fig. 237 gives a transverse section through one of the cylinder ends.

The valves are of the grid-iron form with flat faces and are moved across the cylinder; the two upper valves are the main steam valves, and the two under the cylinder are the exhaust. They are worked from the horizontal-shaft *A* running parallel to the cylinder centre line. The cams *B* for opening the steam valves are keyed on the shaft roll on to the steel roller *C* fixed to the forked lever *D*; the other arm carries another roller *E* which is in contact with the cut-off cam *F*. The cut-off cams are keyed on the tube *G* which is loose on the shaft *A*. It is driven by a steel pin, passing through a parallel slot in the shaft and angle slot *H* in the tube; this pin is fixed in the sleeve *I* and is connected to the governor by the bell-crank *J*, rods *K* and lever *L*. When the governor is at its highest position, the cams are set so that as soon as the steam cams leave the rollers for opening, the cut-off cam has begun to close the valve; as the travel of the valve for a large opening is so little, the cut-off takes place very rapidly. When the governor is down, the sleeve falls back to the end of the slot, and turns the tube back, thus, bringing back the cut-off cams, making the cut-off later. The range depends on the angle given to the slot *H*.

FIG 236

The exhaust valves are worked by cams *M* and levers *N* and remain fully open during the whole stroke; as these valves are placed close to the cylinder, the clearance spaces are reduced to a minimum. A perspective view of one of Messrs. A. F. Craig & Co.'s Inverted-cylinder Engines, fitted with their cross grid-valves is illustrated in Fig. 238. It was made for Messrs. R. & W. Watson of the Linwood Paper Mills near Paisley to drive their paper-machine where it has now been at work for nearly two years.

FIG 238

The speed is varied by shifting a weight on the lever of the governor. The valves are worked from the upright shaft by cams same as described for the Horizontal Engine, the only difference being that the exhaust valves in the upright Engine are worked by one eccentric and weigh shaft.

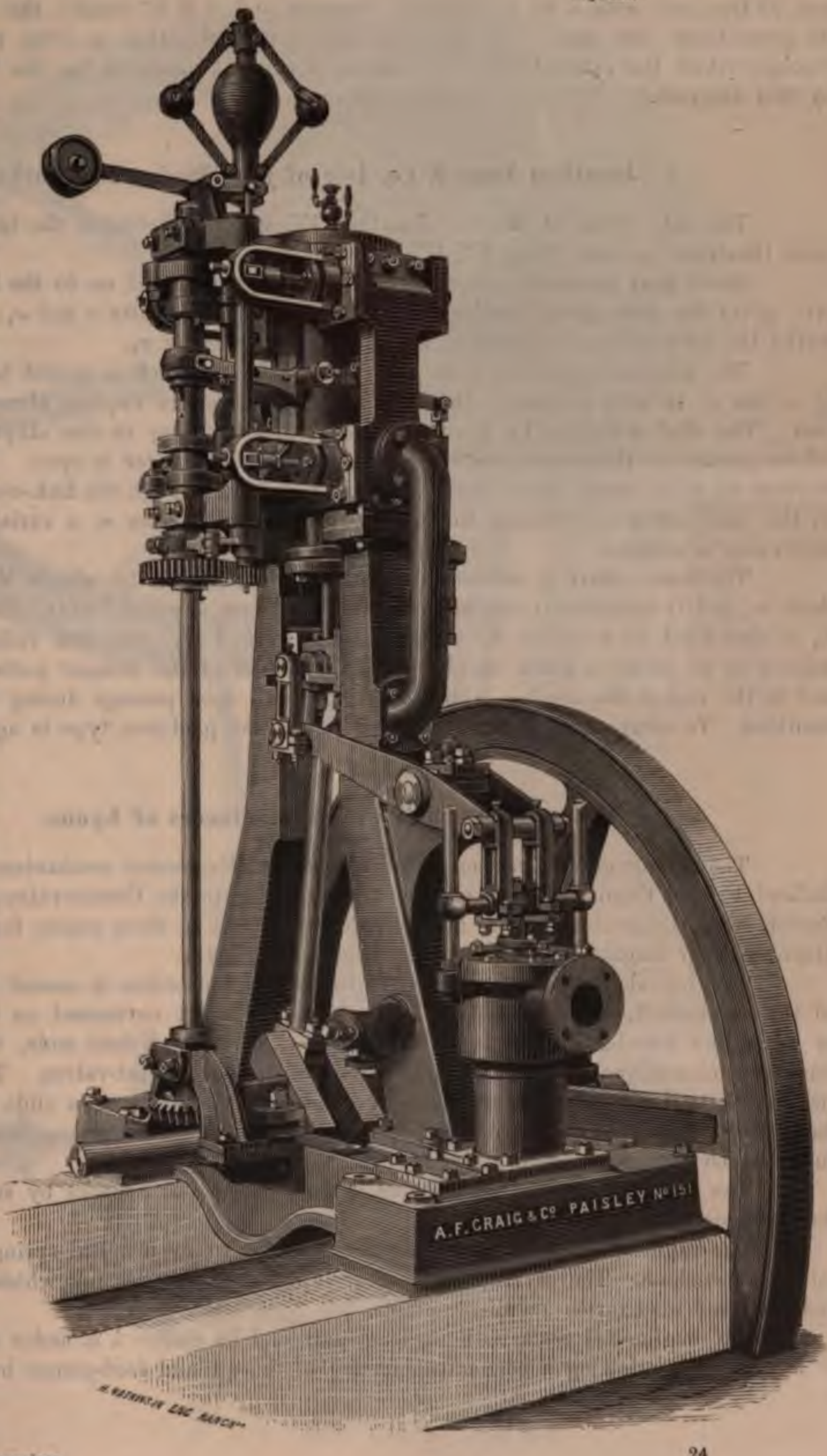
FIG 237

The cylinder is 10" diam. the stroke 20"; the maximum and minimum number of revolutions is 80 and 60 per minute. The Engine is mounted on box sole plate, on which is cast the crank shaft pillow-blocks, and the seats for the foot valve and air-pump; the crank-shaft is $3^1/_2$" diam. at the bearings. The Columns are cast hollow, one of which forms the condenser; the slides are cast on the Columns, means being provided on the crosshead for taking up wear. The piston rod and crosshead are forged together of steel; all the bushes are of phosphor bronze. The air-pump is wrought by levers and links from the crosshead; the diameter of the pump is 7" inches, with a stroke of 10". The bucket and grids are all of phosphor bronze. The valves are India Rubber. The steam and exhaust valves are worked by an upright shaft driven from crank shaft by mitre wheels.

The exhaust valves are worked by one eccentric, the travel being $1^1/_2$" and the ports into exhaust face having an area of 6.5 sqr. in. The steam valves have a travel of $^3/_4$" the opening cam being fixed in position to give the lead at the proper time; it is keyed on the shaft. The closing or cut-off cams are keyed on a tube mounted loose on the shaft; it has an angled slot with a pin passing through a parallel slot in the shaft. The angle in the tube is so cut that it varies the range of automatic cut-off from $^1/_{20}$th to $^5/_{10}$ths of the stroke. The valves have an opening of 4 sq. in. The governor is of the Porter type; it is driven from the upright shaft by a spur-wheel and pinion, which are machine-cut. The whole of the valve-levers and spindles, upright-shaft, cams and governor connections are of steel.

The other parts of the Engine require no description as they are clearly shewn in our perspective view. In Fig. 239, a diagram is reproduced as taken from one of Messrs. Craig's Engines, which they supplied to Mssrs. J. & P. Coats, Ferguslie Thread Works for driving the turning shop. The boiler-pressure

Fig. 238.



was 55 lbs., and with a 20 in. cylinder diameter and a 3′ 6″ stroke, the engine was running at 60 revolutions per min. It may be here observed, that a long range of heating pipes through which the exhaust steam is passed, somewhat accounts for the back-pressure indicated by this diagram.

c. Jonathan Edge & Co. late of the Tipping Ironworks, Bolton.

The late Firm of Messrs. Jonathan Edge & Co. patented the Quadruple slide arrangement illustrated on our Plate XX (Figs. 1 and 2).

Bevel gear transmits rotary motion from the crank-rod on to the lay-shaft w which in its turn gives by mitre-gear, similar rotary motion to the shafts v and v_1; the first of the latter works the inlet-valves, the exhaust valves being worked by v_1.

The inlet-valve spindle F is fixed to a slide T, which is moved backwards and forwards by a cam n, in such a manner that the anti-friction rollers $r\,r_1$ are always in contact with this cam. The shaft v driven by the tooth-gear I to IV, owing to the elliptic wheel II is made to rotate quicker at the opening of the port than when the latter is open. In addition, the shaft v receives an axial thrust under control of the governor, through the link-work of the latter playing on the fast collar m. Owing to the form given to the cam n, a variable return-travel of the inlet-valve is secured.

The lower shaft v_1 receives its motion through the mitre-wheels V to VIII from the lay-shaft w, and it revolves at one uniform speed, without any axial slide. The exhaust-valve spindle F_1 is also fixed to a saddle T_1 and similarly worked by cam and roller gear p, o, in such a manner as to ensure a quick opening and shutting-off of the exhaust ports, at the commencement and at the end of the stroke, whilst securing a full open passage during the intermediate piston-positions. To secure a small travel of the valves, the grid-iron type is again used.

d. Buffaud Frères, Engineers of Lyons.

The disengagement-portion of the Automatic Expansion mechanism, introduced by Messrs. Buffaud Frères, Engineers of Lyons, is exactly alike to the Corliss-valve-gear of Messrs. Bède & Farcot, (resp. Lebrun) which we have already described in these pages; for this reason we merely illustrate their Engine in perspective in Figs. 240 and 241.

The lay-shaft running parallel to the engine-centre-line is caused to rotate by mitre gear off the crank-shaft, and it transmits in its turn, its rotary movement on to two vertical spindles by worm and wheel-gear; the latter are fitted with cams at their ends, the uppermost of which drive the inlet-valves, whilst the bottom pair work the exhaust-valves. The reciprocating movement of the valve-spindles is obtained by attaching the latter to a slide placed in contact with these cams. As in the Bède & Farcot gear, so in the present arrangement, a trip-gear is introduced which works precisely alike.

The governor is fixed at the side of the cylinder, and works by suitable link-combination the disengagement gear.

The rapid shut-off of the inlet valves is effected by a spiral spring, which simultaneously acts as a cushion. The external valve-gear is enclosed in a casing which protects it from dust and dirt, and also forms an oil-receptacle.

The engine-bed rests with its front-part and its end — i. e. under crank-shaft and cylinder — on the floor, allowing a convenient setting of the air and feed-pumps between.

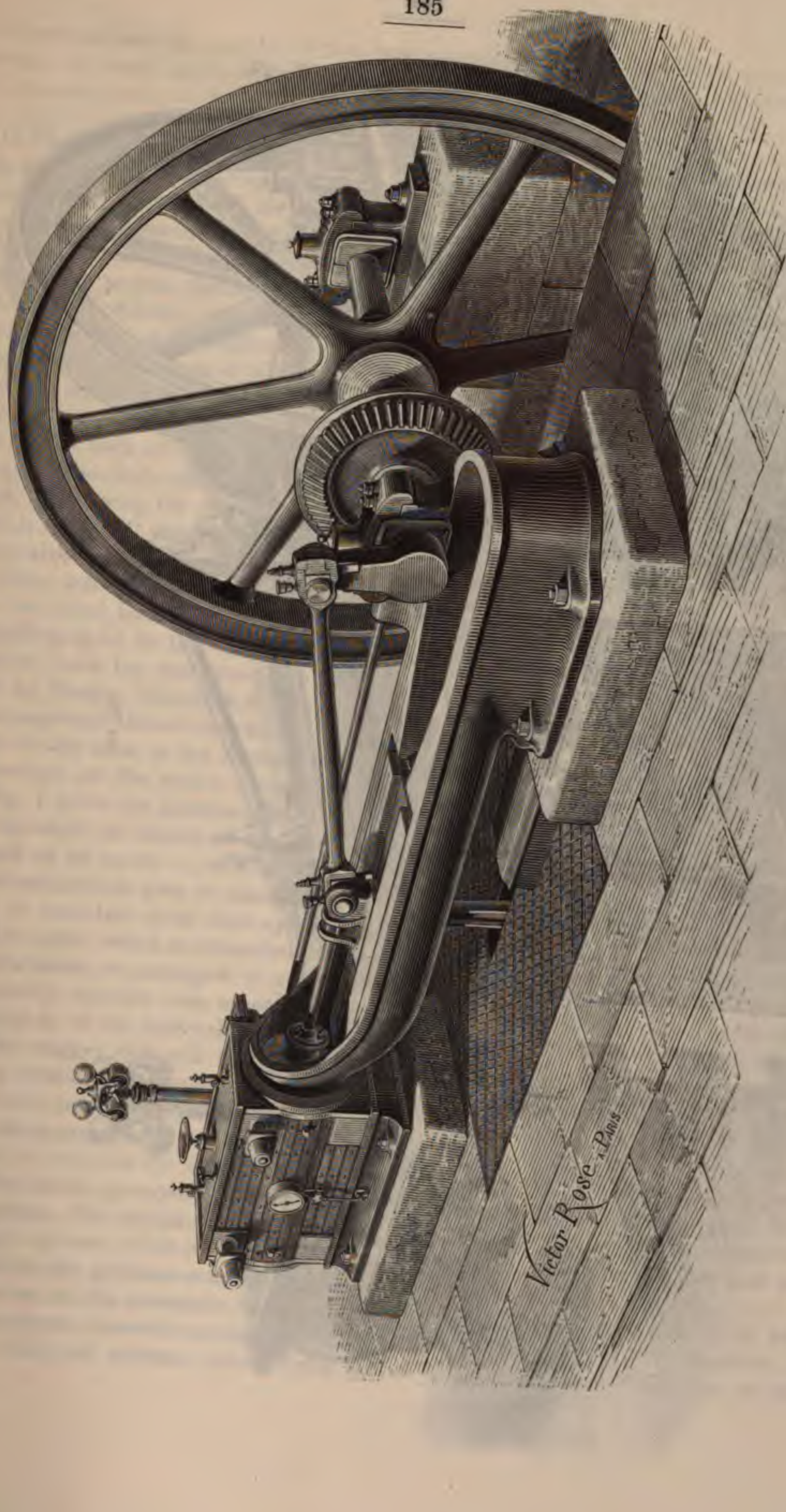


Fig. 240.

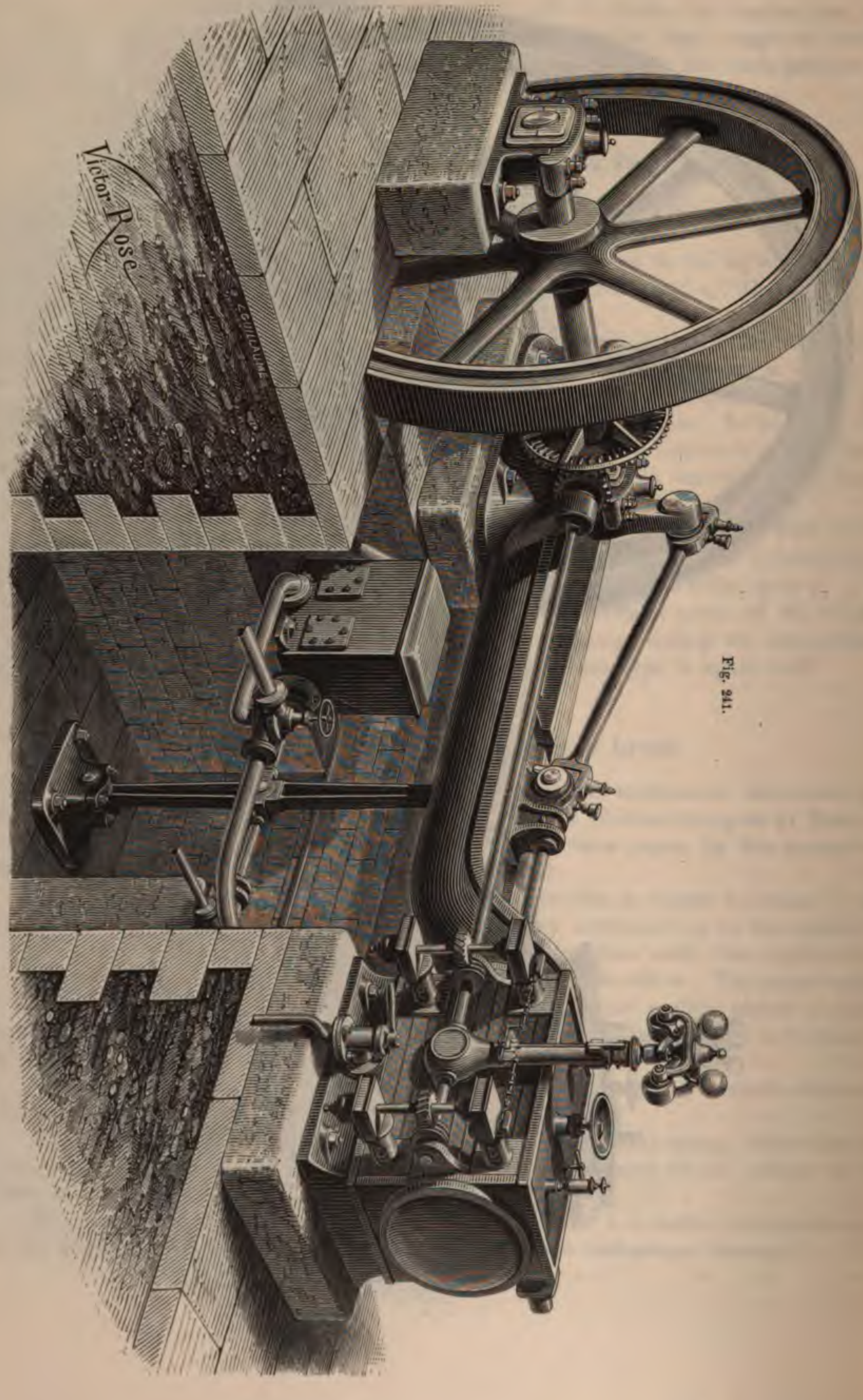


Fig. 241.

e. Fr. Wannieck, Engineer of Brünn.

Type: Wannieck & Köppner.

On Plate 39, the reader will find illustrated the latest improved Expansion-gear of Messrs. Vannieck & Köppner. Considering that we may look upon it, as the outcome of a long practical xperience, we may be pardoned for casting a retrospect on the various mechanical arrangements, hich have led the forementioned Firm to introduce and adopt the present Automatic Variable xpansion-gear in preference to their preceding innovations. The advantages of the Corliss valve-ear, such as they present themselves in the use of separate valves, natural draining of the cy-nder, etc. are self-evident; still the manner in which the modification was carried out, so as to iit the requirements of the different engine-construction (pg. 72) proved too complicated. For iis reason, Messrs. Wannieck & Köppner abandoned the Corliss-gear with its rocking-plate, and turned to the ordinary *D*-slide, which they of course arranged independently, on each cylinder-id — vide pg. 159 —. In this arrangement they employed expansion-plates to slide under the control of trip-gear on the back of the valves, paying little regard to any largely varying engine-loads. In heir subsequent slide-valve gear, — vide pg. 166 — the same machinists merely modified their previous rrangement, by allowing the shutting off and the supply of steam to be performed by four separate alves; that is to say, *D* slides and expansion plates were there no longer used, but we found inlet ind exhaust-valves re-introduced, the former of which supplies and momentarily cut-off the steam, whilst the latter merely controlled the passage of the exhaust-steam.

On the other hand, the advantages of the Corliss-principle, in the arrangement of the iteam-distributing gear on the top and bottom sides of the cylinders, ensuring natural draining f the cylinder, were too conspicuous to allow them to be ingnored, without an extra attempt eing made by Messrs. Wannieck & Köppner to adopt their practically successful flat slide and rip-gear arrangement thereto and combine the same in a novel construction to the Corliss-type. he outcome of this idea, is the Engine which we represent in our Plate 39, where Fig. 1—4 are orking drawings of the entire arrangement, Fig. 5 and 6, shew the valves on an enlarged ale, and Fig. 7 gives the position of the trip-gear at disengagement periods.

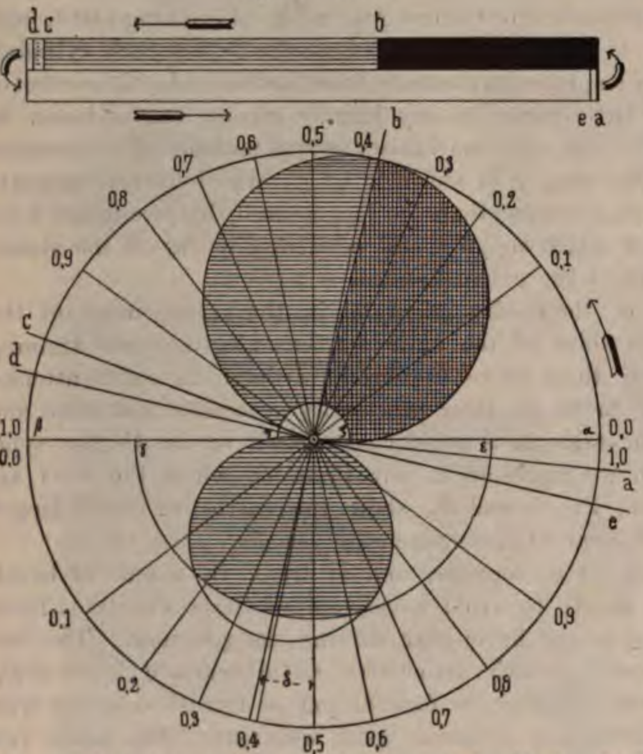
The lay-shaft is carried along the side of the engine, and is driven by a pair of bevel-heels — each of 46 teeth — off the crank shaft; to avoid noise, one of these wheels is fitted ith wooden-teeth, which plan is also adopted in the bevel-gear driving the governor. The lay-iaft carries an eccentric *A* at each cylinder-end, which articulates a three-armed lever BB_1. he arm of the latter which is connected to the eccentric, is forked, and is furnished inside with djustable steel-plates, so arranged to compensate for eventual wear and tear. The other two rms, diametrically opposite each other, have small forked extremities, for taking up at one end ie trigger (Fig. 6) of the inlet-valve spindle, and the exhaust valve-spindle (Fig. 5) itself at the ther end. The trigger end will thus describe a small arc in its travel, whereas the other end f the lever is arranged to furnish the exhaust spindle with a straight movement.

This valve-gear, as may be seen from Fig. 4, makes use of no springs, but advantage is iken of the steam-pressure on the valve-spindle swell, to effect the rapid closing of the corres-onding valve, as soon as the trigger is forced out of gear from the corresponding catch-plate nder the action of the governor; the intensity of any resulting shocks is distroyed by the simple ash-pot appendage. The stroke may be varied by the adjustable wrought-iron disc *u*, which may e made to beat against a felt-cushion on the dash-pot piston. The third Corliss-gear has been artly adopted for the governor-action.

The action of the automatic trip-gear may be seen on referring to Fig. 7, in which the arious disengagement moments corresponding to certain piston positions are inscribed. On ac-ount of both inlet and exhaust valves being moved by one eccentric, the grades of expansion are limited. From position I to position II, the eccentric goes over half its travel and so does the trigger, which consequently takes the valve-spindle over the same travel. In position III, the crank is on its dead centre, and the valve has opened to the extent of its lineal lead. In this and succeeding positions IV — 0.1 cut-off — and V — 0.38 stroke — the trigger is on the point of being pushed out of gear.

In order to explain, the extent to which the ports are opened with corresponding crank or piston positions, we have prepared the Zeuner diagrams shewn in Figs. 242 and 243 based on these measurements. As the lever-arms are of unequal length, the travel of the inlet-valve is greater than that of the exhaust-valve. The constructive arrangement justifies this inequality, inasmuch as the inlet valve has only two ports, whereas the exhaust-valve slides over four steam-passages; in our diagram we need take no account of this discrepancy as it merely represents the travel from one side of one single opening to the other, and because all are equal to each other. Both valve-circles have the same lead-angle (δ) of 12·5°; the semi-circle $n\zeta$ is described with the lap ($^1/_4$ in.) of the inlet-valve as radius, $\zeta\alpha$ representing the width ($1^5/_8$ ths in.) of the port. To complete the upper half of the diagram, take half the travel (20 mm. = $^3/_4$") of the inlet-valve in the compass and describe the circle $\alpha\beta$.

Figs. 242 and 243.



The exhaust-valve has no lap, consequently the semi-circle $r\varepsilon$ is drawn to a radius equalling the port width (25 mm. = 1" in.) and then taking half the travel (14 mm. = $^1/_2$ in.) of this valve into the compass and describing the valve-circle, the lower half of the diagram is also completed. To facilitate the comprehension of the diagram, ten equal stroke portions are added to the figure.

The main points referring to the distribution of the steam, when the crank is revolving as indicated by the arrow, may now be easily traced. With the crank-position a the admission valve begins to open; at b it has reached its extreme position and the limit of variable expansion is attained. Were disengagement not to ensue, the port would only close at c, the period of expansion lasting from c to d, as the exhaust-valve begins to open at d; in this crank-position the valve-gear is midway on its travel. The exhaust-valve has opened during half-a-revolution of the crank because closing at e, compression takes place whilst the crank is moving from e to a. In Fig. 171, we have represented the periods of steam-supply, and of expansion and of compression during the stroke, the top portion of the diagram referring to the forward piston-stroke, whereas the bottom part refers to the return-travel.

The dimensions of the Engine illustrated on our Plate 39 are as follows: Cylinder-diam. $18^1/_2$ in. (474 mm.); stroke 3' 7¼" (1106 mm.); mean piston speed per sec. nearly 6' 6" (2 m.) per sec. when running at 54 revolutions per min. A steam-jacket is not used, but the inlet-valve chests are connected with the steam-passage placed on the cylinder-top, leading to the steam-supply pipe. The latter $4^3/_4$ in. (118 mm.) in diam. is $^1/_{16}$ th piston-area. The steam-exhaust is taken up by the cylinder-legs; a chest is arranged inside each of these legs, which simultaneously serves for the sliding surface of the exhaust-valves, whence the spent steam is taken by an exhaust pipe of $6^1/_4$ in. (158 mm.) diam. or of $^1/_9$th the piston-area. The cross-head pin is prolonged for taking up the guide-rod of the air-pump; this rod is $5^1/_2$ in. (140 mm.) long, 4 in. (100 mm.) diam. and set to an eccentricity of 6 in. (155 mm.). The connecting rod, five times the length of the wrought iron crank has a closed strap end. The engine-trunk frame, is bolted to the crank-shaft bearings 8 in. = (204 m m.) in bore × 16 in. = (408 mm. wide) and to the cylinder.

The governor used is of the ordinary Porter-type, its collar-rise of $3^1/_2$ in. (92 mm.) being calculated for 167.4 revolutions per min. The governor is fitted with cataract cylinder.

f. Hy. Berchtold, C. E., of Zürich.

When discussing Circular-valve gears we observed — see pg. 115 — that the latest Automatic Variable Cut-off motion designed by Mr. Hy. Berchtold of Zürich, belonged to the flat-slide group. It is this arrangement which we represent on Plate 29, in Figs. 1—7, as attached to a Condensing-Engine.

The external valve-gear has merely been so far modified that instead of the lever-mechanism setting a vertical-spindle in oscillation, the same gives alternate motion to an horizontal valve-rod. On the other hand, the lay-shaft placed at the engine-side and driven off the crank-shaft, as well as the vertical governor spindle, have both been retained in the present arrangement. Two cam-discs are keyed on the governor-spindle, the lower one of which — Fig. 7 — works the exhaust grid-valves direct by means of two crank-levers. The inlet-valves are again worked by trip-gear, by an arrangement which from Fig. 3 the reader will perceive to be very similar to the mechanism before alluded to; the construction of the inlet-valves will be seen from Fig. 6, which also shews the patented method of keeping the valves on their seat, by vertical springs.

The same remarks we made, respecting the distribution of steam in the circular-valve arrangement, finds equal application here, for reason that the form of the cam-discs producing the valve-travels has remained the same, and the arrangement of the leverages exercises the same effect on the valve-motion.

The main features of this engine-type, manifested themselves already at the Vienna International Exhibition, where Messrs. Scheller & Berchtold exhibited an Engine. Thus, the peculiar method of driving the air-pump in combination with the placing of the condenser under the slide-bars, together with the overhanging cylinder, are noteworthy.

The principal dimensions of the Engine are as follows: Steam cylinder, $15^3/_4$ in. (400 mm.) diam.; stroke 2 ft. $11^1/_2$ in. (900 mm.); steam supply-pipe $4^1/_4$ in. (110 mm.) or $^1/_{13}$th piston-area. Strictly speaking, no exhaust-pipe is introduced, but the spent steam is allowed to pass straight into the condenser; this steam-passage is 7 in. (180 mm.) wide by 2 in. (50 m m.) deep, or $^1/_{14}$th piston-area. As the double acting air-pump, is $6^3/_4$ in. (170 m m.) in diam. and 1 ft. $11^1/_2$ in. (600 mm.) in stroke, its capacity is as 1 : 8·3 to that of the steam-cylinder.

The connecting rod, $5^1/_2$ times as long as the crank, is constructed in the marine-type fashion at its strap-end. The air-pump is driven by double crank and oscillating lever, the upper arm of the latter driving the air-pump.

g. The Karolinenthal Machine Works of J. C. Bernard, of Prague.

Type: Carl Smrczka.

The Karolinenthal Machine Works of J. C. Bernard of Prague, constructs Engines with a Flat-slide gear from the design of Carl Smrczka, the cylinder arrangement of which we illustrate in different views and sections on Plate 40. According to Carl Smrczka's own admission he borrows the idea of utilising steam-pressure in place of spring-pressure from the Dautzenberg valve-gear shewn at the Vienna Exhibition; still he claims the peculiar arrangement of the valves to have been first used by the Karolinenthaler Machine Works.

The steer-shaft is placed along the side of the engine, and is made to revolve at equal speed with the crank-shaft. By the use of four eccentrics keyed on this steer-shaft, each of which work a valve, the travel of the inlet-valves is rendered independent of the exhaust-valve. All the ports are made grid-fashion, and are each $1^{3}/_{16}''$ (30 mm.) wide, the length of the inlet and exhaust ports being respectively $3^{1}/_{8}''$ and $3^{1}/_{2}''$ (80 and 90 mm.).

As may be seen from the annexed Figs. 244—246, the top end of the eccentric-rod *B* articulates an equal armed lever $k k_1$. The arm k_1 is connected by means of a short link *e* with a steel piston *p*, which slides horizontally in a bracket *T*. The latter is also connected with the dash-pot piston *Q*, and also forms the carriage for the lever $k k_1$.

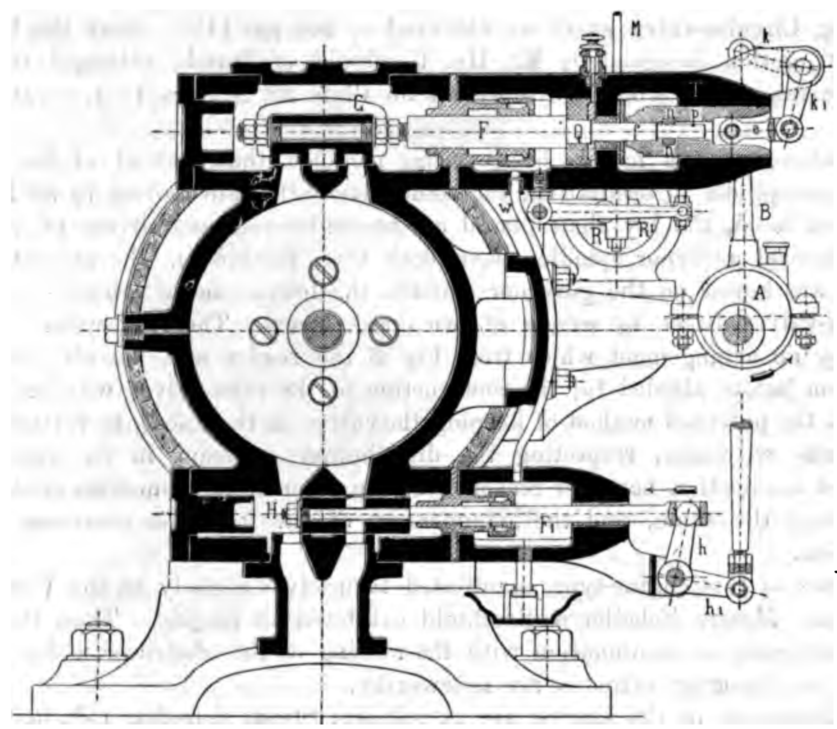


Fig. 244.

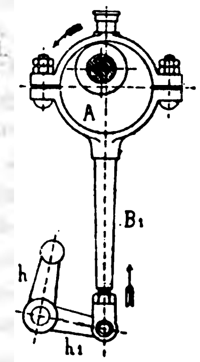


Fig. 245.

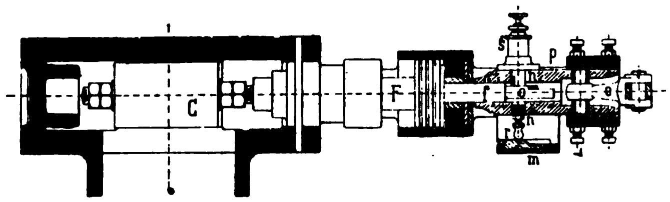


Fig. 246.

The steel-piston *p* takes up the thin end *f* of the valve-spindle *F*, which is swelled to 2 in. (50 mm.) where it fits in the valve-chest, so that the pressure of the steam may have a constant tendency of forcing the valve-spindle outwards. The magnitude of this thrust is limited by the metal dash-pot piston screwed on the valve-spindle, and furnished with a felt-liner. In this extreme position of the valve-spindle *f*, its steel-catch *o*, arrives behind a steel-bolt *n n*, which aided by a spring in the chamber *s* can move parallel to the valve-spindle. When the eccentric *B* causes the piston *p* to move against the steam-pressure, the bolt *n n* imparts the same motion to the valve-spindle, and as a consequence the valve is similarly drawn over and opens the inlet-ports.

To shut-off the steam-supply to the cylinder, all that is necessary, is to thrust the bolt $n n$ against the spring pressure, out of gear. For this purpose, an adjustable pin r is screwed into the bolt, which while taking part in the motion of the piston p and of the bolt, glides over a steel-plate m. This plate is divided in a diagonal direction, in a higher and in a lower contact surface; if the pin is therefore so adjusted, that it is in contact with the lower surface during engagement-periods, it becomes forced, under continued motion, to mount on the higher surface, whereby the bolt $n n$ becomes disengaged from the catch o. The steam-pressure then naturally effects the immediate return travel of the valve-spindle, the air-piston acting as a cushion. The mounting of the pin on to the elevated surface at different times to ensure a variable expansion, is obtained by a vertical shifting of this plate; thus with rising governor balls, a sinking of the plate ensues, and an earlier cut-off is obtained, and vice versa. The connection of the governor rod M by the intermediate levers $R R_1$ and the shaft w, may be read off Fig. 244 and Figs. 2, 4 and 7 (Plate 40). Figs. 7 and 8 of the same Plate shew the details of the bolt, pin and spring on an enlarged scale, whereas Fig. 9 gives various positions of the governor-lever with corresponding positions of the bolt and pin for certain inscribed piston-travels. In the position the disengagement plate is represented, cut-off would ensue at $1/6$th stroke. It is assumed in this sketch (Fig. 9) that the inlet-valve eccentric is keyed 70° in front of the crank, which 70° represent the angular travel of the eccentric when the crank is on its dead-centre.

As the connection of the exhaust-valve H with its eccentric A by means of the crank-lever $h h_1$ is self-explanatory in our Fig. 245, we may pass over it in silence.

The cylinder diameter of this elegant machine, — which want of space prevented us from drawing complete, — is $16^1/_2$ in. (420 mm.) with $31^1/_2$ in. (800 mm.) stroke; the cylinder is carried on a separate cast-iron base. Steam is supplied to the top of the cylinder in the ordinary way through a supply-pipe of $3^1/_8$ in. (80 mm.) diam. or $1/27$th of the piston-area. The spent steam escapes at each end of the cylinder, by a separate outlet, which simultaneously forms the valve-seating; the diameter of these outlets are $4^5/_{16}$" (110 mm.) so that the corresponding cross-area stands in the proportion of 1:14·5 to that of the cylinder. The construction of the piston is explained by Fig. 1 of our Plate, where it will be seen mounted on a piston-rod, $2^3/_8$ in. (60 mm.) diam. protruding through both cylinder-covers. Whereas the front stuffing-box is made *entirely* separate from the cylinder, the hind stuffing-box is *partly* cast with the cylinder. The slide bar casting is bolted to the protruding flange of the front cylinder-cover; the crank-shaft pedestal forms one casting with the slide-bar casting. The connecting rod, of 6 crank-lengths is 4 in. (100 mm.) at its centre. The crank-shaft diameter is 6 in. (150 mm.) diam.; its bearing is 10 in. (250 mm.) wide.

h. J. & V. Florio & Co., Fonderia Oreta, Palermo.

Type: W. Theis.

At the Paris International Exhibition of 1878, a prize was awarded to the Horizontal Engine exhibited by Messrs. J. & V. Florio & Co., Engineers of Palermo. It is this machine which we illustrate on Plate 41 by Figs. 1—3, with the detailed Figs. 6 and 7 shewing the construction of the grid-iron valves. The four valves are worked by two eccentrics in such a manner, that the one eccentric gives motion to the two inlet-valves, whilst the other is made to work the exhaust-valves. By this arrangement, the same effect is obtained as with Smrczka's Valve-gear, since by keying on the inlet-valve eccentric 52° 30' in front of the crank, variable cut-offs up to $6/10$ths stroke are attained. The reader will remember, that in the third flat valve gear of Messrs. Wannieck & Köppner, only two eccentrics were used; alone the range of automatic variable expansion lay in smaller limits, on account of each eccentric, working one inlet and one exhaust-valve.

A vertical shaft A supported in two bearings is arranged at the side of the cylinder (vide Fig. 4, Plate 41); a lever B running underneath the cylinder is fitted to its lower end. The other end of this lever is taken up by a straight moving rod, which is in its turn connected to a short eccentric-rod and to the inlet eccentric. By this mechanism the vertical shaft A is made to oscillate, which oscillating movement is transferred to a peculiarly formed double lever C (Fig. 5) keyed on the top end of this shaft. This double-lever C grips alternately with each oscillation, one of the valve-spindles, so opening one of the inlet-valves; thus during one entire oscillation, corresponding to one crank-revolution, the two inlet valves are moved. We have shewn one of the arms of this lever C on an enlarged scale in Fig. 5; its end is forked and gears on to a trigger plate N connected by link-work to the inlet-valve-spindle F. When nearing the end of its oscillating stroke, the arm C approaches one of the valve-boxes, the trigger N is forced into gear against a steel catch-plate o of the lever, by the action of the spring S; with the change of oscillating motion, this corresponding valve-spindle is pulled outwards by the arm C, and the port is thus opened. The forked end of the lever C has moreover a crank-lever $R R_1$ attached to it, the arm R_1 of which, is connected with the governor by the rod M, whilst its other arm R presses at different times against the trigger N. According as the crank lever $R R_1$ assumes various positions, at the bidding of the governor, disengagement between N and o ensues sooner or later. The valves are closed by spring-pressure, and for this purpose the slide has a second spindle attached to a dash-pot piston and also actuated upon by these springs. During the slight travel preceding the opening of the valve, the latter is balanced by a piston placed in the valve-box cover, and which is connected to the valve by a steel-blade. Equilibrium thus takes place when a smaller pressure is exerted on the external area of the piston, than exists in the valve-box. This pressure varies with the pressure inside the corresponding cylinder cavity, because, as Fig. 1 explains, the external area of this piston is in free communication with the cylinder. If, therefore, one end of the cylinder is in communication with the condenser, the corresponding inlet valve is balanced when it begins to move; but the valve is no longer balanced as soon as it has opened, the inrushing steam then only causing it to partially balance itself.

The inlet-ports are $^3/_8$ in. (10 mm.) wide; the exhaust ports are $^1/_2$ in. (12 mm.) wide. The travel of the first named amounts to 1 in. (25 mm.), the stroke of the latter is $1^1/_8$ in. (30 mm.) and the eccentricity of the inlet-eccentric measures $^3/_4$ in. (20 mm.).

In Fig. 5, we have drawn some of the positions of the trip-gear during certain inscribed stroke portions.

The exhaust-valves are worked in a similar manner to the inlet-valves, inasmuch as the lever B_1 placed underneath the cylinder is also attached to a rod which gives alternate motion to the exhaust-eccentric and to the eccentric rod. This lever is fitted loose on the shaft A; it imparts oscillating motion to a double lever rigidly connected with the exhaust-valve spindles.

The 12 *HP* Condensing engine, herewith illustrated, had a stroke of nearly 2 ft. (600 mm.) and with a cylinder-diameter of 12 in. (300 mm.), the mean piston speed, with the crank running at 70 revolutions per min. thus calculates itself at 4 ft. 7 in. (1.4 m.) per sec. The wood-lagged steam supply-pipe is $2^5/_{16}$ in. (60 mm.) diam., or $^1/_{25}$th of the piston area, the exhaust-pipe, arranged underneath the cylinder, is $4^1/_8$ in. (105 mm.) diam., but the area of the 2 in (50 mm.) injection-pipe must be deducted therefrom, so that its cross-section is only $^1/_{10}$th that of the piston. The engine-trunk frame is of novel design, owing to the cranked flywheel shaft being placed above the condenser; the overhanging cylinder is bolted to the frame. The exhaust-pipe is bolted by a compensating joint-piece, to the condenser, for reason of the unequal expansion and contraction of the two.

The connecting rod, five times the length of the crank, is forked at its butt-end. The crank-arms are each counterweighted for balancing the moving parts. The two eccentrics and the flywheel 9 ft. 10 in. (3 m.) diam. are mounted on one side of the crank-shaft bearings which are each $4^3/_4$ in. (120 mm.) in bore and 6 in. (150 mm.) wide; the opposite crank-shaft carries the strap-pulley driving the pseudo-astatic governor, which revolves at 158 revolutions per min. and the air-pump is also worked from the same end by separate crank-disc. The air-pump is single acting, with a plunger of $6^7/_8$ in. (175 m m.) diam. and 10 in. (250 m m.) stroke. The feed-pump is driven off the air-pump plunger.

The shut-off valve is of the grid-iron form, worked by a small hand-wheel.

As the peculiar form of the engine trunk-frame, renders the cylinder-stuffing box rather inaccessible, the latter may be tightened up by an external hand-wheel, though this is an arrangement, which is certainly not commendable.

i. P. Villette, Engineer of Lille.

We have only been able to secure the rough sketches shewn by our Figs. 247 and 248 of the Engine exhibited by P. Villette at Paris in 1878.

The lay-shaft A has two key-ways, diametrically opposite each other, in which keys $r r_1$ are let in; these keys are wedge-shaped at one end, whilst the other extremity communicates with the governor. The lay-shaft also carries a disc B the circumference of which is grooved, for the purpose of receiving the valve-spindle. This disc is also furnished with a radially adjustable bolt n, which on the one side rests on the key r, and on the other side protrudes more or less into the groove of the disc B; the spring s causes the bolt to follow the oscillations of the cam-rod. With a certain rotation of the lay-shaft, the bolt n catches against the collar o of the valve-spindle, and forces the latter to move against the spring-pressure S, whereby the slide G allows steam to enter into the cylinder. As soon as the bolt n glides off the spindle-collar, the contrary spring-action forces the valve to close. The exhaust-valve H is also driven from the lay-shaft A, by means of the fixed cam K — shewn in Fig. 248 — which articulates a double lever L, the arm L_1 of which is connected with the exhaust valve-spindle.

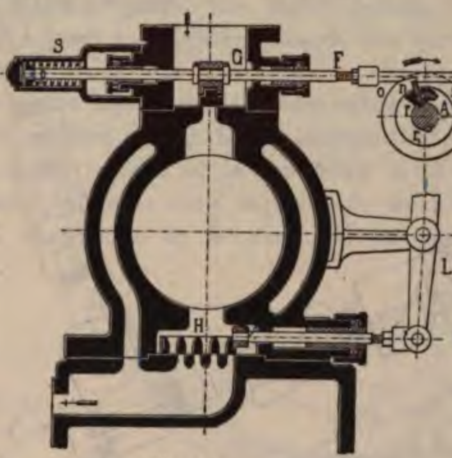


Fig. 247.

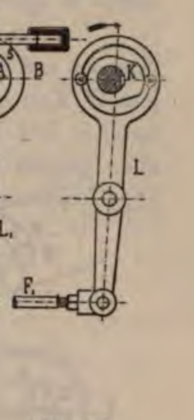


Fig. 248.

j. Moritz Kuchenbecker, of Schweidnitz (Silesia).

The very simple Automatic Variable Expansion-gear, patented in 1878 by Mr. Kuchenbecker, C. E. of Schweidnitz, is identical in principle with the Valve-motion shewn in Figs. 1 and 2 (Plate XXV), merely differing from the latter, in the construction of the cylinder.

We may point to the special advantage enjoyed by this valve-gear, as it obtains Automatic Variable Expansion, between the wide range of 0.0 and 0.9 stroke, notwithstanding the use of only one eccentric for each pair of inlet and exhaust-valves. Steam-pressure is utilised for the rapid closing of the valves, and also characteristic, is the use of only one link for the disengagement tackle.

The inlet valve spindle centre-lines are inclined, being almost in line with the centre of the lay-shaft. On the other hand the axis of the exhaust-valve spindle may be arranged either horizontally or otherwise. The lay-shaft A placed at the side of the cylinder, and revolving at equal speed with the crank-shaft, has two eccentrics $C C$ keyed on it. The short eccentric-rod B, forged in one piece with half the strap, articulates a lever $L L_1$, whereby the articulating centre describes a circular-arc round the fixed centre of the lever. Consequently, the edge of a trip-catch n fastened on the eccentric strap, will approximately move on an elliptical path, and trip up against a steel catch-plate *o* fastened on the extremity of the inlet valve-spindle. The two catches will always get into gear at the same spot on their elliptical travel, hence the lineal lead of the valve will always remain constant. According as the link N_1 (connected with the inlet-valve spindle) is higher or lower, the catch-plate *o* will remain longer or shorter in gear with the catch *n*, so forcing the inlet-valve spindle *G* to follow the eccentric thrust more or less. An adjustable short link P_1 connects the arm *N* with a crank-lever RR_1 which is placed under immediate control of the governor by the rod *M*. The moment the two catches *n* and *o* become disengaged from each other, the steam pressure acting on the cross-area of the valve-spindle, forces the latter quickly outwards, whereby the inlet-ports are naturally closed; this movement is cushioned by the dash-pot piston *O* fitted on the valve-spindle.

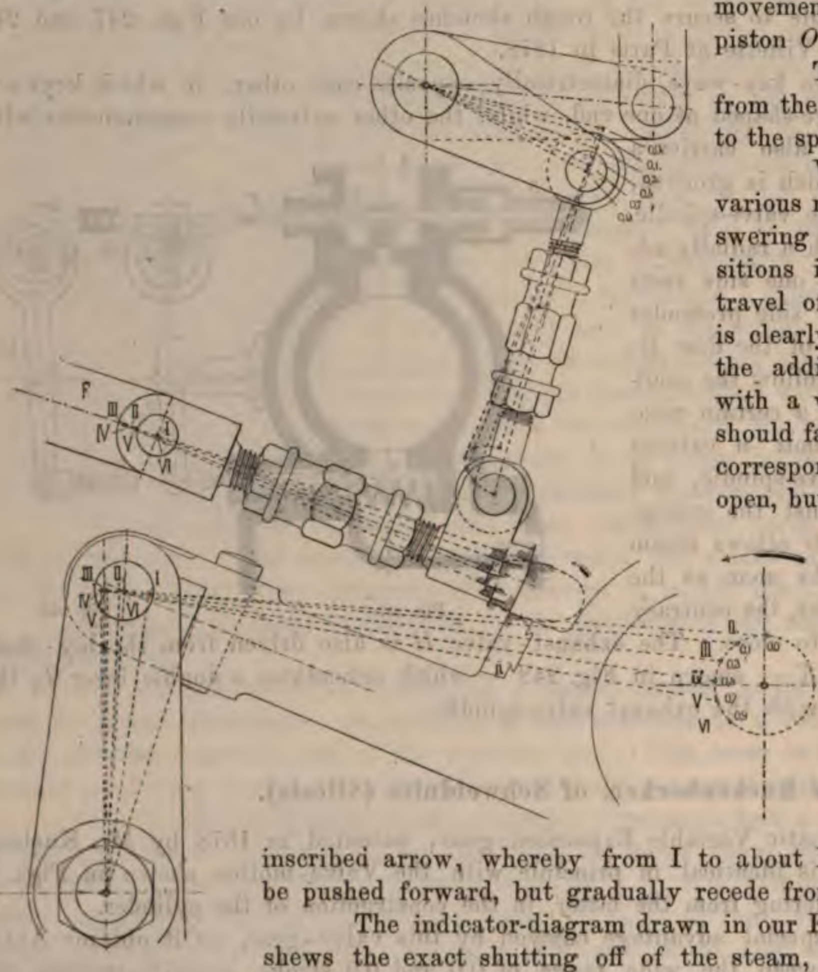


Fig. 249.

The exhaust valve is worked from the other arm L_1 which is fastened to the spindle F_1 of the exhaust-valve *H*.

We have graphically represented various moments of disengagements, answering to certain inscribed piston positions in our Fig. 249; the elliptical travel of the edge of the catch-plate *n* is clearly shewn. This gear possesses the additional advantage, that in case with a very late cut-off, the governor should fail to effect disengagement, the corresponding port would not remain open, but be automatically closed towards the end of the succeeding stroke. We may conclude from this, that from 0.0 to 0.4, the port is continually opening wider, whereas it is gradually contracting from 0.4 to 0.9 stroke. We should arrive at this same conclusion, were we to suppose the eccentric to be moving in the direction of the inscribed arrow, whereby from I to about IV the valve spindle *F* would be pushed forward, but gradually recede from IV to VI.

The indicator-diagram drawn in our Fig. 250, under 60 lbs. pressure, shews the exact shutting off of the steam, but displays too great a back pressure from the condenser. Fig. 251 gives various diagrams under different engine-loads.

The engine cylinder has a diam. of $12^1/_2$ in. (320 mm.) and $27^1/_2$ in. (700 mm.) stroke. All the valves are of the grid-type. The width of the four inlet port-openings is each $^3/_8$ths in. (10 mm.); their length $4^3/_4$ in. (120 mm.): the three exhaust port-openings are each $^5/_8$ths in. (16 mm.) wide and $4^3/_4$ in. (120 mm.) length. The exhaust-pipe placed underneath the cylinder is $3^1/_8$ in. (80 mm.) diameter, or $^1/_{16}$th the piston-area, whereas the diameter of each supply-passage is $3^1/_2$ in. (90 mm.) or $^1/_{12\cdot7}$ the area of the piston.

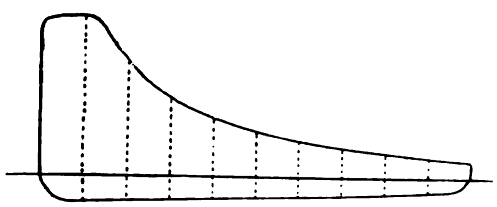
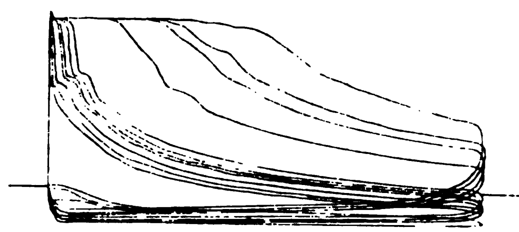
The valve-seatings and valve-chests are made in one casting, to facilitate eventual repairs.

k. Cail, Halot & Co., Engineers of Brussels.

This Engineering Firm was represented at the Paris International Exhibition of 1878, by one of their 60 *HP* Engines, the cylinder portion of which we represent in different views on our Plate XXVI.

The lay-shaft is here arranged at the side of the cylinder, and carried in two bearings. It is driven by a pair of equal bevel wheels off the crank-shaft. Fig. 3 shews the arrangement of the inlet-valve. The cam *C* revolving with the lay-shaft works a slide-block *E* — Fig. 5 — guided by the rail *J*. The latter oscillates round the axis *B*, and as a pin *n* is let in the head *D* of the valve-spindle, it causes its upper end to transfer the motion of the cam *C* on to the inlet-valve *G*. The return of the latter, with which expansion begins, takes place when the cam glides off the slide-block *E*. As may be inferred, to effect variable expansion, the latter has merely to slide in its guide rail *J*; this is done through the governor, off the expansion-rod *R*. The quick return of the valve ensues through steam-pressure, the buffer piston *O* acting for cushioning purposes. Should the stuffing boxes have been too tightly packed, the springs *S* working on the valve-spindles, effect their return-motion.

The exhaust valves *H* are also worked from the lay-shaft *A*. Their outer end has a crank *N* (Figs. 2 and 4) which causes the spindle *w* to oscillate owing to the intermediate link *L* and lever *V*. The lever *X*, fitted on the lower end of the spindle *w*, is connected with the exhaust valve rods by two guide links *Y*. As each of these valves is only required to work during each stroke, — i. e. only during half its oscillation — they have to be arranged unsymmetrically to each other.


Figs. 250 and 251.


This "American" engine has a cylinder diameter of $15^3/_4$ in. (400 mm.) and a stroke of $38^1/_2$ in. (980 mm). The steam is admitted sideways into the cylinder-jacket. The engine trunk-frame is cast hollow in one piece with the crank-shaft pedestal. The crank-shaft bearings are $6^3/_4$" (170 mm.) bore and $10^1/_2$ in. (270 mm) wide; they are arranged in three parts.

The connecting rod, nearly five times as long as the wrought-iron crank is forked at its butt-end, and has an open strap-end. The diameter of the flywheel is 12 ft. $9^1/_2$ in. (3900 mm.), and $12^3/_4$ in. (325 mm.) on the face.

l. Artige & Co., Engineers of Paris.

The Engine exhibited by Messrs. Artige & Co., at the Paris International Exhibition of 1878, is drawn on our Plate 42.

The characteristic feature of this construction, consists in the arrangement of the valves in the cylinder-covers, so as to reduce the clearance spaces to a minimum. But as the exhaust-valves are obliged to be placed inside the cylinder, so necessitating larger clearance-spaces, the piston has lugs cast on each side, which coincide exactly with the openings of the exhaust-valves. The four valves receive their motion from the lay-shaft *A* which revolves at equal speed with the crank-shaft. The shaft has a cast-iron sleeve *b*, on which the exhaust-valve eccentrics CC_1 are keyed. The inlet-valves are worked by cams BB_1 which though rotating with the shaft, possess an axial sliding motion brought about by a cotter passing through a slot in the sleeve and let into the spindle *a*. If during the rotation, the spindle *a* follows an axial thrust, then this horizontal motion is also transferred to the cams. The latter are of the usual shape, so as to effect variable cut-offs with horizontal travels. The governor brings about this longitudinal sliding, inasmuch as its collar is connected with a disc *R*, which it causes to oscillate. The horizontal travel of this disc, is utilised for shifting the spindle *a*.

The valve-spindles pass out of the valve-chests without stuffing-box appendage, through a long sleeve. A steam-tight packing is secured by a number of elastic rings, placed in circular grooves in the swelled portion of the valve-spindles. The valve-spindles $J\,J_1$ are each furnished with a roller, which under the action of a small spiral spring and of the steam-pressure is constantly pressed against the cams. On account of the two inlet-valve spindles at each cylinder-end being in a vertical plane, a small intermediate rod had to be arranged between the eccentric-rod *D* and the exhaust-valve spindle *F*; this intermediate rod, carries two lever arms *E* one of which drives the eccentric-rod, whilst the other works the valve spindle.

Cutting-off at $^1/_{10}$th stroke, and with a steam-pressure of 75 lbs. the Engine is said to develope 40 *HP*. Its cylinder-diameter is $17^1/_4$ in. (440 mm.) and its stroke 34 in. (860 mm.); the mean piston-speed, with crank running at 50 revolutions per min. calculates itself at 4 ft. 8 in. (1.43 m.) per sec. The steam is supplied from the cylinder-side into the steam-jacket, whence it passes direct into the valve-chest is shewn in Fig. 8 in section.

The air-pump is arranged under the floor-line behind the cylinder, and it is driven from the cross-head pin by link and lever. The pipe leading to the condenser is fitted with a two-way cock for allowing the spent steam to rush into the atmosphere when the engine is not working on the condensing principle. The feed pump is arranged on a separate bed and is driven off the crank-shaft by an eccentric.

The modern idea of overhanging cylinder is not introduced in this constructive example, as the cylinder is made to rest on the engine bed. The guide-bars form a cylindrical casting, also carried by the engine bed.

C. Engines working with Lift- or Beat-valves.

I. Valve-gears arranged without Trip-gears.

1. Engines, fitted with simple Lift-valves, working without Expansion-gears.

a. The Wilhelmshütte Machine and Iron-Foundry Co. Lim. near Sprottau.

In their original arrangement, beat-valve gears belonged exclusively to the Mining Industries; for it was with the slow running Winding and Pumping Engines that lift-valves were first substituted in place of the then used Newcomen cocks. It was reserved to a later generation of Engineers, to generalise the adaptation of beat-valve-gears to Steam-motors in general. It would carry us too far, were we to attempt to describe the primitive winding and pumping engine arrangements, which in many cases were constructed by the miners themselves. But in order to facilitate the study of our modern lift valve-geared Engines, we have included the latest beat valve-

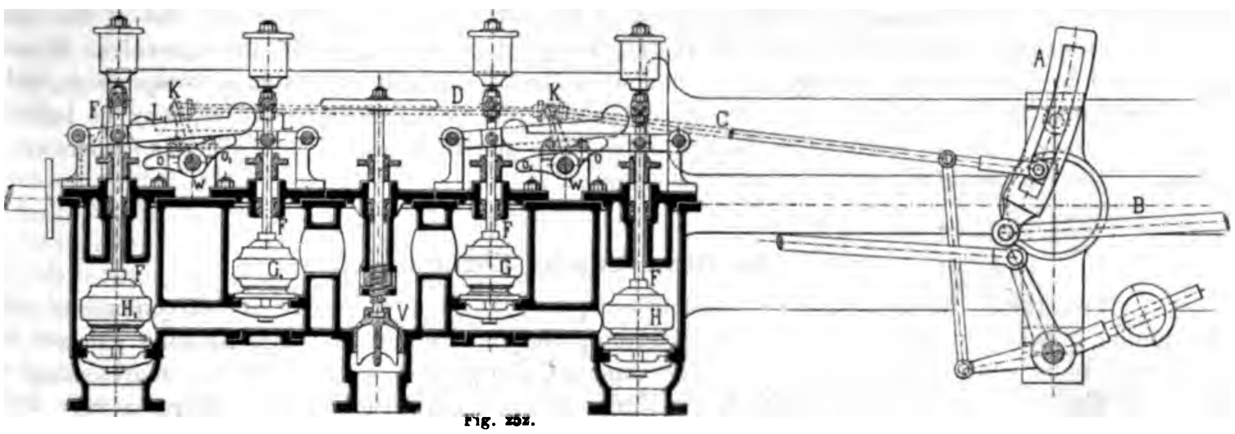


Fig. 252.

gears, belonging to the simpler class of machines simultaneously paying special regard to Winding and Blowing Engines.

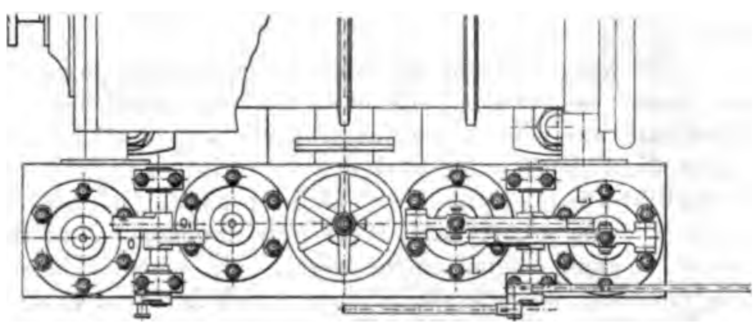


Fig. 253.

A chief characteristic of double-acting lift valve-geared Engines, consists in the distribution of the steam to the cylinder being necessarily accomplished by four separate valves. Naturally the arrangement of the latter may be modified in as great a number of ways, as the Corliss or Slide-valve gears permit. The old types disposes of the four valves and of the shut-off valve, in battery-order at the side of the horizontal cylinder; in the more modern arrangement the Corliss principle has been imitated, and accordingly the inlet-valves are arranged on the top-side, whilst the exhaust-valves are placed at the bottom side of the cylinder. Nevertheless steam-engines of this class, may be found working with all the valves arranged either above or below the cylinder.

Engines, coupled in pairs, with the cranks set at right angles to each other, have been mostly used for modern Winding-engines, in order to overcome all difficulty in starting at any position of the crank. It is perhaps superfluous to observe, that all Winding-engines should be fitted with a reversing-gear, enabling the Engine to be reversed at will, according to the ascent or descent of the cages.

It is one of these simple Winding-engine valve-gears, which we represent in our Figs. 252 and 253, and which is constructed by the Wilhelmshütte Machine and Iron-Foundry Co. near Sprottau.

At the side of the cylinder five valves are arranged, the central one of which is the stop-valve V regulated by hand; the two adjacent valves GG_1 are the inlet-valves, whereas the outer pair HH_1 are the exhaust valves. Owing to all the four valves being worked from one eccentric, the latter is set at an angle of 90° to the crank.

The stem F of each valve is worked from a lever L or L_1 according as these stems refer to the inlet or exhaust valves. The valve-stems are lifted by tappets $o\,o_1$ fitted on a spindle w placed between the valves. As these tappets are symmetrically arranged in regard to the spindle, the rocking or oscillating motion of the spindle causes the valves to be alternately lifted off their seatings. The two spindles w, work with equal angles of oscillation, since their levers KK are each connected together by a rod D. One end of the connecting rod C can be adjusted or linked up in the sweep A. The latter swivels on a centre-pin, and is worked from an eccentric-rod B. The reversing of the engine is effected, by removing the slide-block of the connecting-rod C from one end of the link A to the other; whereas the regulating of the engine-speed is effected by the throttle-valve. Steam is supplied to the cylinder, during almost the entire stroke, without expansion or compression, and for this reason the total expansion of the steam-volume due to the clearance space, may be looked upon as a loss. These Winding-engines are therefore mostly confined to Collieries, where economy in the consumption of fuel is of little moment.

b. American Blowing Engines.

With the increasing sizes of blast furnaces, and the more extensive use of compressed air for mining machinery and underground ventilation, the construction of large Blowing Engines is acquiring more and more importance. The annexed illustration — Fig. 254 — representing a Blowing Engine constructed by the J. P. Morris Company of Philadelphia offers a very fair example of the modern advance made in this mechanical speciality, as the following description shews:

It was sought in the design of this engine, to maintain the whole arrangement, in as compact a space as possible, without in any way sacrificing easy accessibility to all the engine-parts. Great care was paid to the due proportioning of all the mechanical details, so that the Blowing engine should perform the work allotted to it in a satisfactory manner: thus though the engine was to work at a regular pressure of 10 lbs. per sq. in., it was built strong enough to throw off $13^1/_2$ lbs. pressure to the square inch. If we bear in mind, that at the beginning of the present decade, the largest Blowing engine in the world, only supplied blast at a pressure of 4 lbs. per sq. in. to four furnaces, we note the advance which has been made in the last ten years in raising blast pressures.

The highest blast pressures are those carried in the anthracite furnaces, some of the large ones in America being blown at ten lbs, and though opinion varies as to the best pressures, certain it is that very high pillars of blast, cause great and irregular strains on the engine, hence one good feature of the machine herewith illustrated is, that its arrangement of parts offers great stability, in spite of its extreme height when compared to its base. These Blowing engines may be said to consist, of a steam-cylinder over which the air-cylinder is placed; the latter is carried on four strong iron - pillars, which constitute the machine-frame. The steam piston works a cross-beam, the extremities of which run in slides, and the piston of the air-cylinder is similarly attached to this cross-beam. The cross-beam ends are made to form the cross-heads of two connecting rods, which being attached to two crank-discs belonging to the fly-wheels shewn in our illustration, give motion to these fly-wheels.

The steam-inlet to the cylinder, is effected by lift valves — see Fig. 255 — of the Wannieck pattern, and the air-inlet valves are of leather covered with sheet-iron. The air-piston is packed with metal or wood, at the option of the purchaser. The valve motion is obtained from a regulator-shaft driven by bevel, from

Fig. 254.

the main shaft. Two eccentric discs mounted on this regulator shaft, are placed in contact with the valve-spindles and cause the latter to rise and fall, according to the revolutions of the regulator-shafts, thus giving travel to the valve. The naves of the flywheels — which are carefully balanced, — form the forementioned crank-discs, and the flywheels weigh approximately 18 tons. The shafts are made of wrought iron, and the cross-heads are furnished with ball-joints for the connecting rod, so that the latter adjusts itself automatically to any wear and tear of the main-shaft.

The chief dimensions of these Blowing engines are as follows:

Air-cylinder diameter = 7 ft. 6 in.: ditto stroke 7 ft. Steam cylinder diam.: 4 ft. 2 in.: ditto stroke 7 ft. Two flywheels each 24 ft. diam. Foundation plate 13 $\times$ 8 ft. Extreme height $36^{1}/_{2}$ ft. Capacity 10,000 cub. ft. air per minute. Stone-foundation 10 ft. depth, which also carries a light staircasing round the Blowing engine.

On Plate 43, Figs. 18—22 we have drawn two valve-gears, which are largely employed in America. Figs. 18—20 show the construction adopted by Mr. John Fritz, who has had much practical experience in the building of Horizontal and Vertical Blowing-engines. The horizontal arrangement has been found the cheaper of the two, and is also more manageable, hence we confine ourselves to the Horizontal type as applied to a Compound Blowing-engine. The gear-shaft runs over the two cylinders, and is driven by two pairs of bevel-wheels and by a vertical shaft. The blowing-cylinder is placed between the connecting rod and the cross-head (common to the three pistons), so that the gear-shaft is also above the cylinder, whereas two connecting rods, arranged at each side of the latter, connects the cross-head with the two cranks. All the eight valves are worked alike off cams keyed on the gear-shaft, by means of double levers. The cut-off in both cylinders is constant, corresponding to a fourfold expansion.

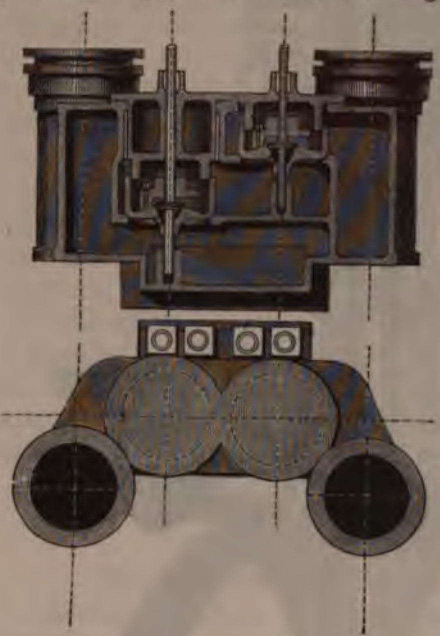


Fig. 255.

The high and low pressure cylinders are of $30^{1}/_{8}$ in. (765 mm.), and 54 in. (1371 mm.) bore respectively with a 6 ft. 8 in. (2032 mm.) stroke; the blast pressure is quoted at 10 lbs. (0.7 atm.). Working at $3^{1}/_{2}$ atm. boiler pressure, the Engine runs at 20 revs. per min.

A valve-gear largely used by several American Machinists, is that known as the "Mississippi-gear" which we illustrate by Figs. 19—22 (Plate 43). Two eccentrics are here used, one of which works the inlet, whilst the other drives the outlet-valves; both valve-sets are placed on the cylinder top. Each valve-spindle is connected to a lever, the outer ends of which coming in contact with an oscillating tappet, are raised and lowered — vide Fig. 21 —. Each pair of tappets — diametrically opposed to each other — effects the admission or exhaust of the steam as the case may be, and they are thus either mounted on a shaft or on a sleeve of the latter, which shaft or sleeve is connected by links to the external oscillating levers shewn in our elevation-sketch; this lever is worked off the eccentric.

The diameter of the steam-cylinder shewn, is 3 ft. 6 in. (1067 mm.); the blowing-cylinder diameter is 4 ft. 6 in. (1372 mm.), and as it is worked by the prolonged steam-piston-rod, the stroke of the two cylinders is equal to 5 ft. (1524 mm.). This Engine, which is delivering blast to a Bessemer plant, runs at 40 revolutions per minute, so that its mean piston speed calculates itself at the slow speed of 400 ft. per min.

Whilst on this topic of air-driving machines, we may be allowed to digress somewhat, by alluding to the fact that no satisfactory reason can be given why, as far as wear and tear and regularity of action are concerned, air-driving machinery should not be equally advantageously worked at the same speeds as the ordinary Steam-engine, where 500, 600 and even 1000 feet per min. is nothing unusual. On the other hand, air-compressing machinery is seldom run at greater speeds than 150 ft. whilst the piston speeds of the two last mentioned Blowing-engine arrangements are respectively 267 ft. and 400 ft. per min.

This slow piston speed is in a great measure due to the defective construction of the inlet valves of air compressors, inasmuch as the opening of these valves is more or less dependent on the vacuum formed in these air-cylinders; thus, if the air piston moves too rapidly, only an imperfect vacuum is formed in the air-cylinder, which causes the working of the inlet valves to work very irregularly and as a further consequence each piston stroke does not throw off its full effect, inasmuch as the full quantity of air cannot enter into the air-cylinder, and be utilised. The lengthening of strokes and enlargening of the air-cylinder diameter necessitates larger constructions, more metal and workmanship, consequently entails a heavier prime cost. A marked advance upon previous Air-compressing machinery, which has resulted in the construction shewn by our Figs. 218 and 219*) and which like the last arrangement, is equally adapted to Bessemer Blowing purposes, is Mr. Sturgeon's application of air-cylinder stuffing-box inlet-valves, which are opened and closed, absolutely and mechanically by the piston-rod, without their being dependent on any vacuum formed in the cylinder. This arrangement has already become so generally known by the various reviews contributed by the writer of these lines to the leading English Engineering journals, that it does not appear necessary to reproduce these, except in the following details:

As we have said before, the chief innovation in Mr. Sturgeon's Air-compressor is in the construction of his valves, and to explain their action, we must refer the reader to Fig. 256, showing the cover of the air-cylinder in section. By describing one of these covers, both are explained, inasmuch as the two covers are naturally similar to each other, in every respect. The air enters through the centre of the cover, its passage *i* being regulated by the frictional gland *h* round the cylinder piston. By the motion of the latter, this gland is carried forward and backward, at one movement, opening the inlet valve to its full extent, whilst with the return stroke the valve becomes closed by being immediately pushed up to its seating by the return motion of the piston. The travel of this valve is further regulated by the stop, *i* clearly shown in Fig. 256.

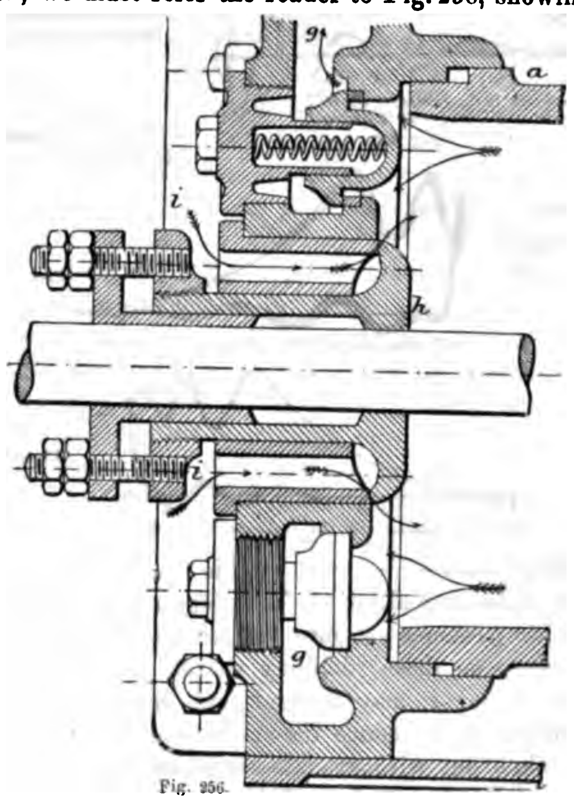


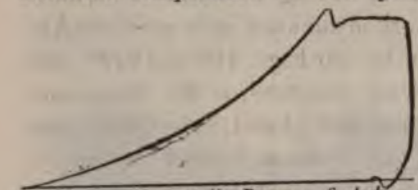
Fig. 256.

The advantages that are claimed for this construction of valve are: that the opening of the inlet valve is totally independent of the vacuum formed in the air-cylinder, inasmuch as they solely owe their action to the driven piston, which can be relied upon, either with slow or high speeds: secondly, the compressed air left in the clearance space and the valve passages at each end of the stroke, which in other types of engines of this sort, proves a direct loss of power to the machine, is in the present instance turned to advantage, inasmuch as it prevents the valve opening until

*) see pg. 164 and 165.

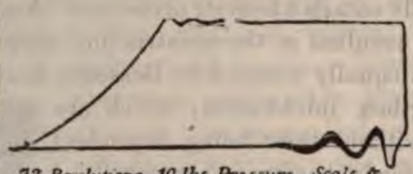
the commencement of each stroke, and until the piston has travelled far enough to reduce the pressure inside, equal to the atmospheric pressure outside, thus giving time for the delivery valve to close before the inlet valve opens. The setting of the crank pin is further so arranged that when the inlet valve comes close on its seating, the respective crank is almost on its centre, and consequently the motion of the piston at its slowest; this arrangement enables the piston to run at a high speed without injury being done to the seatings, as the valve is thus brought gently to its facings without violent concussions.

The outlet or delivery valves are shown at j in Fig. 256; they are placed opposite the direction of the piston and distributed over the inner surface of the cylinder cover. These valves are held close on their seatings by a spring thrusting outwards, and they stand in direct communication with the fore-mentioned receiver b — see Figs. 218 and 219 — by the air passages $gggg$. As the air becomes compressed in the cylinder, so this pressure is transmitted to the outer surface of these



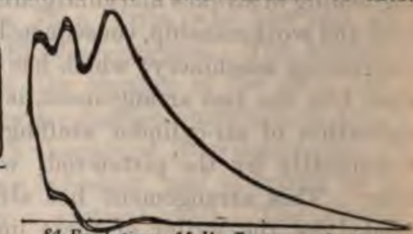
65 Revolutions. 41 lbs Pressure. Scale 1/8

Fig. 257.



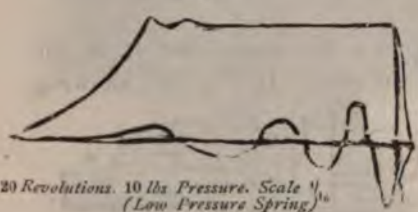
72 Revolutions 10 lbs Pressure. Scale 1/8 (Low Pressure Spring)

Fig. 258.



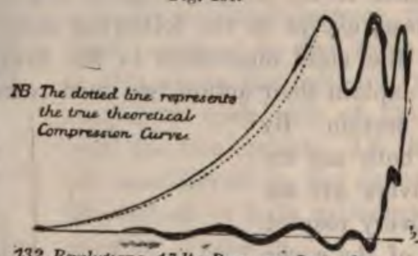
84 Revolutions 45 lbs Pressure. Scale 1/8

Fig. 259.



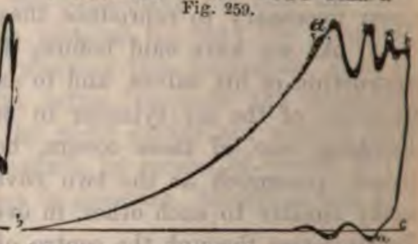
120 Revolutions. 10 lbs Pressure. Scale 1/16 (Low Pressure Spring)

Fig. 260.



132 Revolutions 47 lbs Pressure. Scale 1/8.

Fig. 261.



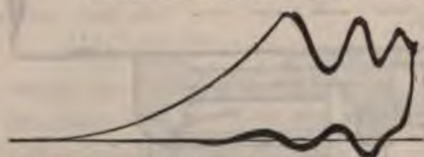
92 Revolutions. 45 lbs Pressure. Scale 1/8

Fig. 262.

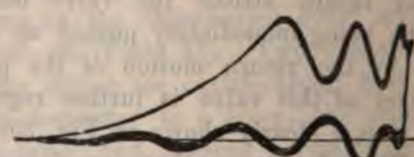
170 Revolutions 30 lbs Pressure Scale 1/8

120 Revolutions 15 lbs Pressure. Scale 1/8

Figs. 263 and 264.



190 Revolutions 25 lbs Pressure. Scale 1/8



220 Revolutions. 23 lbs Pressure Scale 1/8

Figs. 265 and 266.

delivery valves; as soon as this outside pressure is greater than the back pressure on the valves, they open and allow the air (compressed in the cylinder) to pass through the valve openings and the air passages gg, into the receiver b, to be there stored according as it is required. The back pressure on these "delivery valves" is no doubt the "bête noire" of the whole invention, but in their favour it may be said that they are formed in the best conceivable manner under the circumstances, to reduce the friction of the air passing through. For repairing or cleaning they can be taken out without unloosing any fast joints.

With regard to the diagrams, which we here reproduce in Figs. 257—266 they were taken by a Richard's indicator, and, with the reference already appended to each, the explanation of one will render the rest sufficiently clear to prove that, with the various speeds, the compression lines very nearly coincide with each other, thereby showing that each stroke of the piston of the air-compressor performs its full amount of work quite independently of the high or low speed at which the machine may be working. Taking Fig. 262, a to b is the inlet or admission line, the atmospheric line being shown by b c; the compression line is represented from b to d, and the delivery line from d to e. The commencement of the return stroke, where the air left in the clearance space is being expanded back again to its original pressure, to the opening of the inlet valve is shown from e back to a. The amount of expansion caused by the heating of the compressed air and consequent loss of power may be estimated from Fig. 261 by the difference between the dotted line, which represents the theoretical compression curve, and the actual compression line shown in full. Strictly speaking, the actual loss of power is less than this difference shows, inasmuch as some of the heat evolved is taken up by the water, with which the boiler is subsequently fed.

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2. Engines fitted with simple Lift-valves working with Expansion-gear.

A. Controlled by hand.

a. The "Cölnische Maschinenbau-Actien-Gesellschaft", Bayenthal near Cologne o/R.

The drawings Figs. 1—4 (Plate XXVII) of the Lift-valve gear constructed by the Cologne Machine-works Co. Lim. of Bayenthal, shew, that following the example of the Wilhelmshütte, the valves are again arranged in a row. The middle is taken up by a throttle valve V placed under governor control; next follow the inlet-valves, G G_1 and the exhaust-valves $H H_1$ are placed outside the latter. The external valve gear differs, however from the Wilhelmshütte type.

The lay-shaft A is placed parallel to the piston, and driven by bevel-gear off the crank shaft. Cams f keyed on a sleeve of this lay-shaft, effect the lift and fall of the valves, by crank-levers $L L_1$, — Fig. 2 — having their short arms L fitting in slots of the valve spindles F, whilst their longer arm extremities L_1 furnished with small rollers, glide on the cam-surfaces. The packing preventing the easy fall of the valve spindle the spindles are each weighted at their top ends, by weights P. The peculiar design of the cams is shewn in Fig. 4. As this Engine works under fixed expansion only rendered variable by hand, the inlet valves have each several cams D which may singly be brought into gear at different times at the will of the engine-tenter. The gliding of the roller on to the cams corresponding to the opening of the valve, always takes place at one and the same position (y) of the crank. The line X denotes the dead-centre of the crank, consequently the angle included between these two lines X and Y is the lead-angle. According to the desired degree of expansion, the roller may be made to glide off its cam at $^1/_4$th, $^3/_8$ths, $^1/_2$, or $^5/_8$ths of the piston-stroke. Both sets of cams are connected together by a sleeve, so that the sliding into gear of the different cams on the shaft A may be effected by the hand lever shewn.

The cam-discs $K K_1$ working the exhaust-valves are keyed direct on the lay-shaft A, and when the inlet cams are set to work, their sleeve is rendered immoveable by a set-screw.

b. Friedrich Wilhelmshütte, Mulheim on the Ruhr.

c. F. W. Köttgen, Engineer of Barmen.

Type: Schlink.

As the Winding-engine Valve-gear constructed by the Friedrich Wilhelmshütte of Mülheim, is exactly the same, as the one adopted by F. W. Köttgen of Barmen, we shall discuss these two under one heading. The Figs. 5 and 6 (Plate XXVII) refer to the first named, whilst the annexed woodcuts Figs 267 and 268 belong to Mr. Köttgen's arrangement. We observe the same arrangement as before in the placing of the valves. A very simple mechanism admits of the steam being cut-off at different stroke portions, and the reversing gear is also very simply arranged.

A long sleeve *B* sliding on a key-way of the lay-shaft *A*, is connected at its centre to a lever *M*, actuated by the hand-lever *T* — Fig. 6, Plate XXVII —. All the cams, of which there are two serving each valve, are mounted on the sleeve *B*. The cams $D D_1$ of the inlet-valves G_1 are not formed step-fashion, but for effecting variable cut-offs, their side surfaces form diminishing spirals, whereas the limited side which opens the port is straight.

In the position our Fig. 268 shews the sleeve, the machine would be at a standstill, and according as this sleeve is moved to the right or to the left, the engine will be started forwards or backwards; the extent to which this sleeve is shifted, effects the different grades of expansion.

The exhaust is worked by simple cams $K K_1$ in a similar manner to the preceding machine, only they are made wider, so that the magnitude of sleeve-slide may have no effect on the exhaust-spindle. The latter are worked by crank-levers and small rollers off their cams.

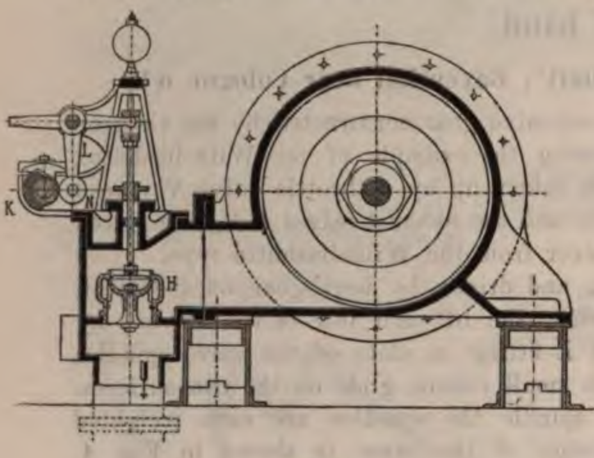

Fig. 267.

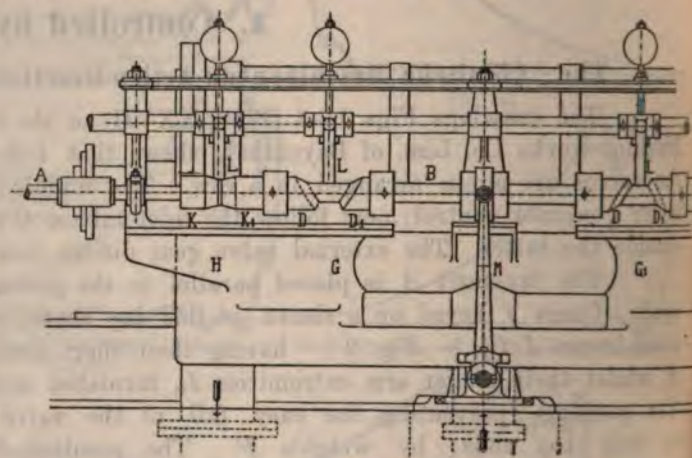

Fig. 268.

The advantage possessed by this valve-gear, consists in the engine tenter having only one lever to attend to for reversing and expansion purposes, both of which functions he is enabled to do without either drawing or throttling of the steam.

d. Wm. B. Cross, of Sacramento (U. S. A.).

Wm. B. Cross, Engineer of Sacramento, has designed an expansion valve-gear, mostly used in connection with Marine Engines. We illustrate the same as applied to a paddle-steamer in our wood-cut, Fig. 269. Each of the valve-spindles *F* carries a support *C* for taking up a lever *D*. The latter receives an oscillating movement from a crank-lever *A* worked from the eccentric rod *B*. On account of reversing, the eccentric is mounted loose on the crank-shaft.

To obtain variable cut-offs, an additional expansion-eccentric is provided, which actuates a sliding-block *n* of the lever *D*, by giving it horizontal motion in the slide *E* in opposite direction to the moving piston. At the commencement of the stroke the lever *D* can raise the support *C*, owing to the sliding-block *n* having a slide between; the latter glides back, whereby the support *C* gliding down the inclined edge of *n*, closes the valve. The lever *D* carries a pin *r* which merely serves as a guide to the support. According to the grade of expansion desired, the positions of the sliding-block must be adjusted by hand; for this purpose, they are worked by

screw-nuts, which are either moved by the eccentric-rod B_1 or by the handle J. The valves are closed by the spring S suspended from the lever M. The latter oscillating centre is on the slide-block E, whilst its other extremity fits in a slot of the support C.

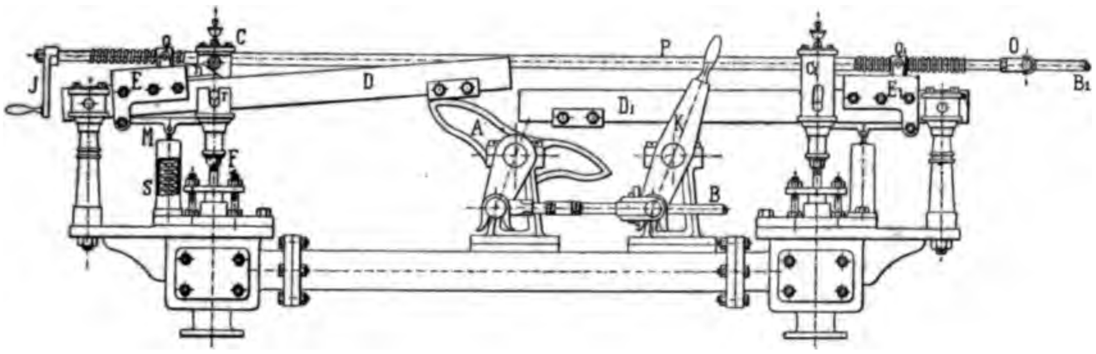

Fig. 269.

e. G. Sigl, of Vienna.

On Plate XXVIII we shew the cylinder-arrangement of the Engine working the Rope-haulage Track used on the Leopoldsberg near Vienna. It was constructed by G. Sigl of Vienna, who places all the four valves on the top of the cylinder in such a manner that inlet and exhaust valves are behind each other.

The external valve-gear is extremely simple, inasmuch as the forward and reversing motions of the eccentric-rod B is obtained by Gooch's link-gear. The lever A attached to the rod B gives motion to the lay-shaft W placed across the cylinder, and carrying four peculiarly formed levers DD_1 EE_1. Each of the levers DD_1 presses during its downward movement on a double-lever LL_1, so forcing down the corresponding inlet-valve spindle and effecting ingress of steam to the cylinder. The other levers EE_1, when rising lift the levers KK_1, which are connected with exhaust spindles HH_1. A spiral spring S contributes to the safe and sure dropping of the valves.

The cut-off is rendered variable by hand, shifting the slide-block working in the link.

B. Controlled by the Governor (automatic).

a. The Prague Machine-works Co. Lim.

The "Prager Maschinenbau-Actien-Gesellschaft" has introduced the lift-valve gear shewn on our Plate XXVII (Figs. 7—8) for Winding engine purposes. Where single-cages are raised and lowered, and are not counterbalanced by the double-cage system, it is evident, that the load thrown on the engine, varies owing to the weight of rope paid in and out; again the different loads raised, both in the single and double cage-systems, give off variable loads, and this induced Mr. Carl Tökei to design the special Automatic lift-valve gear represented on Plate XXVII (Figs. 7 and 8), for this class of Engines.

The arrangement of the inlet GG_1 and exhaust-valves HH_1 is alike the preceding example, and this similarity also applies to the cranked levers LL_1 and the cams DK_1; the latter are keyed on a sleeve B sliding horizontally on the lay-shaft A revolving at equal speed with the crank. The sleeve B may be shifted by hand through the reversing lever T, which is fixed to the transverse shaft W; in this manner the grade of expansion and the reversing moments may be varied.

But as the cams, formed to correspond to the requirements of varying loads, are placed under the control of the governor, automatic cut-offs are secured.

It will be noticed the sleeve B, carries a small toothed wheel x with broad teeth, which by gearing into the toothed wheel z, drives the shaft v. The latter is furnished with a thread, on which the nut M works secured to the quadrant E oscillating loosely round the shaft W.

The action of this gear is as follows: At the commencement of winding, the reversing lever N is set in the dotted position X, which answers to the forward engine-movement, and to the latest cut-off. As a consequence the lever is moved in the direction of the inscribed arrow, so shifting the sleeve B along with its cam-discs. The lever thus approaches more and more its middle position, so diminishing the valve steam-opening. If the lever is placed in position Z, the engine is brought to a standstill. By pushing the lever towards the Y position, the engine-motion becomes reversed.

This valve-gear thus possesses the advantage of automatic cut-offs, though the engine may be set to work in certain cases without expansion by placing the lever in extreme position; simultaneously the reversing action, as well as the grade of expansion, may be regulated by hand.

This valve-gear, was shewn applied to a pair of Winding-engines exhibited at the Vienna Exhibition of 1873, to wind a load of $1^1/_4$ ton (1250 kilog.) from a depth of 416 yds (380 m.) at a speed of from 16—23 ft. (5—7 mm.) per min. The diam. of cylinder was $19^3/_4$ in. (500 mm.), its stroke $35^1/_2$ in. (900 mm.), and to attain the forementioned speed its cranks were run at 36 revolutions per min.

b. Maschinenbau-Actien-Gesellschaft, — late Klett & Co. — of Nürnberg.

This Engineering Firm, has now constructed about 450 Engines of various sizes, since it was established (about 1840). Amongst these, figure a large number of single and coupled engines working with lift-valve gears, furnished either with or without condensers, in sizes varying from 15 up to 300 *HP*.

The general arrangement of a 75 *HP* Horizontal Condensing engine built by this firm is represented on Plate 44, whilst the constructive details of the cylinder and its valve-gear are drawn on Plate 45.

The cylinder has two valve-chests bolted to its side, each of which contains one inlet- and one exhaust-valve; the inlet-valve is placed inwardly whilst the exhaust-valves are arranged outwardly, somewhat below the former. The inner cavity of these valve chests is made to discharge into a rectangular passage, $2^5/_{16}$ in. $\times$ $8^3/_8$ in. cross-section, whence the steam passes into the cylinder. Both valve-chests are in direct double communication with each other, partly owing to the pipe supplying the fresh steam from the cylinder-jacket to the right and left inlet-valves, and partly owing to the larger exhaust-pipe placed under the former, which takes the steam from the exhaust-valves into the condenser. Each valve-chest cover, takes in the two valve spindles which are worked up and down by suitable mechanism. A horizontal lay-shaft, supported on four bearings, runs at the side of the cylinder at equal speed with the crank-shaft, and it is driven by a pair of bevel-wheels, one of which is furnished with wooden cogs. One of the lay-shaft supporting bearings is placed close up to the crank-shaft, another is arranged to the governor-stand, and the remaining bearings are attached to the valve-chests separately. On each side of the latter, the lay-shaft carries case-hardened steel-cams, different in form. The cam placed opposite the inlet-valve is shewn in Fig. 7, the one opposite the exhaust-valve, is represented in Fig. 8. To obtain a uniform distribution of the steam, owing to the inequal piston travels, the cams for each cylinder side had to be made different; thus the full-lined outlines correspond to the crank-side, the dotted outlines refer on the other hand to the condenser-side. Fig. 9 shews how a steel finger o of a cranked-lever NK is made to slide on the surface of one of these cams, which forces it to move forward and backward, when the lay-shaft is revolving. We may infer from this drawing, that the valve-spindle F grasped by the forked end of the lever-arm K is moved up and down, which alternate motion corresponds to the opening and shutting of the valve.

The two cams, formed as shewn in Fig. 8, are keyed fast on the lay-shaft, consequently the opening and shutting of the exhaust valve will remain constant. It is otherwise with the inlet-cams represented in Fig. 7; these are connected together on a loose sleeve drawn on the lay shaft — vide Fig. 2 — and having a longitudinal slide on key and groove. The adopted form of these cams ensures the retreating of the steel point *o* always at one and the same time, so that the valve opens with a constant lead, whereas its advance is retarded or hastened, according to the amount of slide given to the sleeve; thus variable cut-off is also obtained by the shifting of the cams. This is effected by the governor, inasmuch as the sleeve is grasped by a forked-lever connected by link combination with the governor-collar as shewn in Fig. 1. The dash-pots in connection with the valve-spindles are supported on brackets, cast with the valve-chests; the dropping of the valves is facilitated by spring-pressure.

The cylinder-diameter and stroke amount to 1 ft. 8 in. (500 mm.) and 2 ft. 11½ in. (900 mm.) respectively; running at 54 revolutions per min. we obtain a mean piston-speed of 5 ft. 4 in. (1.62 m.) per sec. The steam-pipe entering the steam-jacket is of 4¾ in. (120 mm.) diam. or $^1/_{17}$th piston-area; the jacket is cast in one with the cylinder. The exhaust-pipe 6¼ in. (160 mm.) diam. is $^1/_{9.7}$th part of the piston-area.

The piston, cast hollow is constructed as shewn in Figs. 2 and 3. The prolonged piston-rod reduced to 2 in. (50 mm.) diam. drives the air-pump direct; the piston of the latter is 8¼ in. (210 mm.) diam. and its stroke is 35½ in. (900 mm.), so placing its capacity to that of the steam-cylinder in the proportion of 1:5.6.

The engine-trunk, is cast in one piece with the crank shaft pedestal; its slides are 7 in. (180 mm.) wide. The connecting-rod is wedged into the wrought-iron slide-block, the lower gliding surface of which is made adjustable by bolt and cottar. As the cross-head pin, 6¾ × 3 in. (170 × 75 mm.) is securely lodged in the block, the butt-end of the connecting rod is forked. The latter is lengthened to five crank-lengths.

The crank-shaft 8¾ in. (220 mm.) diam. is supported in bearings 13 in. (330 mm.) wide; reduced to 7 in. (180 mm.) diam. it has a collar between the main-pedestal and crank, which is partly let in to the latter.

Engines up to 17¼ in. (440 mm.) cylinder-diam. are furnished with planed fly-wheels for belt-driving; but for larger sizes this Engineering-firm uses toothed flywheels. The fly-wheel in the present example is 16 ft. (4.9 m.) diam. with teeth 10⅝ in. (270 mm.) long. Its boss fits on the crank-shaft swelled to 10 in. (250 mm.), and it is secured by two extra rings forced on the crank-shaft; the rim is cast in halves, so that the three arms belonging to each wheel-casting are secured to the wheel boss by three screw-bolts, whilst the rim is pieced by flanged plates securely wedged-up.

The feedwater-heater is placed below and at the side of the cylinder and of the air-pump, as shewn in Figs. 6 and 7 (Plate 44). It consists of a cylinder 21¾ in. (550 mm.) diam. and 8 ft. 10 in. (2.7 m.) long, which is traversed by a number of 2⅛ in. (55 mm.) wrought iron tubes. The circulating of steam and water is obtained by allowing the feed water to pass through the pipes, which are enveloped in steam, so that the latter gives off a portion of its heat to the feed-water. The pipe-service between cylinder and heater is furnished with a shut-off valve, and a three-way cock inserted in the steam-pipe leading from the heater to the condenser, enables the machine to be worked either on the condensing or the non-condensing principle, though in both cases the spent steam is utilised to heat the feed-water.

Any water or condensed steam which may accumulate either in the jacket, or in the pipe-service runs out into a water-receiver, or may be let out through a water-discharge cock screwed into the bottom of the jacket. Any water in the cylinder flows of its own accord through the exhaust-valves.

The Porter-governor used, runs at 180 revolutions per min. and with its collar slide of 2 in. (48 mm.) it effects automatic variable cut-offs between $^1/_{30}$th and $^8/_{10}$ths of the piston stroke.

The total weight of this Engine is quoted at 20 tons (20500 ks.) and it is priced at £ 940 (Mk. 18800).

c. Fr. Freiesleben, Engineer of Niesky.

In Figs. 1—4 (Plate XXVIII) we have drawn the patented valve-gear of Mr. Fr. Freiesleben. The valves are here arranged at the side of the cylinder, in such a manner that the inlet-valves are placed above the exhaust valves. The inlet-valves are each worked by a sliding-cam *D* mounted on the lay-shaft *A*, which cam presses down the lever *K* connected by rod *k* and lever *L* to the valve-spindle *F*. The cams $D D_1$ are of the usual spiral form, so that their position will regulate the cut-off.

It will be seen that these sliding cams are each connected to a high-speed governor revolving on the lay-shaft, and in this manner the cut-off is rendered automatic. The governor is driven at a higher speed than the lay-shaft through the toothed wheels $z z_1$, $g g_1$. In order to counteract the sudden jumping of the governor, the latter is connected to the double cataract-cylinders $i i_1$, the pistons of which are attached direct to the governor-collar. To reduce the friction of the cam on to the lever *K*, a small ball *o* is placed in a recess of the latter; this ball easily follows the motion of the cam, and so prevents the valves from striking.

The exhaust valves are driven by a crank *B* keyed on the lay-shaft, which causes the rod *W* to oscillate, owing to the link and lever combination between *P* and *Q*. This rod *W* is supported under the exhaust valves, so as to allow the opposite tappets $o o_1$ to act alternately on the valves, because during half the stroke no motion is imparted to them.

All the valves are pressed on their seatings by spring pressure.

d. Claparède & Co., Engineers of St. Denis.

The 150 *HP* Compound Condensing Engine shewn by Messrs. Claparède & Co. for supplying part of the driving power to Class 54 of the Paris Exhibition of 1878, is not very handsome in appearance, as our Plate XXIX displays.

Availing ourselves of the description given by "The Engineer"*) the principal dimensions of this Engine were as follows:

Diameter of high-pressure cylinder	19·00 in.
Diameter of low-pressure cylinder	32·87 in.
Length of stroke of both cylinders	35·43 in.
Angle of the cranks	90 deg.
Proportion of volume of the cylinders	1 : 3.
Normal number of revolutions	40.
Diameter of air pump	9·84 in.
Stroke of air pump	35·43 in.
Indicated horse-power with 75 lbs. steam	150-H. P.

The distribution of the steam is effected by means of balanced valves placed at the bottom of and on the cylinder covers, by which arrangement the clearance is reduced to a minimum. The valves are double seated, distinct for admission and exhaust, and actuated by cams working against friction sheaves. The cams governing the exhaust valves are fixed; those which actuate the admission are adjustable, under the action of the governor, parallel to their shaft, by a simple arrangement of levers. The cams are fitted with bosses, whose dimensions are variable for every part of their length, so that the admission of the steam is prolonged or diminished correspondingly with the duration of contact between the cams and sheaves, in accordance with the position of the arms of the governor. This system of distribution, which can be applied to any kind of engine,

*) d. 21 Febr. 1879, pg. 142.

stationary or marine, vertical or horizontal, has claimed for it the advantage of doing away with gear working with shocks, such as tappets, triggers, or buffers.

Both cylinders are steam jacketed, and the steam for this purpose is led from the main steam pipe. The intermediate receiver plays the part of a reheater for the low-pressure cylinder. It is kept at a high temperature, on account of the large area of the interior surface of its jacket. All the parts in motion are of steel. The air pump is worked by means of an arm fixed to the crosshead of the piston rod, and this arrangement permits the condenser to be placed below the base of the cylinders, and to isolate it completely, by means of air chambers and non-conducting material, from them. Another advantage obtained by this disposition is that the engine can be erected on one floor and is self-contained, whereby the foundations are reduced to the simplest form, and the usual arrangement of pump rods and levers dispensed with.

The idea of novelty at which Messrs. Claparède & Co. have aimed in this engine is not only to produce a variable expansion in each of the two cylinders of a Compound Engine by means of the governor, but also to vary the duration of admission into each cylinder separately, and in a proportion most favourable to obtaining the maximum effect of the steam, by a single impulse of the governor. The desired proportion between the admission is obtained by means of the different forms given to the cams according as they are intended for the service of the high or low-pressure cylinders. These forms are such that when the engine is running at its normal speed the volume of steam admitted into the low is, as nearly as possible, equal to that escaping from the high-pressure cylinder. If the speed of the engine be altered, the admission to the low-pressure cylinder is not affected so soon as that to the high-pressure, excepting when the speed is sensibly accelerated beyond that for which the engine is intended.

We believe the Firm are now constructing a Compound Engine of 400-horse power for Rolling Mills, on the same principle, and although it was impossible in an Exhibition to test the economical results, the apparent performance was highly satisfactory.

We may add that owing to the guide-bar fitting against the front cylinder cover, the exhaust-valves are arranged sideways above the lowest point of the cylinder, thus automatic drainage of the cylinder is only illusory.

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3. Lift-valves with positive opening and negative closing of the admission-valves.

A. Valves arranged at the side of the cylinder.

a. Briegleb, Hansen & Co., Engineers of Gotha.

For a number of years, the Engineering Firm of Messrs. Briegleb, Hansen & Co of Gotha, have fitted up Engines exceeding 40 *HP* with an original double-seat valve gear, which has been improved upon in the course of time. Three of the most conspicuous improvements brought to bear on the admission and exhaust valve-gearing mechanism, of one and the same Engine, are drawn on our Plate 46.

In these three modifications, the positions of the valves have remained unchanged; namely they are placed together in a valve chest bolted to the cylinder-side, and the rectangular cylinder steam-passage gradually merges into the circular valve-chest cavity. The same remark applies to the horizontal lay-shaft, driven by bevel-gear off the crank-shaft, so that we may now pass on to these three arrangements, in the order corresponding to their development, though we confine our description to the latest mechanism.

The oldest arrangement is shewn by Figs. 1 and 2 (Plate 46). *A* is a second shaft driven from the lay-shaft, the revolutions of which are equal to those of the crank-shaft. The second construction is shewn in Figs. 3 and 4, and the latest arrangement is represented by Figs. 5 and 6. In principle and in its constructive details it is identical to the preceding arrangement. The favourable results to be obtained with cast-iron valves and seatings have been utilised by using this metal for the valves and their seatings.

The cranked-lay-shaft *A*, causes the hollow rod *B* to oscillate, working itself accordingly in and out of the rod *b*. A steel-plate *n* fitted on the rod raises the rod *C*, so effecting the opening of the valve-*G*. The rod *C* is under governor-control through the link-work *M*, *R*, *T*. According as its end is nearer or further off the lay-shaft centre, the longer or shorter will the rod *C* be kept up by the plate *n*, and the later or sooner will the steam cut-off ensue. The working of the exhaust valves, similarly driven off the lay-shaft, is self-explanatory from our Fig. 6.

b. Putnam Machine Co., Fitchburg (Mass.).

The Putnam Machine Co. of Fitchburg, is one of the oldest and best known Engineering Firms of America, and it has earned a famous reputation for the high-class workmanship of its machinery. The Engine represented on our Plate 47 undoubtedly is one of its best constructions, hence Figs. 1 and 2 give the general arrangement whereas Figs. 3 delineates the valve-gear peculiar to this Engine type.

The disengagement-gear is on the same principle as Mc. Culloch's*). The lay-shaft driven at half the crank-shaft speed, and arranged alongside the engine, is furnished with double-cams $n n_1$, both for the inlet and exhaust-valves, which cams do not lift the valve-spindles direct, but do so by the intervention of a step-rail *N* and a bolt *z*. The governor acting on the lever $M M_1$ causes the step-rail *N* to slide horizontally, and according to the latter's position, it will glide off the cams sooner or later. When this occurs the steam-pressure on the valve *G* as well as the tension of the spring *s* on the valve-spindle *F*, brings the valve close on its seating, so cutting off steam. We find a different arrangement in respect to the exhaust-valves, for here the step-rail cannot slide horizontally, but is securely held by the fixed bracket *K*, so that the opening and shutting of the exhaust valves remains constant.

By way of proving the great accuracy to be observed in the getting up of these parts, Prof. Radinger calls attention to the following measurements:

Lay-shaft:	Diameter	1.38 in.	(35 m m.)
	Cam-step or projection	0.53 in.	(13$^1/_2$ m m.)
Step-rail:	Height of front driven-end	1.02 in.	(26 m m.)
	Height behind its step	0.47 in.	(12 m m.).

The step is consequently 0.55 in. (14 m m.) high, and as the cam measures 0.53 in. (13$^1/_2$ m m.), all the irregularities of the entire valve-gear have to be subdued in the exceedingly small range of $^1/_{64}$th in. ($^1/_2$ m m.), otherwise a re-admission of the steam would occur, which is however opposed to actual practice.

The double-beat valves are not cast in one, but each valve-surface is mounted separately on its wrought iron-spindle. The Engine exhibited had a cylinder-diameter of 12 in. (305 m m.) and with a stroke of 2 ft. 9 in. (838 m m.) it was running at 55 revolutions per min. or giving off a mean piston speed of about 5 ft. (1.53 m.). The engine frame is of peculiar form. The motion-block slides in bottom guides, cast with the engine-frame.

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*) Vide pg. 170.

The arrangement of the governor between the two valve pairs may be seen from Figs. 1 and 2. It is driven by bevel-gear at high-speed. The steam-pipe is in the form of a ring, where it crosses the governor-spindle. When the governor balls are rising, the rods carrying the governor balls, force down a spindle encased in the hollow governor stand, which in its turn effects an earlier or a later gliding off of the step-rails from the cams. With dropping governor-balls, the last-mentioned rod becomes raised by spring pressure, so exercising a contrary effect on the step-rails; the pressure of this spring is adjustable at pleasure, corresponding to the engine speed required.

The spent steam escapes by rectangular exhaust pipes, each bolted by two bolts to the valve chests.

c. Société Anonyme de Constructions Mécaniques D'Anzin, France.

This French Engineering Firm under the management of its Director (Mr. Quillacq) has earned a high reputation in the construction of Winding-engines, and on Plate 48 (Figs. 9—11) we shew different views of the cylinder-arrangement of their latest type, as exhibited at the Paris Exhibition of 1878.

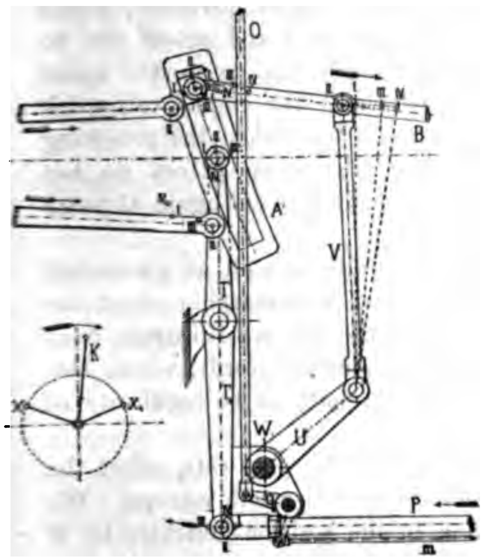

Fig. 270. Fig. 271.

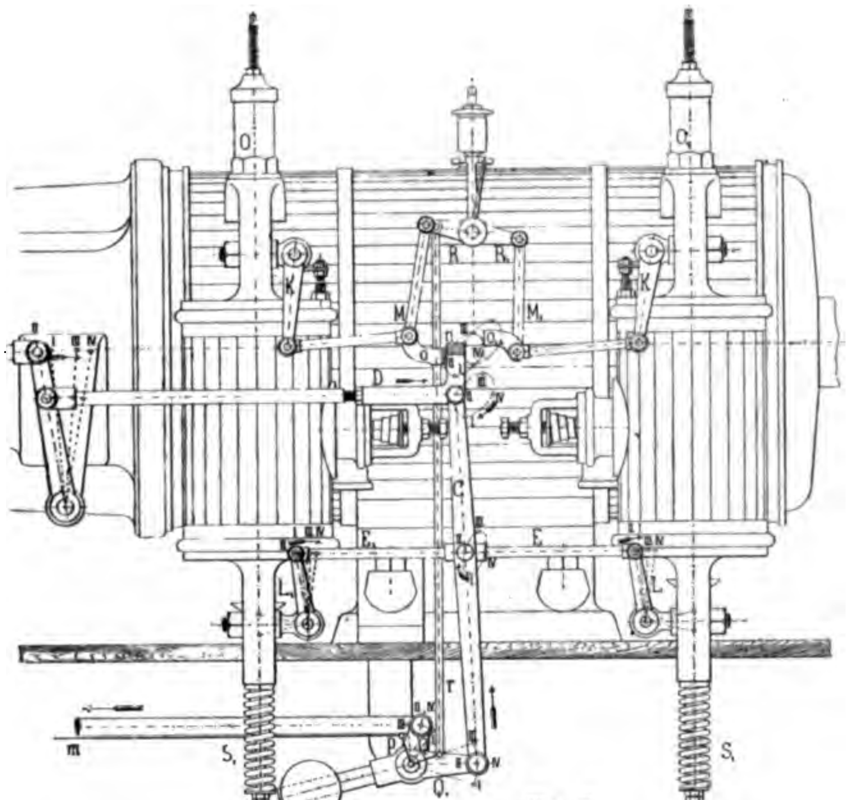

Fig. 272.

The corresponding external valve-gear is reproduced in the annexed woodcuts Figs 270—272, to which we adapt the description given by "Engineering" *). It is, like all the other larger winding engines, a double cylinder engine, the two cylinders and frames being entirely separate, and the drums and brake placed on the shaft between the two journals. The general form of

*) d. 28 Febr. 1879, pg. 178.

each bedplate is that of the Corliss engine, the cylinder being bolted end on to the frame and supported by a separate foot. The guides are bored, and have good surface. The main bearing brasses are in four pieces, the upper one being of cast iron, the sides and bottom piece of brass. Double-beat valves are used, the valves of each pair (for one cylinder end) being vertically above one another in a box bolted to the side of the cylinder. The cylinders are steam jacketed, the jackets receiving steam on its way to the valves; the exhaust valves are placed so that they can drain the cylinders.

The valve gear is somewhat complex in appearance, but its general nature can be explained very briefly. Two eccentrics $X X_1$ are used driving a Gooch link A in the ordinary way. By the link connection shewn, the lever D carrying a catchplate n receives a continual reciprocating motion, the extent of which corresponds to the degree of linking up employed. The centre of the link is caused to move nearly in a straight line by a lever $T T_1$ having a fulcrum about its centre. The lower end of the lever is connected by the link p with the lever c linked to the foremen-tioned lever D. The catch at the top of D receives thus a kind of elliptical motion — shewn in dotted lines Fig. 272 — and so gears alternately with steel edges $o\,o_1$ on the links M and K so working on to the valves, which are themselves suspended (by M) from a lever $R R_1$ working on a fixed pin. The rod Q comes from the governor and through the lever q and the links m and r, it determines the position of $R R_1$, and consequently the cut-off; W is the reversing shaft, shifting the rod connected to D up or down by the lever U and the link V.

Very particular pains seem to have been taken with the arrangement of the working handles—a point of special importance in a winding engine, and they have been brought in very conveniently at one starting platform beside the engine. The main reversing lever is keyed on to the shaft W already mentioned. The engine-driver has control over the cut-off, independently of the governor, when required. The gearing is controlled by a powerful Porter governor, which is said to act very promptly. The relation between the speed of the governor and cut-off can be altered at will by the arrangement shewn. During manœuvring of the cages, and so on, the speed is always slow, so that the governor does not then act on the cut-off, and the engine can work with as full steam as may be wanted. The gear is also so arranged that when the reversing lever is in its mid-position, and the link consequently in mid-gear, the steam-valves do not open, and the engine simply sucks in air through the exhaust valves, sending it out again through the escape-valves on the sides of the valve-chest.

The valves are made of cast iron, which is believed to answer quite as well as gun-metal. The piston rods and other working parts are of steel. The finish and workmanship about the engines as exhibited were very good. Two winding engines similar to the one we illustrate have been supplied by the Quillacq Company to the Compagnie des Mines d'Aniche (Nord), whose manager speaks very highly of the way in which they have been working, both as to regularity of speed and convenience of handling.

To this description we may add that the springs contained in the pots $O O_1$ effect the rapid closing of the valves, the resulting shocks being air-cushioned in the usual manner. We have shewn the whole mechanism, corresponding to the crank being in the position indicated by K in Fig. 270, and moving in the direction of the inscribed arrow, during which the eccentric X is almost in its extreme position. It will be remembered, that in most constructive examples, where only one eccentric is used, the range of automatic cut-off is limited to about $^4/_{10}$ths stroke. The higher grades of expansion obtained in this valve-gear, were merely rendered possible by imparting an additional vertical movement to the lever C. But as this vertical motion coincides with, but is in opposite direction to that of the thrust transmitted by the governor, the range of expansion is, in a manner of speaking, unlimited. The transmission of the vertical motion just alluded to, is obtained in a surprisingly simple manner, from the centre of the link, which when the crank is on its dead centre is also in its extreme position; the latter is indicated by position I, position II being the one in which this mechanism is drawn. In the Engines before us, the cranks are set at right angles to each other, and the diameter of each cylinder is 2 ft. $5^1/_2$ in. (750 mm.), with a corresponding 5 ft. 3 in. (1600 mm.) stroke.

B. Admission-valves arranged on the top-, and exhaust-valves fitted to bottom-of the Cylinder.

a. Gebrüder Sulzer, Engineers of Winterthur.

Sulzer Valve-gears of 1867, 1873 and 1878.

As is generally known, Sulzer Brothers appeared with an entirely new valve-gear, at the Paris Exhibition of 1867. The lapse of time, which has occurred since this bold attempt was made, has had such a stimulating and such a far-reaching effect, on the constructive productions of continental machinists, as to induce Engineers on the Continent to look upon the name of Sulzer much in the same way, as the name of Corliss, is regarded in America: consequently Gebrüder Sulzer take first rank in continental Steam-engine practice!

Such being the prevailing opinion of our neighbours, it is not surprising that the original Edition of this Work, should carefully plod over the ground travelled by this Engineering Firm, and so groupe the Sulzer constructions in three distinct sections, answering to the first, second and third Sulzer valve-gear arrangement. Without any wish of detracting from the meritorious talent evinced by these constructions, English and American Engineers, will scarcely accord the same "place d'honneur" to Messrs. Sulzer in their own ranks!

The reason why, is not far to seek, as it lies in the different national views accepted of what a Steam-engine ought to be. Thus, on the Continent, an Engineering mania may be said to have sprung up since the Sulzer valve-gear came into public prominence, so resulting in an affluence of patterns both surprising and perplexing, and mainly directed to valve-gear mechanisms; contemporaneous English practice on the other hand, has shewn itself chiefly in the machine-production, reduction and simplification of the various engine-parts, with a view of reducing first cost, without losing economy in working *). Again, since discarded or supplanted Engine-arrangements are of less moment to the Mechanical Engineer of to-day, than the *latest* productions, the writer of these lines has grouped the different Sulzer valve-gears into one section, and proposes merely to dwell on the first arrangements so far as they bear, on the latest improved patterns, or on the still accepted practice of other Engineers.

The first Sulzer-valve gear was in design similar to the mechanism represented in the annexed wood-cuts Figs. 273, 274, 275 which shew the cylinder in part side and end-sections, simultaneously representing the form of cam employed for raising the exhaust valve-spindles. We meet for the first time, four separate double seat valves arranged similarly to the Corliss-pattern, a similarity which was extended to the Engine-frame: inlet-valves arranged on top, exhaust valves placed at bottom of cylinder, both sets fitted perpendicularly, and worked off four cams mounted on the lay-shaft A. The connecting rod E_1 linked by the rod J_1 is attached to the rigid cylinder-casting, and thus the opening and closing of the exhaust valves always takes place at one and the same time. The method here adopted of working the admission-valves under governor control has been abandoned, but the general design of the Engine has been retained, excepting that Gebrüder Sulzer, return to the vertical setting up of the air-pump, instead of the original horizontal arrangement; in their latest construction they also furnish the governor with cataract-cylinder.

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*) Sound mechanical advice on this matter was given in "The Engineer" Leader d. 3 Jan. 1879.

The chief defect of this First Valve-gear arrangement, consists in the reaction on to the governor, which takes place owing to the cam at sliding-off moments, pushing the rod B in the direction of its axis, which thrust coincides with the direction of the declension of the lever M, and becomes thus transferred on to the governor collar.

With these observations we pass on to the second valve-gear arrangement brought out in 1873 by Gebrüder Sulzer, and which is still largely adopted by other Continental Engineers. The annexed wood-cut Fig. 276, explains the novel arrangement when we add that the inlet-valves

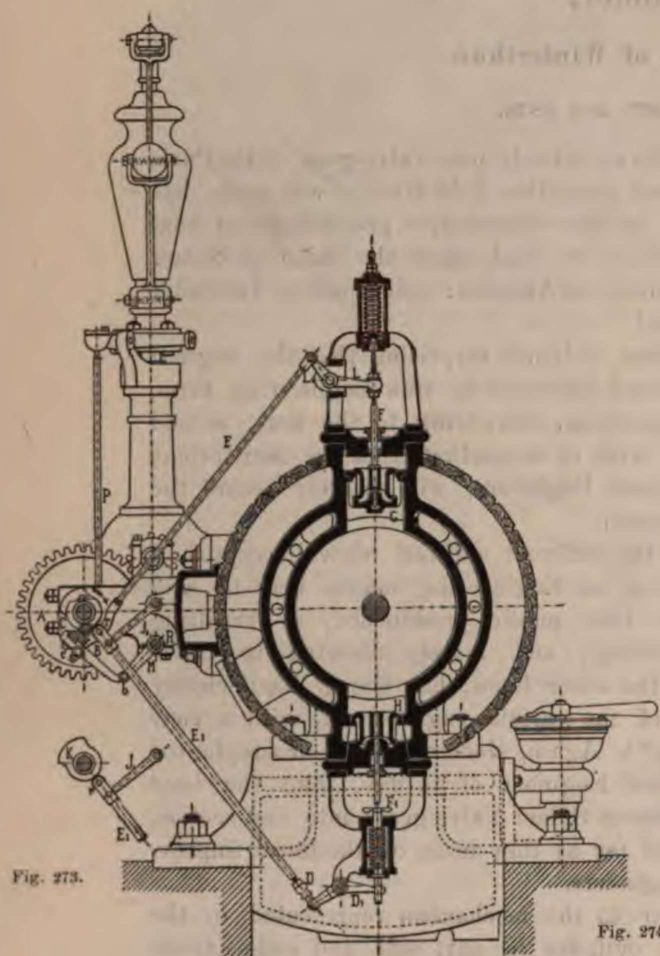

Fig. 273. Fig. 274.

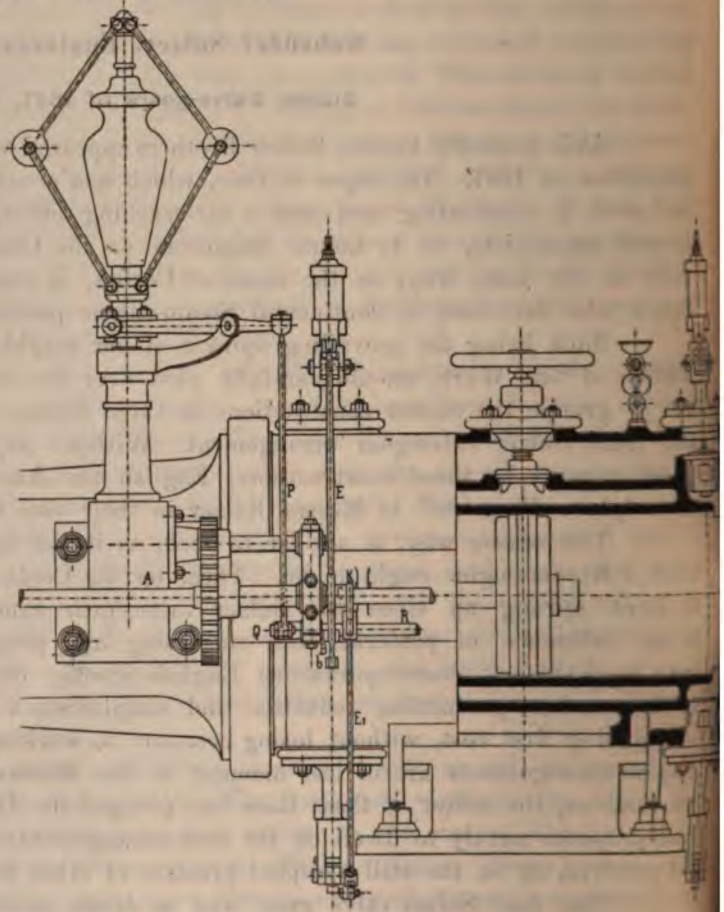

Fig. 275.

are now worked off the eccentric C the tail of which forms two flat bars B, between which the catch n is inserted; at the end B_1 these two bars are united together, and guided by the cylindrical rod E. The lower extremity of this rod carries the steel nibs o, and it is linked to the rocking lever $M\,Q$ under control of the governor rod P. According to the positions of the eccentric and of the lever $M\,Q$, the catches n and o will remain in gear during longer or shorter intervals, and when out of gear the rapid closing of the inlet-valves is again secured by the action of the spring S; variable cut-offs are thus secured through the lever $M\,Q$. Owing to the two independent motions imparted to the catch-plate o, it moves on an elliptical curve as indicated by the annexed wood-cut Fig. 277 shewing different disengagement periods, corresponding to the inscribed piston-travels. The exhaust-valve gear is the same as in the preceding arrangement.

The engineering regard still
:o this Valve-gear has induced us
resent on Plate 49 in Figs. 1 and 2,
rizontal Condensing Engine con-
ed by Messrs. Sulzer Brothers in
lance thereto. The constructive
s of the cylinder*) and slide-bars
be seen from Figs. 3 to 5, and
ir-pump is specially drawn in
. The dimensions of this type
e read off Plate 49, so that we need
dd that the engine indicated 80
unning at 75 lbs. boiler-pressure;
dicated horse-power per hour, the
consumption amounted to $17^1/_2$ lbs.
og.) and the corresponding fuel
ed 2.15 lbs. (0.976 kilog.).

Although the Sulzer valve-gear
3 has been applied in hundreds
es, — many Engineers still paying
for the same, whilst it has also

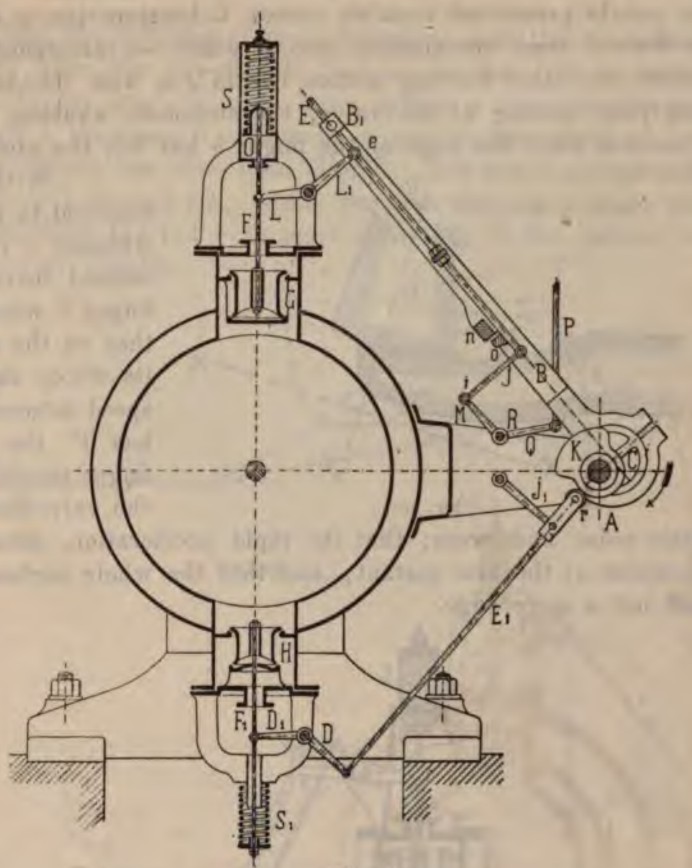

Fig. 276.

been largely imitated for the purpose of eluding the patent-right, — Messrs. Sulzer came before the public with a further improved valve-gear, at the Paris Exhibition of 1878. The preceding arrangement is *not* suited to high piston-speeds, for reason that to obtain a rapid opening of the valves, the contact of the trip-catches takes place during the maximum working speed of the eccentric-rod, so that an increase in the number of revolutions is rendered impossible.

To do away with this "restriction", the Valve-gear of 1878 was designed. Its fundamental principle may be explained with the aid of Fig. 278. Let us suppose a to be a gliding-surface on the end of a bell-crank, the other arm of which is attached to the valve-spindle. Let b be a finger or detent, rigidly connected with the gear-mechanism and moving

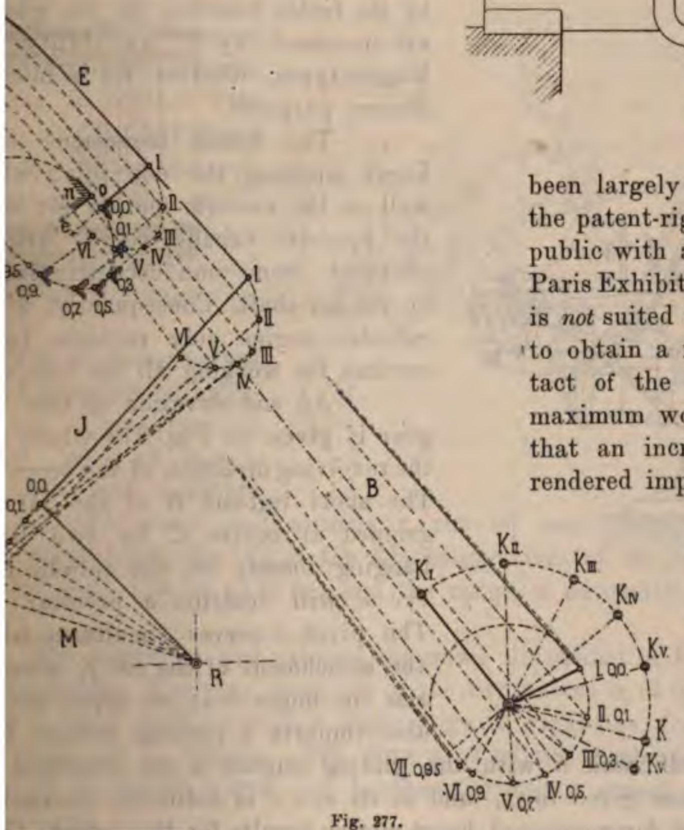

Fig. 277.

*) The different construction of the inlet-valves, as here adopted, will be seen to differ from that shewn in Fig. 274.

in certain prescribed variable curves; a heart-motion is actually given to this finger, which curve is derived from two motions, one of which — corresponding to valve-opening, is in $y\,y_1$ direction, whilst the other heaving motion lies in $x\,x_1$ line. The inscribed arrow $z\,z_1$ illustrates the direction implying opening of the valve, the automatic shutting of the latter answering to the contrary direction when the edge of the finger b has left the gliding-surface a in the $x\,x_1$ line.

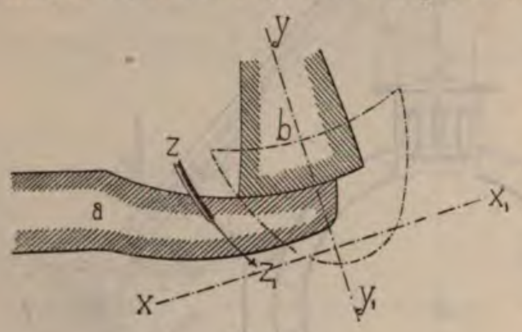

Fig. 278.

With a varied expansion, the whole curve is removed to the right (towards x_1) with earlier cut-offs, whereas a remains stationary. The form of the described curve is so chosen, that the velocity of the finger b when gearing on to a is not very great, but that on the contrary b first comes to lie quietly with its whole surface on to a, after which the opening-speed increases rapidly. In other words "as Engineering has it" the effect of this combination is, that the finger moving slowly at the instant when it strikes the valve-lever, opens the valve with comparatively little noise and wear; that its rapid acceleration, after it has once struck, makes up for its slowness at the first instant, and that the whole surface of the finger end, is in contact at once and not a mere edge.

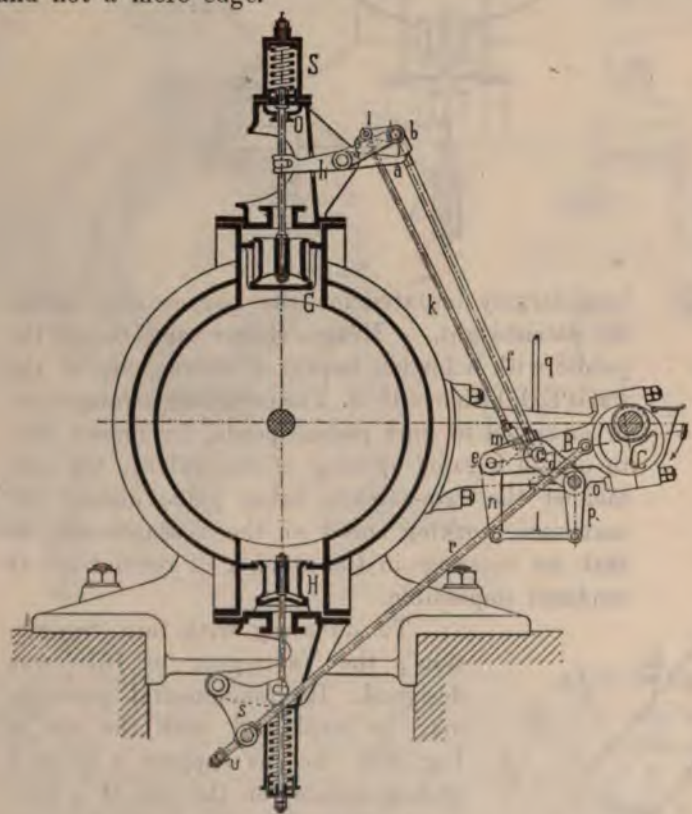

Fig. 279.

The great advantages possessed by this valve-gear, as displayed by its adaptability to high piston-speeds, and by its feeble reaction on the governor, are increased by its suitability to all Engine-types; whether for Winding or Marine purposes.

The double movement of the finger working the one inlet-valve as well as the uniform motion for driving the opposite exhaust-valve, are both obtained from one eccentric mounted on the lay-shaft. Consequently, a single cylinder engine only requires two eccentrics for working all the four valves.

An end-elevation of this Valve-gear is given in Fig. 279 which shews the revolving direction of the eccentric-C. The short tail-end B of the latter, is gripped at centre C by two links d hanging loosely on the spindle o; the eye e will describe a peculiar curve. The pivot c serves simultaneously for the attachment of the rod f, which carries the finger b at its upper end, and also imparts a rocking motion to the double links g, between which the bell-crank h with the gliding surface a are inserted. The finger or detent b has a crank-lever form given to it, and as its eye i is indirectly connected to the point e through links k and m, the forementioned heart-motion results for the detent; the rod f hereby effects the admission-motion whilst the link k heaves the detent to and fro. The usual spiral springs s are employed for accelerating the shutting of the inlet-valves, and the air-buffers O prevent the valves from clacking. To vary the cut-off, all that is required, is to cause the arm m to turn. This arm m forms with the arm n a crank-lever, which is placed under governor-control by means of the coupling-rod l, the lever p on spindle o, and the governor-rod q.

The method of driving the exhaust-valves has also been altered. The rod r is fastened to the eccentric tail B, and works the lever s to and fro, which remains stationary when the exhaust-valve is closed by it, though permitting the rod r to move according to the impulse of the eccentric C. The exhaust valves open very rapidly.

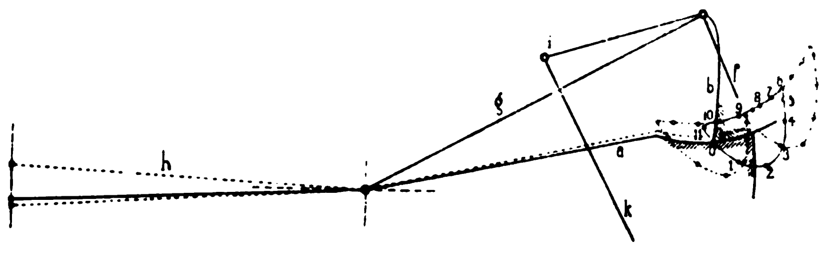

Fig. 280.

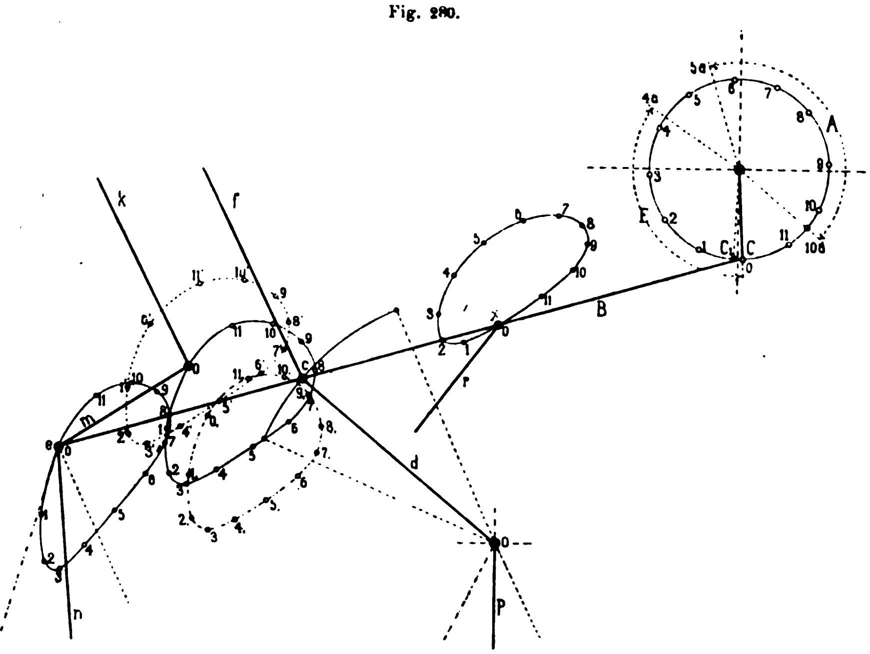

Fig. 281.

In Fig. 281, the curves described by the end of the rod k are drawn under the supposition of the two extreme and mid-positions of the governor-balls. Corresponding hereto, we draw the heart curves described by the detent, the punctuated lines — — — — referring to late cut-offs (as the gliding-off action no longer occurs), whilst the —··—··—··— lines indicate 0.0 expansion (because the detent b comes no longer in contact with the lever a). Fig. 281 shews the position of the eccentric in relation to the crank, whereby C denotes the eccentric of the small and C_1 that of the large cylinder.

The admission valves of the high-pressure cylinder, have a maximum-lift of $^{5}/_{8}$ths in. (16 mm.), the lineal lead amounts to $^{3}/_{32}$ in. (2.5 mm.) and automatic cut-off may take place between 0.0 and 0.9 stroke. On the other hand, the lift of the admission-valves of the low-pressure cylinder is $^{3}/_{4}$ in. (19 mm.), the lineal lead $^{1}/_{8}$th in. (3 mm.) and the range of automatic expansion lies between 0.25 and 0.85 stroke.

The admission and exhaust diagrams illustrated in Figs. 282 and 283, were obtained under these conditions. The very rapid lift of the two valves is at once apparent, and this is all the more important when working with a high range of expansion, for the highest valve position (g) already takes place at $^{1}/_{4}$ stroke. The curves were not prolonged behind the points i or i_1 — corresponding to valves closed, — because the valves remain stationary, their external mechanism alone moving.

The general arrangement of this Horizontal Compound Condensing Engine, which drove part of the machinery of the Swiss Section at the Paris Exhibition of 1878, is represented on our Plate 50. The low and high pressure cylinders are respectively $23^5/_8$" and $11^{13}/_{16}$ in. (60(300 mm.) bore, so that the capacity of the former is four-fold that of the latter; the stroke is $11^1/_2$ in. (900 m m.), consequently running at 70 revolutions per min. the pistons have a speed of 6 ft. 10 in. (2.1 m.) per sec. Working at this normal speed and at 90 lbs. (6 atm. solute pressure, and cutting off at 0.3 stroke, the engine's effective power is said to be 120 horses. steam-consumption per indicated horse-power per hour is quoted at from 16.5—17.6 lbs. (7.5—8 and this steam is supplied by a Sulzer-boiler fitted with a Ten Brink Grate, consuming 1.7((0.8 kilog.) of Saar coal of the best quality, per indicated horse-power per hour. Whilst on subject of working-results, Engineering in its issue for 16th Aug. 1878 placed before its reader results of a series of tests which have been carried out with a smaller engine of the same and which it will be worth while briefly to reproduce here. The three principal trials, of we shall give the mean results were carried on by Mr. Fr. Autenhunier, Director of the Tech School in Winterthur, Professor G. Veith, of Zurich, and Mr. T. A. Strupler, of Lucerne. Th gine and boiler were at work in a part of Messrs. Sulzer's factory, and the following are principal particulars:

Diameter of small cylinder	9.44 in.
" " large cylinder	15.91 "
Stroke "	29.51 "
Heating surface in boiler	387 sq. ft.
Grate surface	9.7 "
Ratio heating to grate surface	40 : 1

The boiler was of the type exhibited by Messrs. Sulzer at Paris, a large inclined cyli with "Ten-Brink" furnace and grate, and tubes from the upper part of the flame-box right thr water and steam space to the top of the shell. The fuel used was Saar coal of the first qu

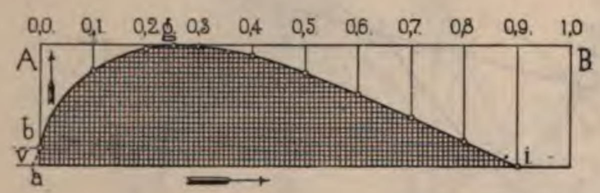

Fig. 282.

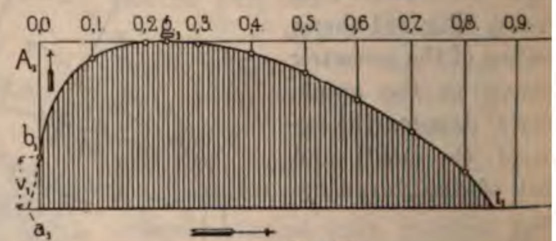

Fig. 283.

from Altenwald. The engine was simply doing its ordinary work. The three tests were car out on the 22nd. and 23rd. of May 1877, the first lasting three, the next four, and the last hours. There is very little difference between the three sets of results, and we shall cont ourselves with giving the mean results of the 13 hours working, which are as follows:

Pressure in boilers	79.2 lb. per sq. in.
" engine-house	76.3 "
Vacuum	26.6 in.
Mean pressure, high-pressure cylinder	32.1 lb. per sq. in.
" " low-pressure cylinder	12.5 "
Revolutions per minute	89.04
Indicated horse-power small cylinder	27.28
" " " large cylinder	29.93
Total indicated horse power	57.31
Temperature of feed water	55.7 deg. Fah.
" " steam in boiler	358.7 "

Temperature of saturated steam corresponding pressure, calculated according to Regnault	323.0 deg. Fah.
„ „ steam on entering cylinder	323.5 „
„ „ injection	51.8 „
„ „ discharge	83.0 „
Quantity of feed water per hour...	990 lb.
„ „ condensed steam from jackets and pipe per hour	123 „
„ „ injection water per hour	24.670 „
Ratio of injection to feed water..	24.9 : 1
Quantity of coal used per hour	103.4 lb.
Pounds of steam (measured as feed) per pound of coal..	9.6
„ „ feed water per indicated horse power per hour	17.58
„ „ coal per indicated horse power per hour ..	1.83
„ „ „ „ foot grate per hour..	10.66
„ „ feed water per foot heating surface per hour	2.55

We have not particulars as to the manner in which the various measurements necessary to obtain these quantities were made, but the experiments seem to have been carefully carried out, and there is no reason to doubt their substantial accuracy. It is unnecessary to point out that they speak for themselves, as to the exceedingly economical working of the engine. The only point about which some doubt may be felt, is the apparent superheating of the steam, a result which we should hardly have anticipated from the working of the similar boiler at Paris. We do not know how the steam pressure was measured. It must be said, however, that without some such superheating we should have expected to see more signs of the existence of wet steam in the cylinders than appear on the face of the results before us.

The results of over thirty experiments conducted by Messrs. Sulzer themselves with the same engine and boiler, and under nearly similar conditions to those we have described, entirely corroborate their accuracy. They give for *mean* figures the following:

Quality of Saar Coal.	1st.	2nd.	3rd.
Pounds steam (as feed water) per pound of coal	9.75	8.49	7.97
Pound coal per indicated horse-power per hour	1.83	2.10	2.24
Feed water for indicated horse-power per hour		17.85 lb.	

The cylinders are placed tandem fashion, with the Engine trunk-frame cast with the crank-shaft bearings bolted to the front high-pressure cylinder, whilst the low-pressure cylinder with distance-piece cast on, is similarly bolted to the former by this distance-piece.

The valve arrangement has already been discussed. The two cylinders are jacketed and lagged. On the other hand, the high-pressure cylinder is alone supplied with steam direct through its jacket, its supply pipe is $3^1/_2$ in. (90 mm.) or $^1/_{11\cdot2}$ the area of steam-piston. This cylinder passes the steam through a pipe $4^3/_8$ in. (110 mm.) diam. into the jacket of the low-pressure cylinder; this is certainly a defective arrangement as regards economy, though it presents certain constructive advantages. This last named pipe is $^1/_{7\cdot4}$ the cross-area of the small and nearly $^1/_{30}$th part of the large piston-surface. As expansion also takes place in the large cylinder, the jacket of the low-pressure cylinder simultaneously serves as an intermediate receiver. The condenser pipe is 5 in. (125 mm.) in bore, or $^1/_{23}$rd part of the large steam-piston in area.

The front cover of the low-pressure cylinder can be pulled out through the hind cover of the same cylinder, and as the hind cover of the high-pressure cylinder is similarly made to pass through, both pistons and their rods can be removed at one operation. No red lead is used for joints, but these are merely formed by close grinding down. The cylinder distance-piece opens out to view the respective stuffing boxes. Fig. 1 on Plate 50 illustrates the simple piston-construction, no longer made in two parts as formerly.

The double acting vertical Air-pump is driven off the prolonged piston-rod, by a forked link and lever. Small air-valves enable a silent action to be still maintained with high-speeds. The Feed-pump is worked off the same lever driving the Air-pump. The mechanism adopted for the automatic expansion-gear of the low-pressure cylinder is shewn in Fig. 3, and other constructive details are drawn to an enlarged Scale in Figs. 4—6.

We may supplement these data, with some modifications introduced in the Engine-parts not before alluded to.

The connecting-rod, gradually strengthened up to the cross-pin, has its head forged off vertically. The brasses of the crank-shaft bearings are in four, rendered adjustable by wedges. The fly-wheel cast in two, has 6 channels for rope-driving. To prevent the high speed of this wheel causing violent air-currents, its arms are elliptical in section.

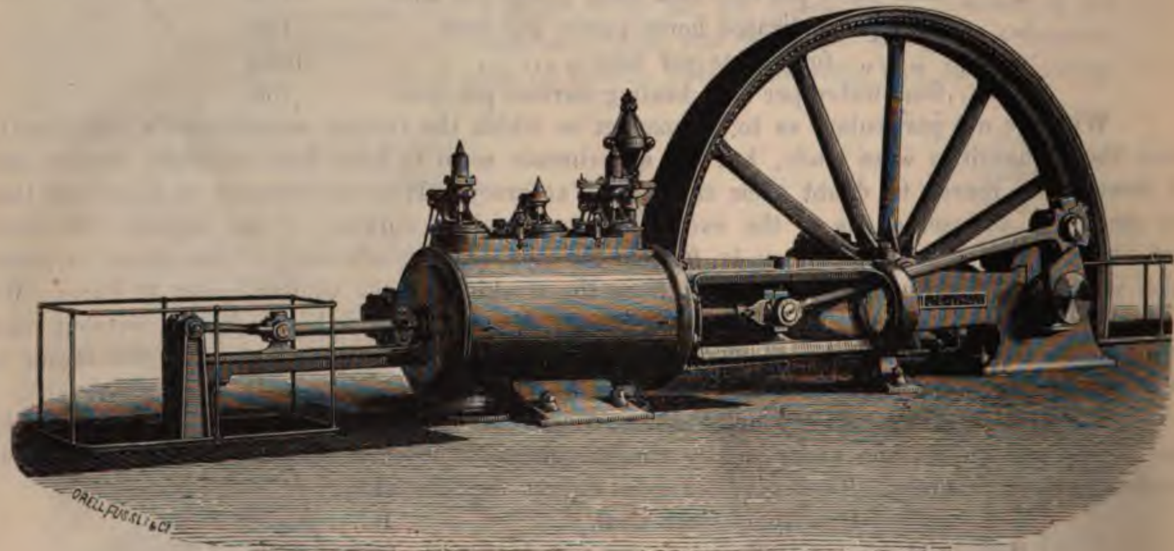

Fig. 284.

Our wood-cut Fig. 284, shews a simple Condensing Engine erected in 1877 by the same Firm at Ochtrup, (North Germany) and indicating 230 *HP* with a cylinder diam of 25½ in. and a 4 ft. 4½ in. stroke.

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b. Engines working with the Sulzer Valve-gear of 1873.

a. **Joseph Pallenberg, Engineer of Mannheim.**

The Sulzer valve-gear of 1873 has undergone a modification at the hands of Mr. Joseph Pallenberg, Engineer of Mannheim; it is this alteration which we represent in Plate XXX. As here shewn, the eccentric rod B is again forked and furnished with a catch n; it is however differently guided in its motion, for it is fitted with pin-joint and guided by the rigid bracket T.

The rod E furnished with corresponding catch o, is connected with the valve-lever LL_1, and is supported at its other end on the articulating lever J. The governor by turning the expansion shaft R to which the link M is keyed, alters the position of lever J and consequently also the position of the rod E, so causing the gearing of the catches n and o to be retarded or hastened, as the case may be.

The exhaust valves are worked as in the Sulzer-gear. The cam K presses down the valve-spindle-lever connecting rod, thus opening the valve, whereas the spring S in the pot O effects the closing of this valve. The cylinder is of $17^1/_2$ in. (445 mm.) bore and has a 2 ft. 11 in. (890 mm.) stroke.

b. Maschinenfabrik Augsburg.

Since 1845, the Maschinenfabrik Augsburg has made a speciality of Steam-engine building, their aggregate turn-out now amounting to 12800 *HP.* Lift-valve gears and the trunk-engine frame, were already adopted by this Firm in 1871, and the Vienna Exhibition of 1873 bore ample testimony of the high-class work turned out by these machinists.

We shew a perspective view of one of their Engines, in Fig. 285, the valve-gear of which is exactly alike the Sulzer arrangement of 1873, excepting that a cross-armed governor is used. The diam. of cylinder was $13^1/_2$ in. (345 mm.) its stroke $29^1/_8$ in. (740 mm.); running at 62

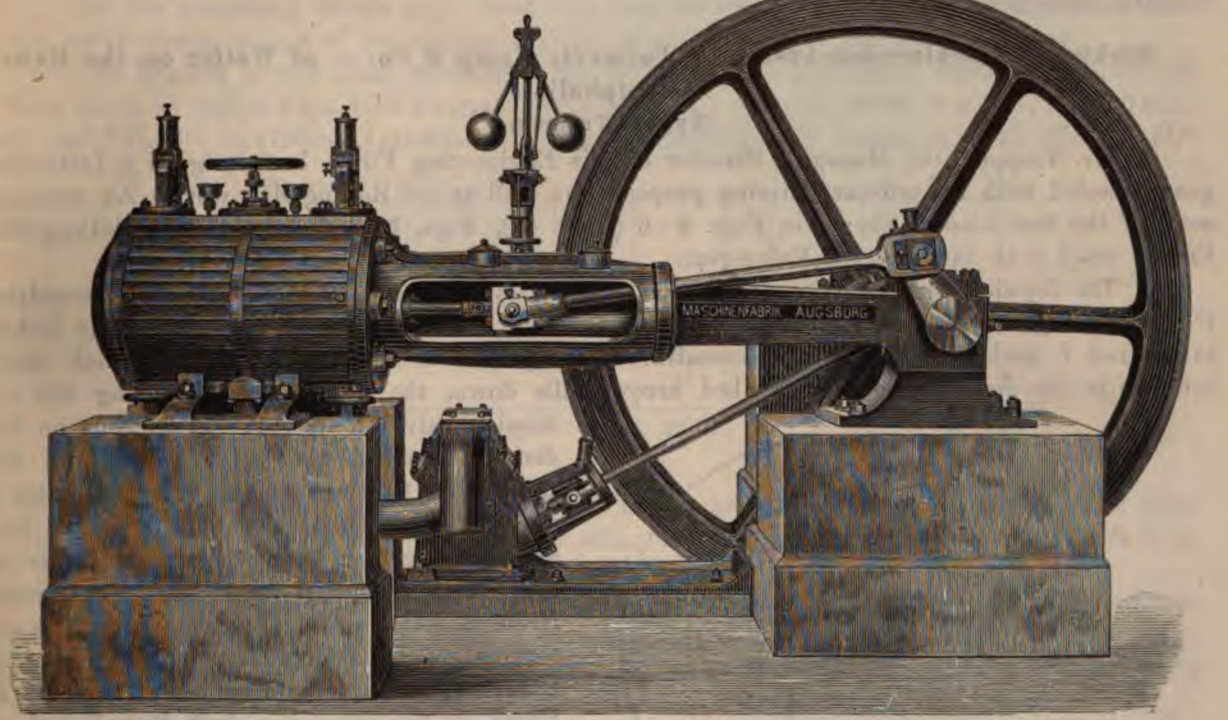


Fig. 285.

double-strokes per min. a mean piston speed of 4 ft. 11 in. (1.5 m.) was given off per sec. Power was conveyed by a belt $10^1/_4$ in. (260 mm.) wide from a flywheel 11 ft. $9^1/_2$ in. (3600 mm.) diam. Rather peculiar is the arrangement of the air-pump which is set inclined, and worked by an eccentric off the crank-shaft.

Our Plate 51 illustrates the arrangement adopted by this Engineering Firm in the construction of a Pair of Coupled Condensing Engines, for driving the "Kölnische Baumwollen-Spinnerei and Weberei" *). The cylinders are each of 20 in. (500 mm.) bore and 3 ft. 7 in. (1100 mm.) stroke; running at 58 revolutions per min. the mean piston-speed is about 7 ft. (2.12 m.) per sec. According to the Circulars issued by this Firm, it would appear that they construct similar Engines running at as high a speed as 70 revolutions per min, whence we may conclude that the Sulzer valve gear of 1873 admits of such speeds. Although the principle of this arrangement permits all

*) Cologne Cotton Spinning and Weaving Factory.

expansion grades, still the governor limits the steam-admission within the limits of 0.0 up to about $^1/_3$rd stroke. The running away of the Engine is thus prevented, and simultaneously the machine is kept working within rational limits for a Cotton mill. Within these limits the governor is exceedingly accurate; this the more so, since special regard has been had in furnishing it with a small lift. The steam-pipe, $5^1/_2$ in. (140 mm.) diam. and the condenser-pipe 6 in. (150 mm.) diam. are placed side by side under the cylinder; the former is $^1/_{12}$th, the latter $^1/_{11}$th the piston-area. The construction of the cylinder, piston etc. is exactly alike Sulzer's; the long valve-spindles enable any condensed steam to collect, so reducing friction in the stuffing-boxes to a minimum.

The air-pump is again worked by an eccentric, and the feed-pumps are driven by wrought iron levers off the former.

Twelve ropes convey the engine-power to the Mill-shafting, and the consumption of steam in Engines of this type, varies according to their size from $18^3/_4$—20 lbs. (8.5 to 9 kilog.) per indicated horsepower per hour.

c. Märkische Maschinenbau-Anstalt — Formerly Kamp & Co. — of Wetter on the Ruhr (Westphalia).

(Type: Trappen.)

Mr. Trappen, the Managing-Director of this Engineering Firm, has designed a Lift-valve gear, adapted both for ordinary driving purposes, as well as for Rolling-Mill work. An arrangement of the first kind is shewn in Figs. 4—6 (Plate 52), Figs. 1—3 representing a Rolling-Mill Engine fitted with the Trappen Valve-gear.

The lay-shaft *A* (Fig. 7) is placed alongside the cylinder and mounted with four eccentrics *C* for working the two inlet- and the two exhaust-valves. The tail-end of the eccentric is linked to the rod *I*, and the strap of the eccentric sheave carries a steel catch-plate *n*, which when rotating in the direction of the inscribed arrow pulls down, the valve-rod *E*, so lifting the admission valve off its seat. It depends on the distance between the valve rod *E* and the catch *n*, as to how long the valve-rod catch *o* remains in gear with the plate *n*; if the two are close together, they will remain longer in gear than if further apart and vice versa. Hence it follows that the inlet valve will accordingly remain open, during longer or shorter intervals, as the case may be. The lever *P* keyed on the expansion shaft *R* is linked to the valve rod *E*, through the piece *M*, and the position or the relative distance of the rod *E* from the eccentric point *n* is thus under governor control, as the governor causes the expansion-shaft *R* to rotate, according to its bidding; consequently automatic variable expansion is obtained. The governor is made to react on this expansion shaft by a pair of bevel wheels.

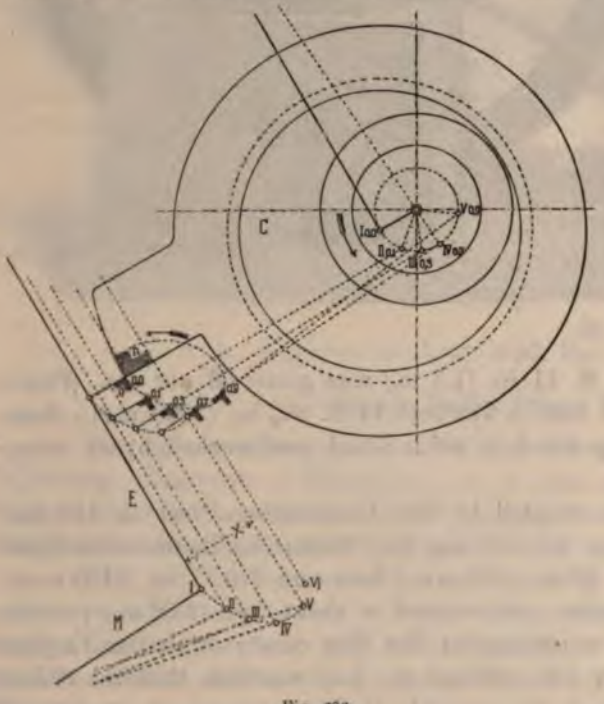


Fig. 286.

Further insight into the working of this Valve-gear is afforded us, by the annexed Fig. 286, shewing the travel of the edge of the catch *n*. The valve-rod *E* is always geared by the catch, at one crank-position. In the Engine before us, the lineal heave of the lever *R* through the governor amounts to 1 in. (24 mm.), which travel is indicated by X, the range of automatic expansion lying between 0.0 and 0.9 stroke. The diagram drawn in Fig. 287 explains, that the admission-valve is continually opening up to $^3/_4$ stroke; the moment, corresponding to the highest position of the valve, does not coincide with the disengagement-limit — vide diagram — but on the contrary this range may be lengthened out at will, if the link M is only adjusted to suit the lowest declension of the governor-balls, so as to approach the valve-rod E to the catch. We further perceive, that disengagement must always take place, because, if the connection remained intact, the shutting of the valve would only occur at i during the next stroke. Such would only happen, if with the governor-balls in their lowest position, the rod E had been so far pushed forward, as to exceed position VI, when a gliding out of gear would no longer take place. Theoretically, the range of expansion might lie between 0.0 and 1.0 stroke. In reality this valve gear is very simple, for both its adjustment and its supervision cause little difficulty during the working of the engine.

All the remaining details shew what may now be termed well known arrangements, such as the valve closing action of the springs and the usual working of the exhaust-valves.

The Engines of this class, constructed for ordinary driving-purposes, retain the Corliss-type in their build, so that in Figs. 4—6 we have merely drawn the cylinder, which is of $13^3/_4$ in. (350 mm.) bore, and 2 ft. $3^1/_2$ in. (700 mm.) stroke. When non-condensing, this Engine is of 25 effective HP,

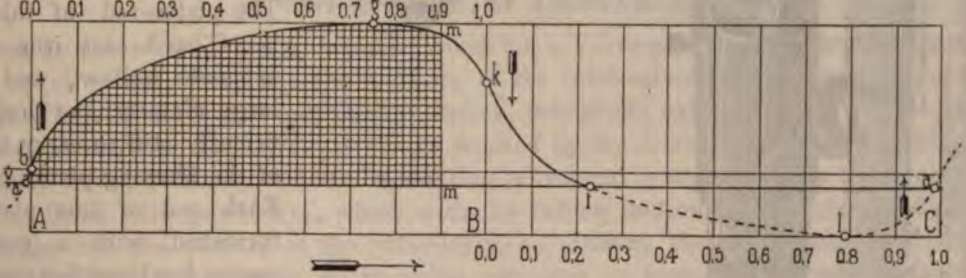


Fig. 287.

which is augmented to 30 HP when condensing. In the first case, the crank is run at 72 revolutions and in the second at 66 revolutions per min., so yielding mean piston-speeds of 5 ft. 6 in. and 5 ft. (1.67 and 1.54 m.) respectively.

Crank-shaft bearing and trunk-frame are cast in one piece. The connecting rod is made five times the crank-length. A guide-rod is attached to the crank-pin for working the air-pump, placed underneath the floor-line, in the same style as we noticed, with the practice of the "Erste Brünner Maschinen-Fabrik" — vide pg. 34 and Plate 5 —.

This valve-gear mechanism suffers no alteration in the Rolling-Mill Engine illustration, excepting that the governor-rod is outside the stand, and acts by a lever arrangement on to the expansion-shaft. "Engineering" described*) an engine identical in principle to the Rolling-mill Engine here illustrated, which was built for Prince Solms Braunfels, for supplying blast to his furnaces at the Georgshutte Iron Works, near Braunfels. This Blowing Engine has a steam cylinder 37 in. and a blowing cylinder $86^5/_8$ in. in diameter, the stroke in each case being 6 ft. 2 in. The engine is run at 25 revolutions per minute, giving a piston speed of 308 ft. per min., and it supplies blast at a pressure of 4.4 lb. per square inch, while the pressure of steam used is 60 lb. per square inch, the steam being cut off at three-eighths of the stroke. Unfortunately a deficiency of water prevented the engine being made condensing.

As will be seen from our engravings the cylinders are kept as low down in the frame as possible, so as to reduce the cross-bending strain on the bedplates. The distribution of the steam is effected by double beat valves, the admission valves being on the top of the cylinder

*) d 12 July 1878, pg. 28.

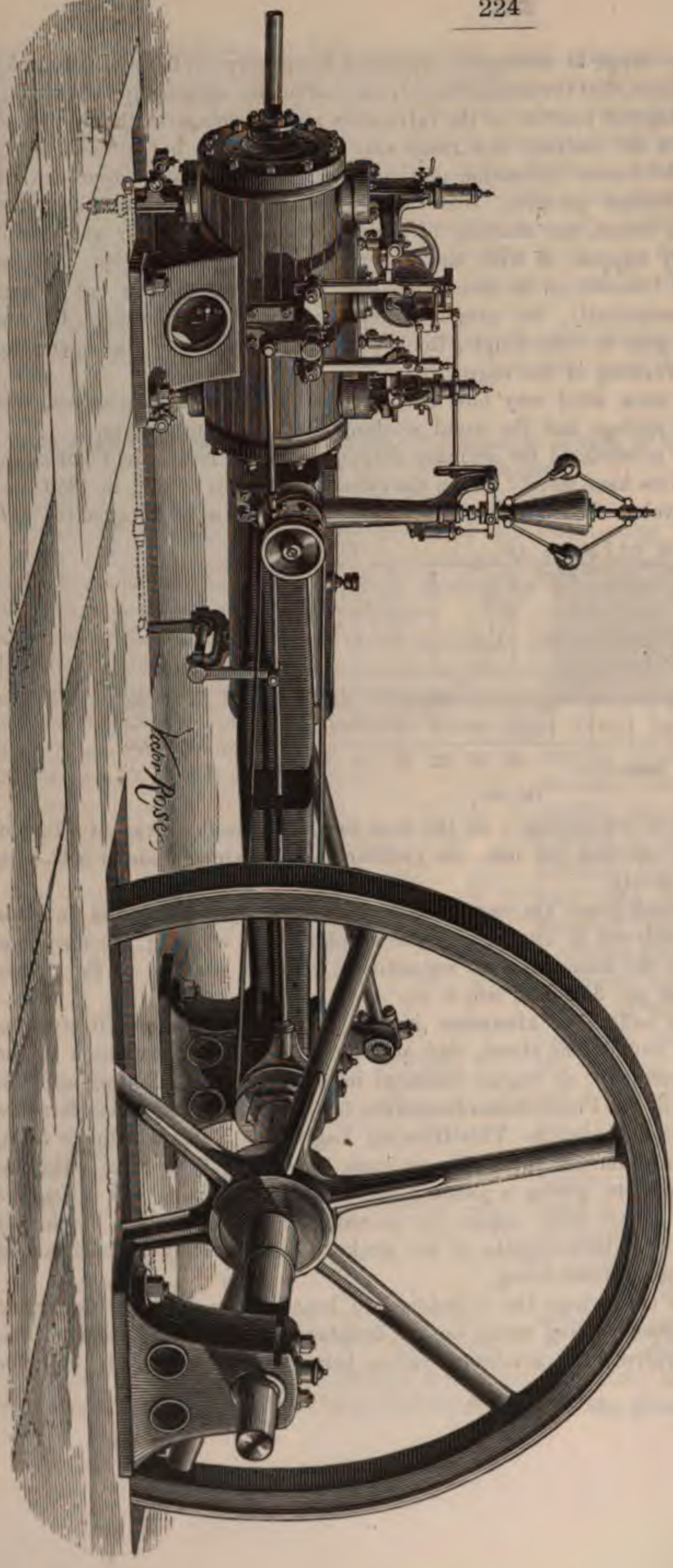


Fig. 288.

and the exhaust valves below. Both steam and exhaust valves are driven from a countershaft which is geared to the crankshaft by bevel wheels, as shown. Th admission valves are actuated by cams on this shaft and the exhaust valves by eccentrics, while the period of admission is variable by adjusting screws on the steam valve levers. The steam cylinder is not steam-jacketed but it is carefully lagged.

The blowing cylinder has the inlet and outlet valves fitted to the end covers, these valves being of felt, mounted on leather. The piston-rod of this cylinder is of hard cast iron, while it is made hollow, and of very large diameter, so that it is sufficiently stiff to carry the weight of the blowing piston effectively. Each end of this piston-rod is furnished with a guide. The engine has large bearing surfaces to suit it for the speed at which it is run, and it is altogether an interesting example of recent German practice.

d. Lecointe & Villette, Engineers of St. Quentin.

(Type: Alb. Zimmermann.)

The valve-gear fitted to the pair of coupled Engines, exhibited by Messrs. Lecointe & Villette at the Paris Exhibition of 1878, owes its origin to Mr. Alb. Zimmermann C. E. of Marchiennes (Belgium), who took out German Letters Patent for this gear.

In Fig. 1—3 (Plate 53) this valve-gear is shewn fitted to a steam-cylinder, whilst a perspective view of an Engine working with this Valve-gear as constructed by Messrs. M & J. Feder

Engineers of Eupen is given in Fig. 288. One eccentric is used for working the four valves. The eccentric rod articulates a double lever to whose ends two lay-shafts are attached, one of which drives the inlet, whilst the other works the exhaust valves. For this purpose, the first named *(B)* is attached to a rocking plate *C* — see Fig. 3 —.

The inlet valve-chest covers have each the ordinary dash-pots cast in one piece, so that these valves are closed by spring-pressure. These castings also form a bearing for a pivot shaft, round which the valve-spindle levers *L* and L_1 oscillate; these levers are furnished with a steel nib $n\,n_1$. Confining ourselves to the one cylinder-end, the lever *N* is pressed down by a trigger *o* of the rod *E*, receiving up and down motion off the rocking-plate *C*; the inlet valve is opened thereby. The upper end of this rod *E* is moreover linked to a connecting rod *r*, which is moved to and fro, because the governor articulates the lever *R* to which it (*r*) is attached, through the rods *M* and *P*. These two independent motions communicated to the trigger *o* cause its edge to describe a circular arc, the extent of which determines the duration of its remaining in gear with the steel nib *n*. In this manner a variable cut-off under governor control, is obtained.

As only one eccentric is used, and disengagement only ensues with the downward motion of the rod *E*, the range of expansion is limited to about $^4/_{10}$ths stroke.

e. Carl Trostorff, of Aix-la-Chapelle.

Carl Trostdorff took out a German Patent for a Valve-gear motion, the mechanism of which is merely novel, so far as regards the working of the inlet-valves. We therefore confine our illustrations (on Plate XXXI Figs. 1—3) to this portion, though the exhaust valves are said to be driven by a separate eccentric. The inlet-valves are worked by the lever *A* receiving a rocking motion off the tail-end of an eccentric rod, and this oscillating movement is transferred to the double-lever $B\,B_1$. The latter is fitted with pawls $n\,n_1$, which with the falling motion of the corresponding lever arm, gear on to the free end *o* or o_1 of the valve-lever, so pressing the valve spindle down and opening the valve. This lifting action of the valve continues so long, as the pawl *n* is in gear with the lever-end *o*, and as soon as disengagement ensues, the valve closes in the usual manner.

The form given to the valve-lever, allows the pawl to pass it during the rising of the arm *B* because the end *o* is knuckle-jointed. The pawls $n\,n_1$ slide on the lever $B\,B_1$, being kept against the cone-surface *M* by spring-pressure; this cone is under governor-control. The falling into gear of the pawls always takes place at one particular piston-stroke, but the duration of the engagement depends on the relative distance of the pawls $n\,n_1$ from the valve-lever ends $o\,o_1$; consequently, admission of steam will continue all the longer, the further apart the pawls are from each other, for then the release of the valve-levers will be all the more retarded. A bell-crank *R* transmits the governor motion on to the cone *M*.

f. A. Knœvenagel, of Hannover.

The introductory remark we used in the last example, also applies to the patented Valve-gear of Mr. Knœvenagel, Machinist of Hannover. The inlet-valves are here worked off an horizontal lay-shaft running alongside the Engine. End view of this Valve-gear is supplied by Fig. 4 (Plate XXXI) Fig. 5 giving various positions of the positive driving gear.

The tail-end *B* of the eccentric *C* is guided by the sleeve *E* made to pivot on the forked-end of the lever *D*, so that the upper end (*e*) of the eccentric rod, oscillates in an opposite moving direction to its lower end. With the inscribed rotation of the lay-shaft *A* a steel catch-plate inserted in the upper end of the eccentric-rod *B* presses down a steel nibbed link *K* along with the valve-spindle lever *L*. This action is placed under governor-control, by the following mechanism: With rising governor-balls, the lever *R* rises and vice versa; the latter is keyed on the expansion shaft M, which carries the pin r at its end, in eccentric fashion; this pin r forms the swing-centre of the bell-crank Dc. The sleeve E is attached to the arm D, whilst the end of the arm c slides in an open link, which with the motion of the lever R, slides up and down about the fixed point u. Consequently, according to the position of the governor-balls, the pivot e of the sleeve E, changes its position, so bringing about variable engagements periods.

In Fig. 5 we have accepted the two extreme as well as the mid-declensions of the governor-balls. When at their highest, indicated by R_1, the pivot-centre of the eccentric-rod is at e_1, whilst e_2, would similarly correspond to the lowest declension of the balls. In the first case n no longer gears on to o, as the curve shewn in Fig. 5 falls outside the edge of o, so implying no opening of the valve. In the second case, the disengagement merely takes place at $^8/_{10}$ths stroke, which consequently corresponds to the latest admissible automatic cut-off. The parallel motion given to the link K has been designed, so as to afford an almost flat contact of n and o during the times required. The shortening or lengthening of the rod J, also affords capital means of regulating the Engine, and especially of compensating for any variations in the piston-length.

The Machine-department of the Trades-Exhibition held in 1878 at Hannover, was driven by an Engine fitted with this Valve-gear, and supplied by Mr. Knœvenagel. Its cylinder was $14^1/_4$ in. (360 mm.) bore, and 2 ft. 6 in. (780 mm.) stroke; running at 75 revs. per min. the mean piston speed of 6 ft. 3 in. (1.95 m.) per sec. was attained. The fly-wheel rim 13 ft. in diam. (4 m.) was furnished with 5 grooves for rope-driving.

g. Johann Völl, of Eupen.

On Plate XXXI we also shew the Valve-gear patented by Johann Völl of Eupen. It is represented attached to a cylinder in Figs. 6 and 7, whereas the detached disengægement-gear is illustrated in Fig. 8. The cylinder carries a horizontal sliding-saddle A, actuated by the excentric-rod B; the four valves are worked off this saddle.

For lifting the inlet-spindles F (Fig. 8), we have the levers $L L_1$ keyed on the shaft D. The lower end of the first named lever is sleeve formed. In this sleeve U, a tongue Z formed in two is inserted, the upper end N of which oscillates in the eye of a double lever $R R_1$. The arm R_1 is under direct control of the governor-rod M, so answering to each motion of the governor collar, as is evident from Fig. 6. Consequently, the tongue Z participates in the declensions of the governor-balls, so moving up and down in the sleeve U. It is further evident, that by this sliding in and out of the tongue Z the leverage is varied.

The forementioned saddle has knife-edge formed catches $C C_1$, which alternately gear on to the tongue ends Z, forcing the latter to describe circular-arcs, the length of which will be longer or shorter according as the tongue Z lies out of, or in the sleeve U. The connection between the levers L and the valve-spindle F, causes the oscillation of the former to be transferred as a lift on the latter, and it is at once evident that the valve will remain opened, longer or shorter, according to the larger or smaller oscillating angle described by the lever L. The disengagement of the two edges of C and Z, is quickly followed by the valve closing.

With the return stroke of the saddle, the inclined edge C is forced in by coming in contact with Z, and so allowed to pass the latter, when the catch C_1 gears on to Z_1, and so on.

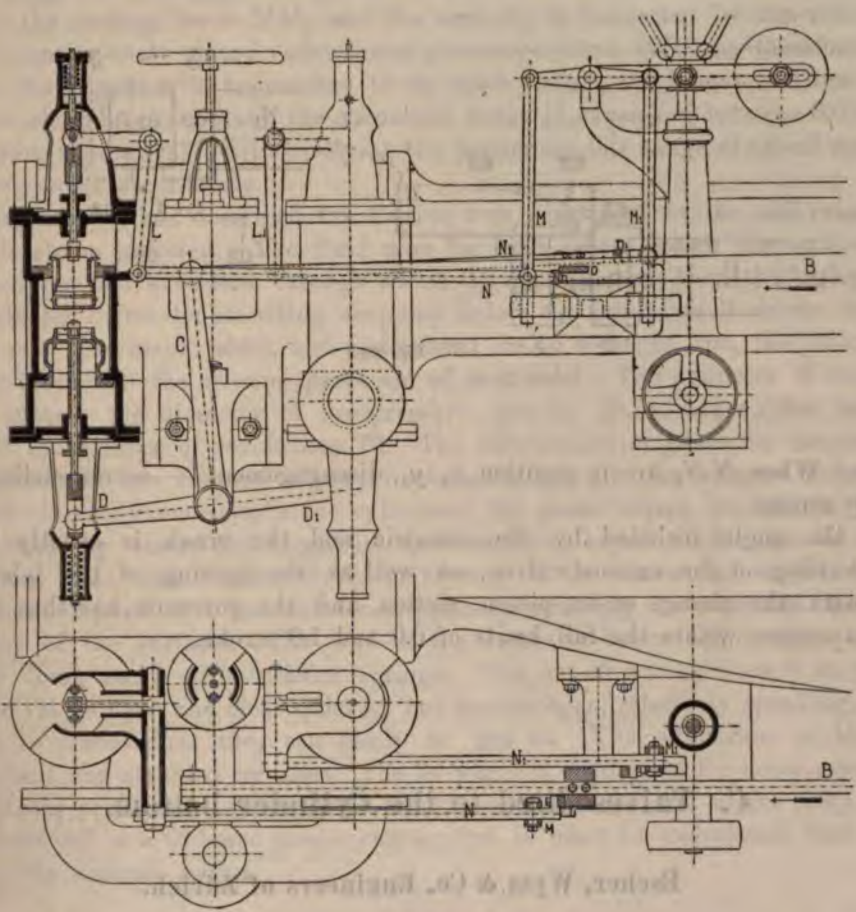
The exhaust-valves are worked by a rod K fixed to the saddle, which alternately forces the spindle valve-levers $Q Q_1$ to mount and glide off the steps $r r_1$.

h. Carl Teichmann, of Stuttgardt.

Amongst the feed valve-gears displaying great simplicity, and admitting the widest range of expansions with the use of only one eccentric, we may class the Valve-gear, designed by Prof.

rl Teichmann of Stuttgardt. It is this arrangement, which we illustrate in the annexed wood-ts Figs. 289 and 290.

The exhaust-valves receive their motions, in the usual manner, from the crank shaft, by an centric rod B and a bell-crank DD_1. The rod B carries at a suitable distance a trip-plate o, ıich alike all other points of this rod has nearly elliptical travel, resulting from a horizontal d a vertical movement. When the eccentric of the crank approximately follows at right angles, e dead centres of the vertical motion coincide with those of the steam-piston, whereas with gard to the horizontal movement, the central positions coincide with the crank dead-centres.



Figs. 289 and 290.

The inlet-valves are worked by the bell-cranks LL_1 and the rods NN_1; the latter re suspended on rods MM_1 actuated by the governor. They each carry a catch nn_1, which is eld up at a certain height, by the forementioned rods MM_1.

Supposing the crank on its dead centre, and the trip-plate o (either above or below) in s central horizontal position, then the catches nn_1 will lie close up to the right or to the left of the ›rmer, and the valves will be closed. If o now moves to the right or to the left, the right or left and inlet-valve will be opened. This position of N and N_1 is denoted by x and y in Fig. 291, ıough the lead has here been taken into account.

In the lowest position of the governor-balls, the altitude of the catch-plates nn_1 so chosen, that during the entire vertical motion of o, one of these is in gear, thus opening its corresponding valve; full steam is then admitted to the cylinder, and the Engine works non-expansively. With rising governor balls, the catch-plate *n* is lowered, whereas the catch n_1 is raised, so that disengagement takes place sooner during the vertical motion of *o*, when the corresponding inlet-valve is closed rapidly under spring-pressure. When the governor balls have attained their maximum ascent, the catch *n* has been thereby so much lowered, whilst n_1 has been so far raised, that neither of them can gear with *o*, so that in that case, neither of the inlet-valves is opened. Our Fig. 291 shews this trip-action, the curves travelled over by the edges $o\,o_1$ of the trip-plate being also in-

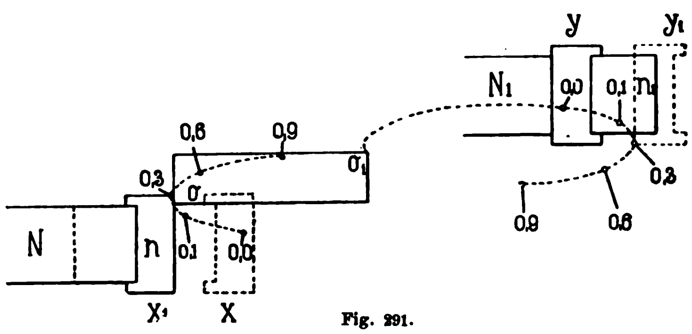


Fig. 291.

dicated therein. When $N N_1$ are in position x_1 y_1, disengagement — corresponding to cut-off — ensues at $^3/_{10}$ths stroke.

When the angle included by the eccentric and the crank is exactly 90°, then the opening and shutting of the exhaust-valves, as well as the opening of the inlet-valves, takes place exactly with the change of the piston motion, and the governor has thus a control over the range of expansion within the full limits of 0.0 and 1.0 stroke.

C. Valves fitted to the Cylinder bottom.

Escher, Wyss & Co. Engineers of Zürich.

Amongst the Engines shewn in motion at the Paris International Exhibition (1878) we may now cite, the Sixty Horse-power Compound Tandem Engine of Messrs. Escher Wyss & Co. of Zürich. In general appearance as our Plate 54 shews, this type bears some resemblance to the Sulzer-design, though the Valve-gear is of novel construction.

The arrangement of the valves to the bottom side of the cylinder is represented in Fig. 4, whilst the noteworthy details of this gear are shewn on an enlarged scale in Fig. 5. The lay-shaft at the cylinder-side, merely extends to about the middle of the trunk-frame, where it is driven by spur-wheels off a second parallel shaft placed in bevel-gear with the crank-shaft. The high-pressure cylinder alone works with variable expansions, so that all the valves of the low-pressure cylinder are driven off fixed cams, in the same way, as the exhaust-valves of the high-pressure cylinder. The cylinder-legs have a double-armed bracket bolted on each side, each arm-pin of which forms a swing-centre for the valve-spindle lever, the right driving the inlet and the left driving the exhaust valve. Consequently the one end is connected with the valve-spindle (exhaust) whilst the other end receives the required motion by cam-gear, in the same style as we have already met. It is otherwise with the inlet-valves of the high-pressure cylinder; there, the steel nibbed end o of the bell-crank $L L_1$ (Fig. 5) is perfectly free, and is only pressed down at the beginning of the admission, by a catch-plate n of the pivot z fixed to the lower end of the eccentric rod B — worked off an eccentric on the lay-shaft A —. This pivot z is forged in one piece with the strap C and bar D; the latter slides in a sleeve E made to oscillate round the pivot z so as to ensure the proper position of the trigger n at engagement periods. The lower extremity of the eccentric rod B is linked by J_1 to the rocking lever MM_1, and the arm M_1 is connected by the rod R to a small crank on the expansion-shaft placed under direct governor-control. We may therefore now perceive, that the nearer the trigger n is approached to the catch-plate o, the longer will the admission last. Theoretically we should again obtain, the automatic range of expansion between 0.0 and 1.0 stroke, but so as to ensure a rapid valve-lift already at the beginning, this range of cut-off must be reduced, by setting the excentric accordingly.

"The Engineer" *) has described the Engine here illustrated in the following terms: The small cylinder is steam jacketed. The fixed pipe for fresh steam passes through a super-heating chamber between the two cylinders, through which the steam passes from the high-pressure to the low-pressure cylinder. The double-acting air-pump below the bed plate is driven by a lever from the connecting rod. The crank, shaft, and piston-head are of wrought iron, the pinions, piston rod, and the greater portion of the moving parts are of cast steel. The diameter of the high-pressure cylinder is 7.8 inches, the diameter of low-pressure cylinder 15.74 inches, the length of stroke 23.6 inches, and the number of revolutions 70. The distribution of steam in the smaller cylinder is effected by means of two distinct valves for admission and two for exhaust, which are placed in pairs at each extremity underneath the cylinders; the steam valves are each worked by an excentric, the exhaust by cams; the excentrics and cams are keyed to the spindle communicating with the governor. The transmission of the movement of the excentrics to the valve levers is produced by a contact parallel to the surfaces of pressure, reducing the wear and tear, and preserving the accuracy of the surfaces. The jaws of the excentric levers act directly on those of the valves, thereby doing away with tumbler springs. The cut-off varies from 0 to 95 per cent of the stroke. The valves open and close quickly, but remain open, relatively speaking, a considerable time; they are so placed that they can easily be got at. The admission to the low-pressure cylinder is constant and actuated by cams. The fly-wheel is channelled for hemp ropes. The engine is built for a steam-pressure of about 105 lb. on the square inch, and works very smoothly and well. The makers call it a 60-horse power engine, but it must be understood that this refers to the real, not to the nominal power.

4. Lift-valves with positive Admission and positive Exhaust-gears.

a. A. Collmann, Engineer of Vienna.

Notwithstanding the various modifications of the Collmann-gear, adopted by different Machinists, the principle remains the same as shewn by our wood-cut Fig. 292.

*) d. 12 July 1878 pg. 22.

The admission (G) and exhaust (H) valves are set in pairs at each cylinder-end, and are worked by one eccentric or crank C of a lay-shaft A driven at equal speeds as the crank-shaft. Our drawing, corresponds to the crank being on its dead centre; during the next half of its revolution, — vide inscribed arrow — the crank C will therefore control the admission of the steam, whereas it will regulate the corresponding exhaust during the remaining half-revolution. Simultaneously, two motions are obtained off this crank-motion, which combined, work the inlet-valve. In the first instance, this crank-movement, gives an oscillating motion to a portion of the valve-gear, which as a consequence, apart from the lead, is shifted during the first half-revolution of the crank, from one extreme into its opposite extreme position, returning to the former position during the second half-revolution. As the piston, is supposed to correspond to dead-centre, this oscillation will occur in a vertical direction. Simultaneously a horizontal to and fro motion, is imparted to another portion of the valve-gear, so similarly causing this portion to move from one extreme position into another extreme position, and to return to the former during the forementioned second half-revolution of the crank.

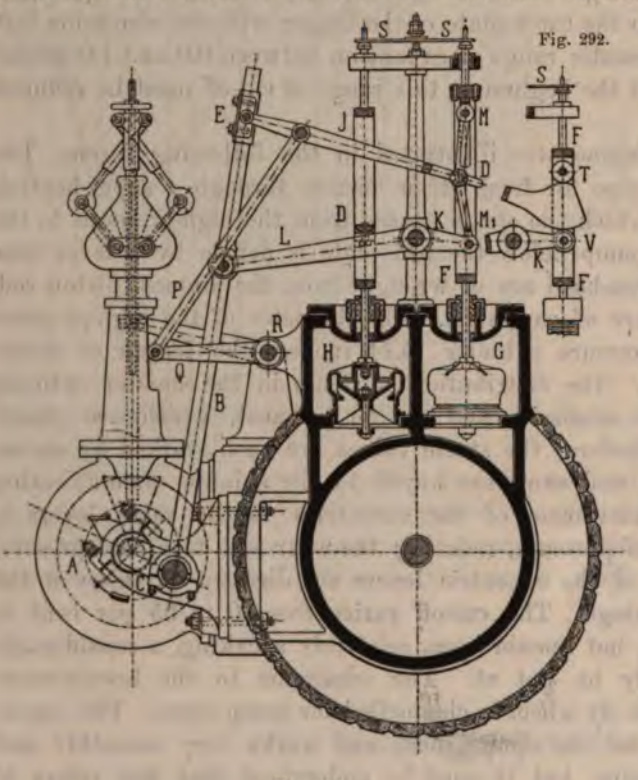


Fig. 292.

Fig. 293.

The rod B connected with the crank C is linked to a bent-lever LK, the one arm L of which, simply lifts and lowers the forked-spindle D of the exhaust valve H; the other arm K, on the other hand is utilised to produce the required motion of the inlet-valve spindle F. The upper end of the rod B carries a sliding sleeve E linked by rod J to the knee-lever MM_1. The position of the sliding sleeve E on the bar B is determined by a rod P which in its turn is linked to a lever Q keyed on the expansion-shaft R. The knee-lever MM_1 placed in the forked portion of the inlet-spindle F, has its bottom arm M_1 linked to the forementioned arm K of the bent-lever LK; its upper arm M carries a block, which can slide in two perpendicular grooves of the inlet-spindle prongs; this block when the valve is closed, slides down these grooves, and effects the free moving of the mechanism, even after this valve is closed.

The action of this mechanism, supposed in our drawing to be on the point of opening the inlet-valve, is as follows: The downward pull of the crank, stretches the knee-lever, so that the block lays itself against the top of the groove, whereby the arm M raises the inlet-spindle. Simultaneously the sleeve E begins its horizontal motion, by swinging towards the cylinder, so pressing the knee-lever through, on to the other side of the inlet-spindle. The combination of these two motions causes an earlier shut-off, than if the valve-spindle were only linked to the lever-arm K. This shut-off is the more accelerated, the more the sleeve E is pushed outwards, as then, the horizontal declension of the same is increased, which brings about an earlier sinking of the valve-spindle, and vice versa.

Our Fig. 293 shews a flat cam, which would produce an analogous motion to that of the knee-lever, if placed as represented, as a substitute for the knee-lever.

In consequence of this positive closing action of the inlet-valves, assisted as it is by blade-
's S, the dash-pot appendage is dispensed with. Though this simplification deserves attention,
st be borne in mind, that it is introduced at the cost of neglecting to require at the outset

Fig. 297.

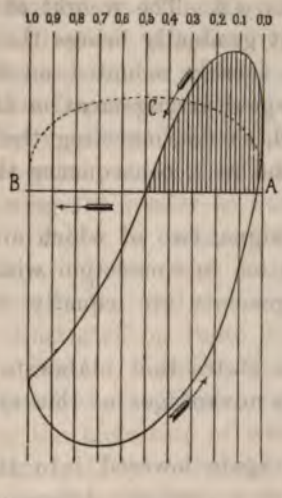


Fig. 296.

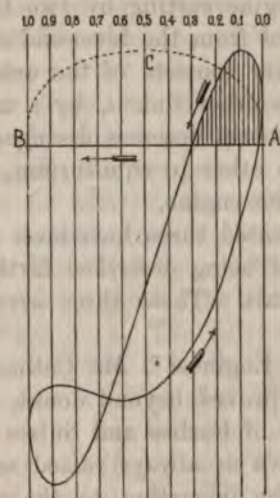


Fig. 295.

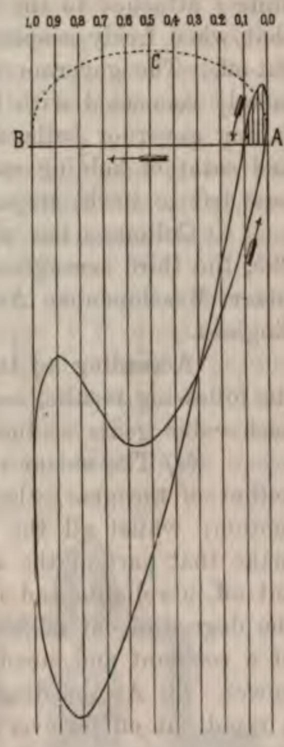


Fig. 294.

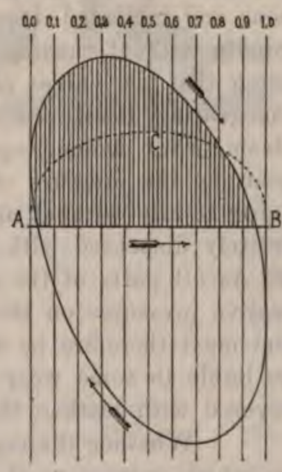


Fig. 298.

eedy a closing action as possible: This is clearly demonstrated
e valve-lift diagrams shewn in Figs. 294—298 in which, the
shewn above the horizontal line AB indicates the valve-lifts at
.3, and 0.8 stroke, whilst the lower curve represents the casual dis-
of the valve lifting catches. The diagram drawn in Fig. 298
ponds to the exhaust-valve lift, which remains constant for all ex-
on-grades.

In addition, the curve ACB has been added to all our dia-
s; it is supposed to represent the (ideal) valve-lifts, calculated for
an piston-speed of 6 ft. 6 in. (2 m.), under which all wire-drawing
e steam, would be prevented. Steam-throttling will, therefore, in
y commence and continue from the point, where the actual diagram-
, intersects the ideal curve.

The Engine driving the Austro Hungarian Section of the Paris
national Exhibition of 1878, was fitted with the Collman valve-gear,
sented in our Fig. 5 (Plate 55). In this arrangement, motion is
mitted from the horizontal lever, by the intervention of a counter-
on to the exhaust valves. The closing of the valves is secured by
hts.

The patented forms of the inlet and exhaust valves are respec-
illustrated by Figs. 7 and 6. They have been constructed with
w of preventing unequal expansion of the metal, which is often
ded with sticking fast or getting leaky. Cones do not alter their
s during expansion or contraction, whence we may conclude, that two cones rigidly connected
eir tips will remain quite coincident, in spite of unequal expansion and contraction taking place.
this principle, Collmann makes his double-seated valves with the connecting tip all concen-
d in one point of the axis. The cone surfaces are only shewn in punctuated lines in
6 and 7.

A safety-mechanism, for instantaneously stopping the engine in case of a break-down in the governor-gear, is shewn in Figs. 9 and 10. The expansion-shaft *a*, carries a lever *b* connected with a heavy cataract by the governor lever *c d*; the cataract piston *e* forms one piece with the slide *f* attached to the engine casting by two links *g h*. The weight of this cataract is so great, that when freely suspended from the lever-end *d*, it gradually brings the valve gear to a minimum cut-off. The governor lever consists of the arm *c* loosely mounted on the shaft *i*; this arm *c* is merely connected with the other link *d*, by a trip-gear arrangement *m* fitted in the slide *k*. With falling governor balls, the trip becomes disengaged, so disconnecting the two weights of governor and cataract holding each other in equilibrium, and as a consequence the weight of the cataract now left to itself, stops the engine.

Collmann has patented three knee-lever designs, two of which are shewn in Fig. 294 and 295, the third arrangement being described further on, in connection with the Engine of the Görlitzer Maschinenbau Anstalt. These three arrangements are equally well adapted, to Vertical Engines.

According to the Engineer*) Mr. Collmann states that elaborate experiments have given the following results, and proved beyond doubt, the advantages of this system, in comparison with such valve gears as those of Corliss and Sulzer: —

(1) The steam valve is always raised and again lowered into its closed position by the action of the gear, thereby imparting to the valve a perfectly determined, and therefore secure motion; whilst all the present gears, especially the Corliss type, drop the valve, and thereby make that part of the action which determines the value of the engine, namely, the certainty of cut off, unreliable and insecure. (2) The experiments have shown that the governor determines the degree of cut off between $^1/_{80}$ to $^8/_{10}$ of stroke with the utmost facility, keeping the engine at a constant and steady speed, however much the resistance may vary within the limits of its power. (3) As the diagrams show, the engine, working at sixty-six revolutions per minute, has a rapid cut off for every degree of expansion, any wire-drawing of steam being prevented. (4) The diagrams promise the same economy of fuel as the experiments have proved really to take place; the consumption of steam being, when a good boiler is used, from 19 lb. to 22 lb. of steam per hour and indicated horse-power. (5) The engines can be worked up to 100 revolutions**) per minute without causing any noise, thereby ensuring the utmost durability of the valve; the reason being that the valves of the Collmann engine are closed by constant and unchangeable action of the gearing itself, the speed of closing being sufficiently great to prevent wire-drawing of the steam, while hammering is prevented. Variable frictional resistances are overcome in this new gear, by the pressure of a flat spring as shown, the amount of pressure caused by this spring being totally without any influence on the closing speed of the steam valves, and dash pots are entirely dispensed with; the exhaust valves are worked by cams, and no springs are made use of. (6) As all parts of the engine are purposely made very strong, so as to avoid vibration and excessive pressures on the wearing surfaces, all ratchets or parts that are liable to wear and tear and must therefore be frequently replaced, are omitted, and the only buffer surfaces that would be liable to some wear are made so large — 5 in. in the present case — that, although they are covered with leather, they will wear for any length of time.

Whether the engine is really much superior to that made by Sulzer or Corliss is a matter on which opinions will differ. It is at least certain that Mr. Collmann has produced a valve-gear which should be noiseless and which is capable of giving a nearly perfect diagram.

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*) d. 1st March 1878, pg. 144.

**) According to "Engineering" Collmann is making Engines for a much greater speed (135—150 revs. per min) with the steam valves actuated in the same fashion as the exhaust valves of the Görlitz type, but automatically attached to the governor.

b. Schweizerische Locomotiv- und Maschinenfabrik, Winterthur (Switzerland).

(Type: Ch. Brown.)

We have before us, several lift-valve gears, designed by Mr. Charles Brown, Manager of the Schweizerische Locomotiv- and Machinen-Fabrik of Winterthur. The primary object sought in these designs, was the practical adaptability of lift-valves to high piston-speeds. The inlet-valves are arranged on the top of the cylinder, whereas the exhaust valves are placed below. A constant motion is of course imparted to the latter from an independent mechanism, whilst the inlet valves are worked by a patented mechanism placed under governor control.

The external valve-gear has not been changed, and for reasons already stated*), we will content ourselves by allowing the reader to notice for himself, the various improvements or simplifications consecutively brought to bear on the construction of the inlet-valves, such as they present themselves on comparing the older designs illustrated by our Figs. 299 and 300, with the admission-valve form shewn in Fig. 301. Corresponding hereto, the external valve-gear, patented along with this valve, is illustrated on Plate 56, Figs. 3 – 6. The valve-proper *V V* is cast in one with the small hollow cylinder *U U* fixed to the valve-spindle *z* by *m*. The lower extended portion of *U U* works over a piston *k* cast with the valve-seat *d*. The axis of the piston *k*, is furnished with a small steel valve *e*, the underside of which, is in free communication with the boiler-steam owing to the radial openings *i*. If the valve-spindle *z* and the cylinder *U U* are raised, steam opens the valve *e* and fills the resulting empty cavity of the cylinder *U U*. But as soon as the valve

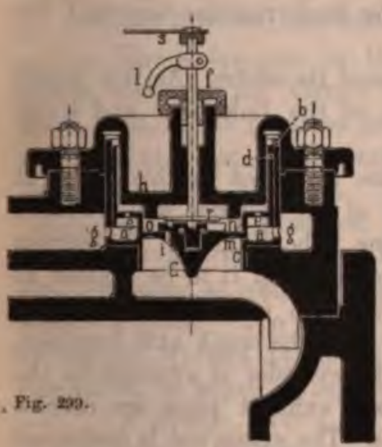


Fig. 299.

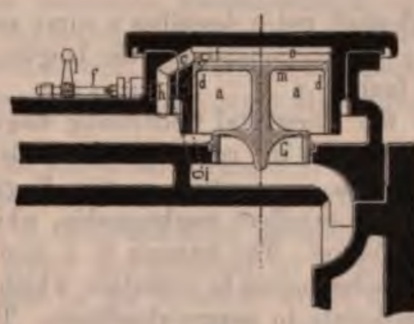


Fig. 300.

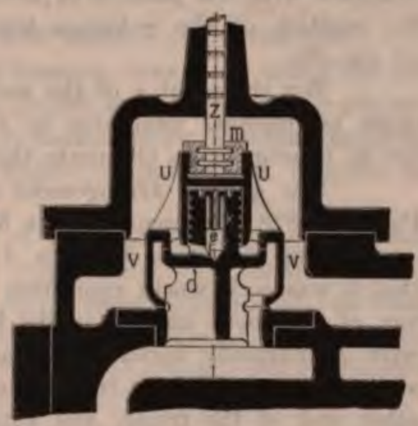


Fig. 301.

V V returns or drops, the valve *e* closes, when the trapped steam would prevent the drop of the valve, if it were not for the small axial passage, in the valve *e*, through which, the imprisomed steam can gradually make its escape. This axial passage is suitably dimensioned to effect a noiseless steam cushioning of the valve against its seat. The valve-spindle *z*, fits loosely in *m* and is grooved circumferentially these grooves become filled with condensed steam, which with the aid of a slight cotton packing, forms a good steam-tight joint with very slight wear. At the other extremity of the valve-spindle — vide Fig. 3, Plate 56 — a number of small steel-plates *s s* are placed, which are carried on two small pillars *f f*, and connected with the adjustable ring *o*. The latter is gripped by the forked end of a lever *b* receiving its motion by the rocking lever *a* and steer-shaft *p*. The lifting of the forked lever *b*, corresponds to a lifting of the valve *V* whereby the spring appendage softens the working of the valves and of their gear.

Variable cut-off, depending on the extent of the oscillations of the forked lever *b* or *a*, is obtained by a lever-combination, subjected to the governor. During one revolution of the crank,

*) see page 213.

the point o of the connecting rod, describes an elliptical curve. A guide rod R, connected at one end to the oscillating lever S and at its other extremity to the centre O has the rocking lever P attached at about its middle point Q; consequently it imparts a rise and fall motion to the lever P in addition to a rocking movement. Whilst the point Q describes the flat elliptic curve $Q\,Q_1\;Q_2\;Q_3$, the other extremity n of the lever P travels equi-distances off the axis $u\;u_1\;u_2$. A lever-union — or perhaps better a "parallel motion" — swinging on the double-lever $u\;u_1\;u_2$, controls the travel of this point n. According as the lever $u\;u_1\;u_2$ is brought into different positions by the governor influence, this point n travels parallel or inclined to the governor axis; the former corresponds to early, the latter to later cut-offs.

The weigh-shaft p is connected to the rocking lever P at centre r. Consequently the latter will describe approximate ellipses, simultaneously shifting the weigh-shaft p to the extent of the horizontal axes of these curves. As this axis is the minor (conjugate) axis of the ellipse, it follows that the point r will have the least travel, when the major axis is perpendicular — vide Fig. 5. — The inclined position of the latter, corresponding to the low declension of the governor, will necessarily augment the travel of the point r, and its maximum travel is drawn in Fig. 4, whereas the mean position of the governor balls would correspond to our Fig. 3. Therefore, according as these minor axes become smaller or larger under the action of the governor, so accordingly, the valves remain open during a shorter or a longer portion of the piston-stroke, and thus, variable expansion is obtained. It should be also stated, that the point n of the rocking lever P, always coincides with the point w of the axis, when the crank is passing its dead-centres, no matter what the position of the governor lever may be at the time; hence, the lead remains constant for all cut-offs.

But the point r of the weigh-shaft rod p describes a curve round its centre. As this would cause an unequal admission to the two cylinder-ends, the lengths of the links $u_1\,x$ and $n\,x\,u_2$ are so chosen, as to eliminate this fault.

The general arrangement of the Horizontal Condensing Engine exhibited by this Firm at Paris in 1878 is shewn on Plate 56, whereas the constructive details of its cylinder will be seen on referring to Plate 35 Figs. 1—3. In commenting on this Engine "The Engineer" *) observes that it was well worth inspection for its excellent workmanship, which entitled it to be ranked as one of the best engines in the Exhibition. The framing is a modification of the Corliss frame, with cylindrically bored cross-head guides bolted to pedestals, which form the crank axle bearings, and are connected by a transverse bed-plate to ensure steadiness. The cylinder is attached to the other end of the frame, and supported by a pedestal. The feed and exhaust pipes are carried underneath the cylinder, so that the latter can be got at from all sides. The piston rod is continued through the cylinder cover, and serves, by means of a neat arrangement of guide-bar supported on a column, to relieve the weight of the piston and to work the air-pumps. The connection between these and the guides, as will be seen from the drawing, is very simple.

The crank consists of two cast-iron discs with pressed crank pin and counterweights. The cylinder is fitted with a steam jacket, through which the steam must pass before it reaches the valves. The stop valve is placed in the middle of the cylinder's length, and is worked by a lever handle, which it is claimed can be manipulated more easily than the usual hand-wheel. The two steam-valves are placed one at either end of the cylinder, on the top, in the same straight line as the stop valve. The exhaust valves, which act at the same time to get rid of condensed water, are placed on the underside of the cylinder. All the valves are equilibriated and double-seated, with dead level surfaces. Steam can be cut off at any point from 5 per cent. up to 70 per cent. of the stroke. The contact apparatus for lifting and lowering the valves differs from the ordinary valve gear in regulating the action of closing the valves independently of springs and air dash pots, and the surfaces being directly brought together, there is no sliding motion and no friction;

*) d. 24 May 1878, pg. 364.

the contact discs being provided with leather washers, the action of the valves is nearly noiseless. Instead of the usual dash pot, a steam buffer is used, the upper part of the valve forming a hollow piston, and fitting on the solid piston of the valve seat. The connection of the spindle with the valve, is effected by means of rings held in their place by a split nut; this arrangement is very solid, and prevents the spindle from getting loose, at the same time allowing the valve to turn on its seat and keeping the surfaces uniformly worn.

The valve spindle works in a long spindle case, so that the stuffing-box is so far removed from the cylinder, that it is always kept comparatively cool, and as drops of condensed steam only, — but never steam, — escape, the stuffing-box seldom requires tightening up, and the danger of fixing the spindle or of quickly wearing it away in the usual neck-shaped attenuation in the length of the stuffing-box is avoided.

The exhaust valves are worked from an excentric and lifted by means of radial cams, which impart a quick but silent motion. The engine, nominally 100-horse power, is capable of working up to 160-horse power, makes 120 revolutions per minute, and works so silently and steadily that there is no doubt that the speed might easily be increased. The leading dimensions will be seen from the drawings.*)

II. Valve-gears, arranged with Trip-motions.

A. Valves, fitted to the side of the cylinder.

a. Sächsische Maschinenfabrik, — Formerly Richard Hartmann — of Chemnitz.

The Valve-gear of the Sächsische Maschinenfabrik of Chemnitz, was first introduced to public notice by the Vienna Exhibition of 1873, where it was attached to a 100 *HP* Mill-engine. Since then, it has rendered good service, and has also been found to answer well on Winding-Engines.

Our Plate 57 illustrates an 80 horse-power Horizontal-Engine of this kind, adapted to ordinary driving purposes.

As will be observed, the valves are arranged at the side of the cylinder, exactly over each other with the inlet-valve above the exhaust-valve. They are both driven by a horizontal lay-shaft, running at equal speed as the crank-shaft, though driven by an intermediate shaft, running twice as quick. The latter drives the governor by bevel gear at a high speed. The exhaust-valves are worked by two cams on the lay-shaft, whilst the admission-valves are geared off two eccentrics, so keyed in relation to the crank as to admit of later cut-offs.

A double lever $L L_1$ (Fig. 5), is connected to the eccentric rod, and articulates on a centre of the vertical bracket cast with the valve-chest cover. The arm L of this lever, plays in a slot of the valve-spindle; this slot has a transverse steel catch-bar o let through it, on to which the taker-up n — owing to the small spiral spring s — may trip, when the arm L is in its lowest position, corresponding to the valve being closed. The rising motion of the taker-up n, lifts the valve-spindle F. The taker-up has an horizontal arm N, which participating in this rising motion strikes at some time or other, against the cam M which is placed under governor control; but as the swing-centre of the taker-up still continues to rise, the pressure of the cam forces the taker-up out of gear, and the valve-spindle then rapidly falls again, owing to the spring-pressure acting on its top end.

The cam M is keyed on an expansion-shaft, which is supported on the two vertical brackets, and which oscillates according to the governor vacillations. In the mean position of the governor-balls, the cam may come to lie vertically on the expansion-shaft, as shewn in our Fig. 5, and it is so formed to ensure its coming into contact during different piston positions.

*) "Engineering" in its issue d. 23 Jan. 1880 pg. 75 illustrated a Brown's Engine of smaller size working with the Rider system of valve, in which the change in the cut-off is effected by the turning of the expansion valve upon or rather inside the back of the other.

The exhaust-valves are worked by a double-lever actuated by a vertical rod, the upper end of which carries a small roller, which is always kept by spring-pressure, in rolling contact with the surface of a cam keyed on the lay-shaft. By arranging the valves at the side of the cylinder the clearance-space has been enlarged, though the latter is again reduced by the addition of a cast-iron block. Cast-iron valve-seatings appear to be used, the design of the inlet-valve seating allowing it to expand freely.

The 80 horse-power Condensing Engine herewith illustrated has a cylinder-diameter of $23^5/_8$" (600 mm.) and a stroke of 3 ft. $11^1/_4$" (1200 mm.). The crank-revolutions number 42 per min., thus throwing off a mean piston-speed of 5 ft. 6 in. (1.68 m.) per sec. The steam, entering at the bottom part of the jacket, circulates over the whole length of the inserted liner, and passing into the shut-off valve placed between the main-valves, it then enters into the valve chests. The cross-areas of the steam-supply pipe and of the condenser-pipe stand in the proportion of $^1/_{18}$th and $^1/_{14}$th to that of the piston-surface, their diameters being respectively $5^1/_2$ in. (140 mm.) and $6^1/_4$ in. (160 mm.).

The cylinder and crank-shaft-bearings rest on separate beds. The piston-rod is prolonged through both cylinder-covers, and is $3^1/_2$ in. (90 mm.) diam. in front, and $3^1/_8$ in. (80 mm.) diameter behind the piston. The slide-block is 4 in. wide $\times$ $5^1/_2$ in. (100 $\times$ 140 mm.) long, and is attached to the forked end of a connecting-rod made five-times the crank-length. The crank-pin is prolonged ($6^1/_8$" long $\times$ 5 in. diam. = 156 $\times$ 126 mm.) so as to drive the horizontal double acting pump, arranged under the floor-line. The pump has a diameter of $13^3/_8$ in. (340 mm.) and a stroke of $21^5/_8$" (550 mm.); consequently, capacity of air pump: capacity of cylinder = 1 : 6.8.

The crank-shaft, 10 in. (250 mm.) diam. is reduced to $9^1/_2$ in. (240 mm.) where the crank fits on; its bearings are $16^1/_2$ in. (420 mm.) wide and they are set resting on separate foundations, at 7 ft. (2134 mm.) apart, from centre to centre. Exactly midway between these bearings, the toothed fly-wheel is mounted on the crank shaft, here augmented to $11^5/_8$ in. (295 mm.) diam. Its six arms are bolted to the wheel-boss, and the external diam. of this fly-wheel is stated to be 16 ft. 10 in. (5130 mm.). The Porter governor, with crossed arms is run at 110 revs. per min.

b. Société Anonyme de Marcinelle & Couillet of Belgium.

The Société Anonyme de Marcinelle & Couillet, was represented at the Paris International Exhibition of 1878, by a Blowing-engine for Mine-ventilating purposes, which was driven by an automatic variable expansion Lift-valve gear. Before proceeding to describe the peculiar semi-automatic regulating action of this Engine, or to discuss the pneumatic regulator, we may conveniently explain the lift-valve gear, by the aid of Fig. 304.

Two valve-chests are fitted to the side of the cylinder, one of which our wood-cuts shews in section, so as to elucidate the arrangement between the admission-valve G and the exhaust-valve H A portion of the external gear, bears great similarity to the original Corliss-valve gear, inasmuch as the eccentric B causes the wrist-plate A to oscillate round its centre z placed between the four-valves, somewhat over the cylinder centre-line. To this wrist-plate, four rods $E E_1$ are linked, each of which is connected with one of the valves. The exhaust-valve H is worked direct and uniformly through the bell-crank $K K_1$ off the rod E_1. The inlet-valve G on the contrary, can only be considered rigidly attached (by trip-gear) to the rod E during its lift. This connection becomes severed when the desired degree of expansion is attained, and the valve is then forced back on its seating, through the usual spring-pressure. For this purpose, two levers are keyed fast on the short spindle J; one of these levers L is articulated by the rod E, whilst the other L_1 is furnished with a steel catch-plate. When the latter is in its lowest position, the steel nib n of the bell-crank $N N_1$ suspended in a slot of the valve-spindle F, comes to lie over the catch-plate o of the lever L_1 owing to the pressure of the flat spring s. Consequently the ascending motion of the rod E lifts the valve G, till the other arm N_1 of the bell-crank, strikes against a projection r placed under governor-control; the arm N_1 being thus prevented from continuing to rise, causes the trip-gear $n\,o$ to become disengaged. At this moment, the valve is closed, whereby concussion is prevented through the air-buffer o.

The projection r is attached to a cranked-lever $R\,R_1$ mounted loosely on the spindle J. To effect variable expansions, the other arm R_1 (which could also be connected to an ordinary ball-governor) of this lever, is attached to a vertical rod M, the lower extremity of which rests on a step-block Q — shewn enlarged in Fig. 303. It is evident, that all that is required in order to vary the work or the speed of the Engine, is to change the relative position of the rod M; in the arrangement before us, the resting of the rod M on a lower step is made to correspond to a later cut-off and vice versa.

Fig. 303.

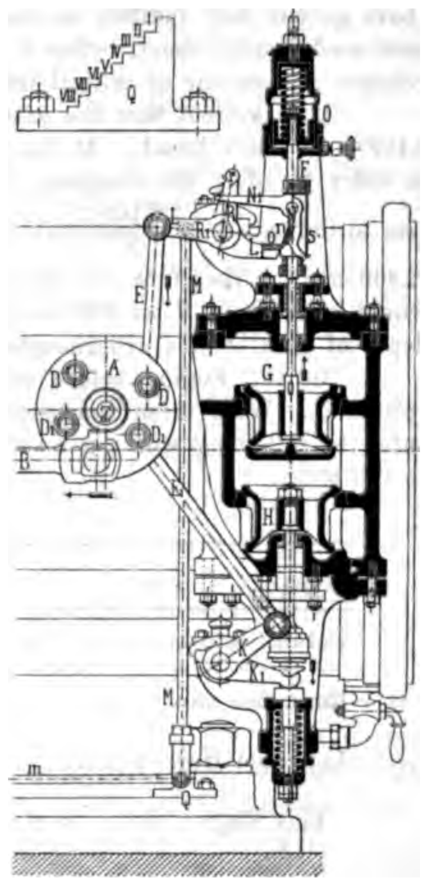


Fig. 302.

The principle of the pneumatic regulator designed by Timmermann is based on the following phenomena. Practical observations have conclusively proved that the main cause of fire-damp explosions are due to a rapid sinking of the atmospheric pressure. For, with low atmospheric pressures, the highly explosive gases given off from the workings, expand in volume very rapidly, and blow with all the more speed through the galleries or workings, the lower the air-pressure is. A quick elimination of these noxious gases can therefore only be attained by increasing the volume of artificial air, obtained from the speed at which the ventilating fan is driven. Hence, the idea to use a pneumatic regulator, which should control or rather increase the speed of the Main-engine when the atmospheric pressure in the workings was on the decrease, must be allowed to be exceedingly ingenious. Such is Timmermann's idea, though it has been found advisable, not to allow this contrivance to regulate the Engine automatically when atmospheric pressure is rising, but to reduce the engine working speed by hand to its normal rate.

The practical construction of this idea is shewn in Figs. 4—7, Plate 53. The rods $M\,M$ of our Fig. 302, are actuated by the regulator lever f — see Fig. 6 — through the connecting-rod m, but owing to the ratchet-gear k — vide Fig. 4 — only in one direction. As soon as the pressure of the air diminishes, the rod m is pulled forward, causing the ends of the rods M to fall a step lower on the forementioned step-block Q. But if the pressure of the air increases, the lever f is *not* able to lift the rod-ends on to a step higher, but the ratchets shewn in Fig. 7 of our Plate 53 then slip over the grooves of the rod m, without shifting the latter. As soon as the normal atmospheric pressure has been restored, the engine-tenter lifts up the rods $M\,M$ by unloosening the ratchet gear k, and sets the engine to work at the desired cut-off.

Timmermann's Pneumatic Regulator as shewn by Fig. 6, consists of a closed casing a communicating through pipe b, with the mercury trough c. The latter carries a float d, which transmits its rise or fall to the crank-lever $f_1\,f$. The distance between the lower casting and the casing a may be adjusted by the three rods g, and the whole top part of the apparatus is enclosed by an ornamental casting furnished with indicating dial h. If the atmospheric pressure falls, then the mercury flows out of the casing a into the trough c, so raising the float d, which in its turn lifts the arm f_1; in this manner the end of f is drawn over to the left, and the two clips or ratchets, accordingly move the rod m, so bringing the ends of M on a step lower; this as before stated causes a later cut-off or more steam-power to the cylinder-piston, hence increased speed. The pressure of the atmosphere may be read off the forementioned dial at any time, and an electric bell-sounding apparatus is moreover attached, which raises an alarm when the atmospheric pressure causes the mercury-column to drop $^3/_{16}$ in. (5 mm.). Though this pneumatic-regulator certainly becomes an effective tell-tale, as regards the barometric state of the atmosphere above ground, still in the opinion of the writer of these lines, it stops short of all that is required, inasmuch as it takes no note whatever of the atmospheric state in the workings, which at a moments notice may become highly saturated with fire-damp, whilst simultaneously the barometer above ground may indicate no reason for fear. In this direction therefore, this pneumatic regulator needs improvement, before it becomes a perfect safeguard in automatically supplying increased volumes of pure air at critical times*).

It is evident that the extent of cut-offs, is limited to the number of steps, which are each 0.169″ (4.3 mm.) broad. As the arms of the regulator-lever $f\,f_1$ are in the proportion of 1 : 3, in order to effect the dropping of the rod M from step to step, the float d must consequently rise to the extent of $\frac{0.169}{3} = 0.056$ in., which corresponds to a barometric pressure drop of 0.113 in. (2.866 mm.). Therefore as there are altogether seven steps the barometric pressure reduction would be $0.113 \times 7 = 0.79$ in. (20 mm.) between the earliest and latest automatic cut-off. The depth of each step is experimentally ascertained for each case.

In the Engine before us, the cylinder-diam. is $24^1/_2$ in. (620 mm.) its stroke $33^1/_2$ in. (850 mm.). With these dimensions, and with the Engine working at 45 lbs. (3 atm.) boiler pressure, the following working results were given off for the different expansion grades corresponding to the steps:

Steps.	I	II	III	IV	V	VI	VII
Cut-off: (stroke)	0.165	0.175	0.20	0.24	0.27	0.31	0.37
Revs. per min.	40	44	48	52	56	61	68
Indicated Horse-power .	36	43.5	56.5	71.8	89.7	110	147

This Engine drives a Guibal fan of 39 ft. (12 m.) diam. and 4 ft. 11 in. (2.5 m.) wide.

*) At a meeting of the Glasgow Philosophical Society, held on 21 January 1880, Professor George Forbes exhibited and gave a brief account of a new fire-damp indicator which he has invented. Professor Forbes said it occurred to him that the principle of acoustics might be applied to measure very accurately the quantity of fire-damp mixed with air in a mine. The agent employed was an ordinary tuning fork. When brought into the neighbourhood of a tube of a certain length full of air, the air responded to the noise of the tuning fork only when the tube was of a certain length. If they had an atmosphere in which fire-damp, which was about half as light as common air, was mixed up, the velocity of the sound would be greater than in common air, and therefore the length of the tube would be greater; so that by means of an index on the tube they could measure the quantity of fire-damp in the air to within about one half per cent. Messrs. Merry and Cunninghame, Colliery proprietors, have already employed the instrument, and they feel satisfied it will lead to good results.

c. Messrs. Pusey, Jones & Co. of New-York.

(Type: John Baird.)

If we bring to mind the Marine-Engine constructed by Messrs. R. W. Peek & Co. of New-York, which was discussed by us on pg. 51, and compare the same with Plate 43 shewing the Machinery of the steamer Hudson (Cromwell Line) designed by John Baird and constructed by Messrs. Pusey, Jones & Co. of New-York, we must come to the conclusion that the Americans are applying Variable expansion-gears to their Marine-engines.

This valve-gear also works with fixed expansions not controlled by the governor, but by hand, though in other respects it fulfills the conditions of an expansion-gear.

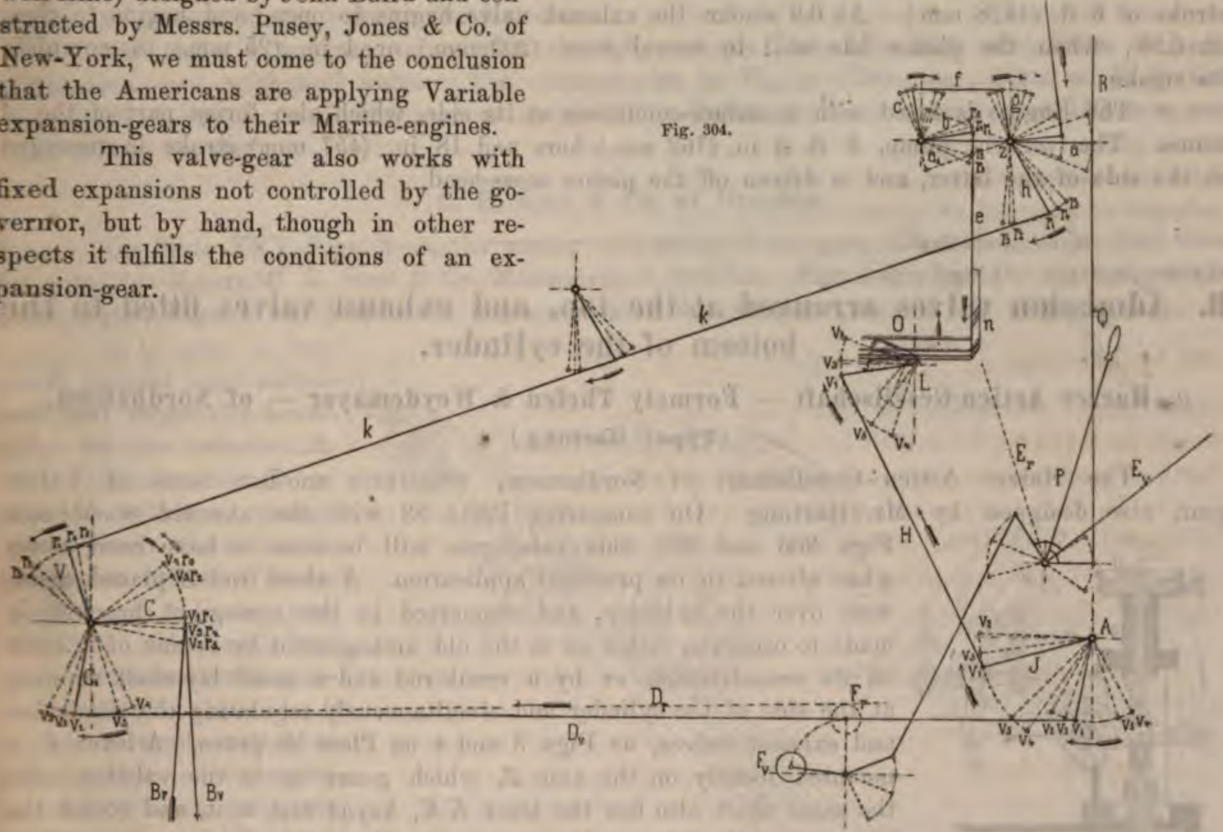


Fig. 304.

Fig. 305.

The Engine, of the "overhead system" has the crank-shaft running under the cylinder; two eccentrics are mounted on this crank-shaft, of which only one, according to the forward or backward motion of the Engines drives the four valves. The principle of the Valve-gear is graphically represented in our woodcuts Figs. 304 and 305. Here v_1 is the forward-motion eccentric, r_1 being the reversing-eccentric. Both eccentric-rods Bv and Br, run up the side of the Engine-frame, and cause the lay-shaft A to oscillate. The hand lever Ev and the lever $Fv\ Fr$, necessitate either one or both of the rods $Dv\ Dr$ to be disengaged; the last named arrangement is shewn in Fig. 1, which further correponds to the Engine being at rest. On the other hand, in Fig. 304, the rod Dv is engaged, consequently the engine is moving forwards. In the middle of the lay-shaft A, the balanced lever J is mounted, one end of which, communicates by the short link H with the lower valves which are alone noticed in our Fig. 304. The form of trip-cams used is shewn in Fig. 17 (Plate 43) and the details of the trip-gear in connection with the inlet-valves are represented in Figs. 6—10.

Referring to Fig. 17, also giving the different positions of the cams during various stroke portions, position IV indicates the mean position of the gear, when the exhaust-valve has already lifted to the extent of $^1/_8$" (3 mm.). The admission valve opens at VI, whilst simultaneously the opposite exhaust valve at position II has already lifted to the extent of $1^3/_{16}$ in. (30 mm.). Both attain at I their highest position, the lift of the former corresponding to $1^7/_8$" (48 mm.) that of the latter being $2^3/_4$ in. (70 mm.). As the eccentric is keyed at a lead-angle of 24°, at position VII (corresponding to the limit of variable expansion), the piston has travelled over 0.34 of its stroke of 6 ft. (1828 mm.). At 0.9 stroke the exhaust valve begins to open, and begins to close at 0.98, when the piston has still to travel 8 in. (203 mm.) or 1 in. (25 mm.) to complete its stroke.

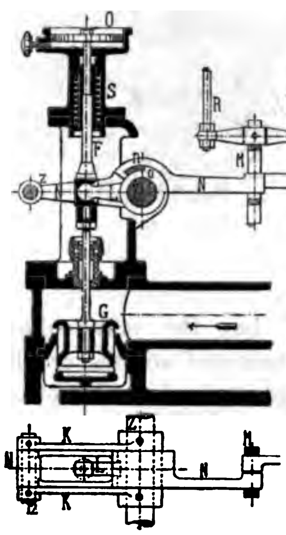
The Engine is fitted with a surface-condenser at its side, which also forms part of the *A* frame. The vertical pump, 2 ft. 6 in. (762 mm.) bore and 18 in. (457 mm.) stroke is arranged at the side of the latter, and is driven off the piston cross-head.

B. Admission valves arranged at the top, and exhaust valves fitted to the bottom of the cylinder.

a. Harzer Actien-Gesellschaft — Formely Thelen & Weydemayer — of Nordhausen.

(Type: Hartung.)

The Harzer Actien-Gesellschaft of Nordhausen, constructs another form of Valve-gear, also designed by Mr. Hartung. On comparing Plate 58 with the annexed wood-cuts Figs. 306 and 307, this valve-gear will be seen to have been somewhat altered in its practical application. A short rod *Z* placed crosswise over the cylinder, and supported in the spring-pot bracket, is made to oscillate, either as in the old arrangement by means of a lever off its eccentric-rod, or by a crank-rod and a small lay-shaft running at the side of the cylinder and simultaneously regulating the admission and exhaust valves, as Figs. 3 and 4 on Plate 58 prove. A lever *L* is mounted loosely on the axle *Z*, which gears on to the valve-spindle, the same shaft also has the lever KK_1 keyed fast to it, and round the lever-eye *z*, the trigger *N* can swivel. The latter carries a projection *n* or a steel-plate, which with each oscillation of the shaft *Z* gears into a corresponding catch *o* of the lever *L*. Consequently with the upward rise of the lever KK_1, the loose fitting lever *L* is taken up by the trigger *N*, and steam-admission begins. Simultaneously the prolongation of the trigger *N* moves downwards, and as it fits in a slot of a rod *M* under governor control, it is stopped in its motion sooner or later according to the governor position, whereas the supported end of the trigger continues its upward motion. The trip-gear *n*, *o*, becomes disengaged, so liberating the lever *L* when the valve is pressed upon its seating through the spring *S*



Figs. 306 and 307.

With increase of speed, the slot in the bar *M* is raised, causing disengagement of the trip-gear to ensue all the sooner, an earlier cut-off takes place, resulting in uniformity of the engine-speed. As already observed, in the valve-gear arrangement shewn on our Plate 58, the exhaust-valves are also worked off the small steer-crank. The exhaust valve-lever has sufficient play in the slot of the valve-spindle, as to allow one lever to do no work whilst the other is lifting the spindle and vice versa. As the stroke-directions of the two crank-rods are perpendicular to each other, a range of expansion between 0.0 and 0.9 stroke is obtained with only one eccentric rod. For, if the exhaust-valve-gear is in its middle position, the mechanism of the admission-valve is in its extreme position. With regards to the different positions taken up by the trip-gear, these are delineated in Fig 6, Plate 58.

The Engine shews a few departures from ordinary practice. Thus the cylinder, 2 ft. 4 in. (710 mm.) bore and 4 ft. (1240 mm.) stroke, rests on two ∩ formed bed-plates, connected together and extending to the end of the slide-bars, so also forming a support for the trunk-frame. This arrangement, makes the engine appear very high, as the machine's centre-line is thereby considerably raised (39 in. = 1000 mm.) above the floor-line.

The steam enters the valve-chest, through a supply pipe, 7 in. (180 mm.) diam. or $^1/_{18}$th piston-area, and a shut-off valve. The exhaust-pipe is $7^7/_8$ in. (200 mm.) bore, or $^1/_{12}$th the piston-area. Fig. 4 shews the manner in which the Porter governor is driven, at 120 revs. per min. off the lay-shaft.

b. C. E. Rost & Co. of Dresden.

On Plate XXV Figs. 3—5, the reader will find a Valve-gear illustrated, which has been patented by Messrs. C. E. Rost & Co. Machinists of Dresden. Fig. 3 displays the disengagement-gear, whilst Figs. 4 and 5 shew the arrangement of the cylinder.

A is again a lay-shaft, parallel to the piston-rod and driven by bevel-gear off the crank-shaft. The exhaust-valves *H* are worked by cams, though an eccentric *C* drives the admission valves. The eccentric rods *BB* each consist of two rail-pieces, which slide on the valve motion-rod *E* and in the slide *D* which is firmly bolted to the motion-rod; simultaneously these eccentric rods *BB* move up and down with the rod *E*. The rails carry the pin *b* as centre to the bell-crank *M N*; the arm *N* of this lever plays between the rails *B B*, the spring *S* pressing the arm against the slide *D*. Our Fig. 3 is drawn representing the eccentric in an extreme position. If the shaft *A* be now supposed to revolve in the direction indicated by the arrow, then a steel-edge *n* of the arm *N* will gear on to the steel plate *o* of the slide *D*, so pulling the latter down and consequently opening the valve.

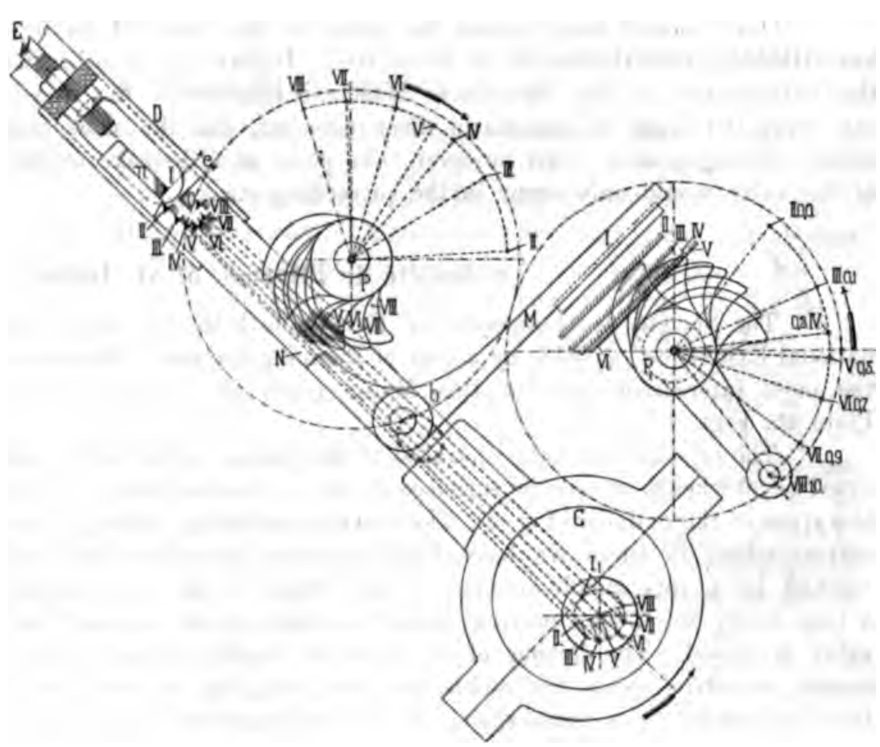


Fig. 308.

An ingenious arrangement admits of the wide range of 0.0—1.0 stroke being obtained for the cut-off, though the valve-opening takes place whilst the eccentric is moving at its quickest. This arrangement consists of the following mechanism: Two cam spindles $r\,r_1$ are fitted with two equal toothed-segments $Z Z_1$ in addition to the two steel-cams $p\,p_1$ intended for working each inlet-valve. The spindle r_1 also carries a lever *R*, which is forced by a connecting link to take part in the motion of the governor-collar. The slide D is geared so long by the trip-lever N, till it becomes disengaged by either one of the steel-cams p or p_1; in the position, corresponding to our Fig. 3 this would only take place after the completion of the stroke. The working action of this mechanism will be understood from the geometrical relation shewn in Fig. 308. During the moving of the eccentric from position I up to nearly II, the steel-catch n works without effect $= e$. Position II coincides with the crank on its dead-centre, and the valve will consequently begin to open. During the time the piston attains $^1/_{20}$th of its stroke-travel, the eccentric B continues to move away from the cam P; from 0.05 to 0.1 stroke corresponding with position III, the eccentric approaches very-slightly; hence the work attending disengagement is divided amongst two levers N and M standing at right angles to each other, so ensuring a uniform action of this mechanism. The simple lines, marked II—V, in Fig. 308, indicate the positions of the lever M at disengagement-moments between 0.0 and 0.5 stroke. In order to increase certainty of action, the lever N already comes into play during the last named limits, inasmuch as it is released from the cam P between 0.4 and 1.0 stroke. The mechanism has also been represented in light lines in positions V—VIII corresponding to 0.5—1.0 stroke.

By giving different forms to the four cams working the two admission-valves, equal grades of expansion can be easily secured for the two cylinder ends.

Our woodcut also enables the extent of the valve-lift to be easily calculated. The valve has attained its maximum lift at about 0.65. Differing from other valve-gears, though similar to the Valve-motion of the "Märkische Maschinenbauanstalt" the maximum valve-lift does not coincide with the limit of automatic disengagement, but the same may be extended to nearly full-stroke; disengagement must however take place at full-stroke at the latest, otherwise the closing of the valve would only occur in the succeeding stroke.

c. Société de l'Horme, of St. Julien.

The Société des Fonderies et Forges de L'Horme, were represented at the Paris International Exhibition of 1878, by a pair of Pumping-Engines. We content ourselves with illustrating the most interesting part of this Motor (such as it presented itself in the Valve-gear) on Plate 48, Figs. 1—8.

The lay-shaft is carried parallel to the piston, and is driven off the crank-shaft by a pair of equal bevel-wheels, as will be surmised from the cross-section of the cylinder (Fig. 1) and the semi-elevation of the cylinder (Fig. 2). The steam-distributing organs, consist of four equilibrium valves; corresponding to these we have four eccentrics keyed on the lay-shaft. The exhaust-valve is worked in a very simple manner — vide Fig. 6 — by eccentric shewn behind in Fig. 1 and by a bent lever, the latter moving freely in a slot of the exhaust-valve spindle, when the exhaust valve is closed. The closing of the valve, is ensured by spring pressure in the usual way. The second eccentric opens the admission-valve (Fig. 5), whereas the instantaneous closing of the latter is secured by a spiral-spring placed under control of the governor, a disengagement or trip gear — shewn in Figs. 7—8 — contributing hereto. A vertical pillar T is screwed to the side of the cylinder, and it carries two spindles. The longest spindle (w) of the two, runs along the cylinder, and has the lever R keyed on it; this lever communicates with the governor. The shortest spindle carries a loose lever KK_1, one arm of which K_1 is rigidly connected — vide Fig. 1 — with the valve-lever, through a connecting-link. The other arm K is of segment-form with a steel-catch o; a trigger n is forced into gear with the latter by a spring S as shewn in Fig. 7, and this trigger is centred on a lever LL receiving a rocking motion from the eccentric-rod.

The position of Fig. 7 would result when the corresponding eccentric was at its extreme point; consequently the lever K_1 would be made to articulate, owing to the trigger gearing on to it, and the valve would thus be opened. During this oscillation, the bent horn N of the trigger-lever strikes at some time or other (corresponding to the cut-off) against the cam r which is under governor-control, and is keyed on the upper spindle of the pillar T. Disengagement of the trigger-gear ensues, and instantaneous closing of the valve takes place. As the inlet and exhaust-valves have each their separate eccentrics, the admission eccentric may be keyed under any angle to the crank; it is however advisable to allow its mean position to coincide nearly with the dead-centre of the crank, in order to obtain a rapid lift of the valve. But, as contact between the horn r and trigger lever N only takes place in one direction, the limit at which automatic disengagement can ensue, is thereby reduced to between 0.0 and 0.43 stroke. If the governor has not then effected disengagement, the admission of steam continues to 0.82 stroke. The valves lift to the extent of $^1/_2$ in. (15 mm.) with a normal expansion rate of 0.15, and the steam attains a velocity of 82 ft. (25 m.) per sec.

The construction of the cylinder, shews a diameter of $15^3/_4$ in. (400 mm.) and a stroke of $31^1/_2$ in. (800 mm.). Jacket and cylinder are cast in one piece. To reduce the clearance space, the inlet-valve has been lowered half-way into the end-jacket, the cylinder-cover taking up the remaining cavity. The valves are of cast-iron, with steel-spindles.

The pumping capacity is calculated to raise 7063 cub. ft. (200 cubic metres) 148 ft. (45 m.) high, with the crank running at 60 revs. per min.

d. A. Möller of Holzminden.

On Plate XXXII (Figs. 1—3) we illustrate the Automatic Variable Expansion-gear, patented by the late Mr. A. Möller of Holzminden.

The admission-valves are placed on the top of the cylinder, and in the drawing before us — Fig. 2 — we see the inlet valve driven off a cam C keyed on a lay shaft A running at equal speed with the crank-shaft. The rod E partly suspended on the link J and partly on the lever B has a small roller at its foot, which is thus kept rolling on the cam surface. As the forked lever L articulates on the same centre D as the lever B, the oscillations of the latter are communicated to it, its upward rising motion lifting the admission valve-spindle F. This spindle is connected with the lever B, by what its inventor is pleased to call a "lock". The latter is composed of the following pieces: The link K connecting the lever L with a trigger N attached to a fast collar P on the valve spindle: then we find the tappet U furnished with a steel catch-plate o, which is always kept horizontal by a spring s attached to link K. Fig. 2 shews this mechanism locked; consequently the valve will be lifted, until the tappet U strikes against a pawl r placed above it, when this tappet will yield to the opposing pressure of the pawl. Disengagement between n and N is thereby caused, and cut-off ensues, whilst the lever L continues its motion. The pawl r is connected with the governor collar, through the spindle R, and the levers $M M_1$.

The lock assumes the form shewn in Fig. 3, when the lever L moves downwards, to lock (engage) this trip-gear. Following the movement of L, the link k is similarly lowered, the edge n strikes against the catch-plate o and forcing down the latter, locks itself behind it through the pressure of the spring s. If the lever L now begins to ascend, the valve is opened after its "dead" (ineffective) motion is completed.

The form of the cam C was designed to offer a sufficiently wide opening for the steam-admission at $^1/_{10}$th stroke. From this point, the mechanism rises but slightly, though uniformly until the piston has nearly completed its stroke. During the end of the stroke, a somewhat more rapid rising movement takes place, so as to ensure disengagement taking place, even should the pawl r be at its highestposition. If the valves are closed, and the Engine has to be started, the pin z is pulled out, and the trip-gear is then locked by means of the hand-lever X; subsequently this lever X is raised, and consequently the valve lifted, so that the bolt z may again be inserted in its place.

e. E. König, of Nordhausen.

We will describe König's Automatic Variable Expansion-gear by means of the annexed woodcuts Figs. 309—311.

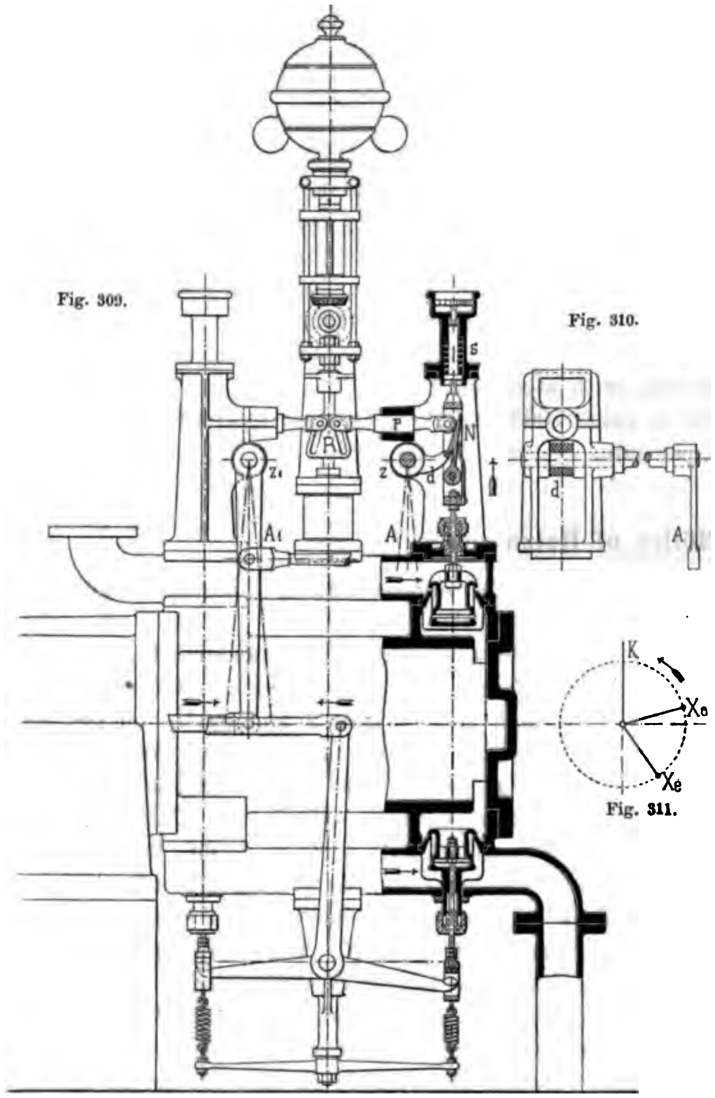


Fig. 309. Fig. 310. Fig. 311.

The tappets *d* are keyed fast on the spindles *z* and z_1 which receive their motion from an eccentric and from the levers *A A*. The ends of these tappets gear on to triggers *N* placed in slots in the valve-spindle, and thus raise the valves. The lower end of the governor link-work has a vertically sliding block *R* attached, having two inclined slots for the purpose of taking in the disengagement-links *r*. The valve-motion then takes place in the following manner: Presuming the crank is on its dead-centre, then (leaving the lead out of the question) the trip-gear is engaged. With the continued travel of the piston, the valve is lifted so long by the tappet *d*, till its end is forced out of gear by the disengagement rod *r*, when the valve is forced rapidly back on its seat, by the spring *S*.

With the return stroke of the piston, the valve remains closed, till shortly before the commencement of the next stroke, the trigger *N* falls into gear with the tappet *d*. If the engine-speed increases, the rising governor-balls lift the block *R* so forcing outwards the disengagement rods *R*, which naturally implies earlier disengagement of the trip-gear, or an earlier cut-off.

Our woodcut Fig. 309, shews the adoption of two eccentrics for the admission (*Xe*) and for the exhaust valve (*X a*), the position of which, when the crank *K* is in its middle position is illustrated in Fig. 311.

f. Crespin & Marteau, Engineers of Paris.

The Engineering Firm of Messrs. Crespin & Marteau of Paris, were represented by a Horizontal Condensing Engine, which presented a novel external valve-gear mechanism. We illustrate this arrangement on Plate 59.

The fundamental idea underlying this construction, was the attainment of a variable expansion-gear from 0.0 to 1.0 stroke, by using only one organ for the four valves. But as in this instance the motion of the gear is obtained at once, that is to say, is not composed of two or more motions as in the Sulzer-valve-gear of 1878 — see pg. 215 —, means have to be provided to close the exhaust-valves instantaneously at the end of the stroke, when they are at their highest-lift; for the latter have only one direction during the piston-stroke. The sudden shutting off of the exhaust-valves is effected by a trip-gear arranged with a constant disengagement-period.

Still, in order to obtain as great an opening of the valves as possible already with the commencement of the stroke, a cam is used in place of an eccentric. The form of the latter is shewn on an enlarged scale in Figs. 6 and 7. As represented in Fig. 6, the cam is drawn in the same position as our elevation and plan of Engine, and the piston is then half-way. After a quarter revolution of the cam, the latter receives a somewhat accelerated motion, so as to be certain to effect disengagement of the trip-gear. At this moment, the whole arrangement is in its extreme position, and consequently the piston at its stroke-end. If we suppose the cam to continue turning, then on account of its symmetrical form, a short accelerated return-motion will ensue; the mechanism then adopts the normal crank-speed, till the next change of stroke.

Fig. 5 shews the trip-gear, which is the same both for the admission- and the exhaust-valves; our drawing represents specially, the trip-mechanism of the hind inlet-valve.

The rod attached to the frame gliding on the cam, is linked to a double lever placed at the side of the engine-frame; the upper and lower arms of this lever drive respectively the admission and the exhaust valves.

Two sleeves B, each furnished with a trigger N, are linked to the upper arm of this lever A, and these sleeves slide on a cylindrical rod G, suspended on the bell-crank L of the valve-spindle. This rod G carries a steel catch-plate o, by means of which it is moved when the latter (o) is in gear with the trigger N; this motion of the rod G is naturally transmitted through the bell-crank L on to the valve-spindle, so opening the valve. The other arm of the trigger N comes sooner or later in contact with a projecting pin r under governor-control, so effecting disengagement of the trip-gear. Fig. 5 shews the trip-gear mechanism out of gear. The only difference hereto, to be observed in the exhaust-valves, is that the sleeves are placed side by side, and the tappets r are rigidly fixed to the engine-frame.

The distribution of the steam is clearly explained by our Fig. 4. The valves a and d continue to lift, when the piston is half-way on its stroke, whilst the valves b and c are at rest though their corresponding triggers are approaching nearer and nearer to the catch-plates, ultimately gearing on to the latter.

A special advantage of this mechanism, is that the Engine allows itself to be reversed at once; for this purpose, the triggers about to come in gear need only be disengaged, (when the corresponding valves are thereby closed), and the other rods are then pushed up so far that the respective trigger may gear on to its catch-plate. The steam-distribution to the cylinder becomes thus reversed, and the Engine assumes a contrary working-direction. The cam is set with an eccentricity of 180° exactly opposite the crank. The diameter and stroke of the cylinder of this Engine were respectively $11^3/_4$ in. (300 mm.) and 1 ft. $11^1/_2$ in. (600 mm.). The arrangement of the valves is illustrated in Fig. 3.

C. Valves placed above the cylinder.

a. H. Borgsmüller, Hofstede nr. Bochum.

In the patented Valve-gear of Mr. Borgsmüller, illustrated on Plate XXX (Figs. 6 and 7), four cams $C C_1$ are keyed on a lay-shaft A driven at equal speeds with the crank-shaft; these four cams give motion to the four valves placed over the cylinder. The admission valves are worked off the two double levers $B B_1$ and $L L_1$, which are supported on a pillar-stand T. The arms B and L_1 are coupled together by an adjustable rod E. A counterweight added to the arm B_1, causes the roller r of the arm B to continually glide over the cam-surface, whereby an up and down motion is given to the lever-arm L. The end of the latter which passes through a slot in the valve spindle, carries a trigger N in the form of a bell-crank, which owing to the spring-pressure s gears on to the valve-spindle itself. With the falling motion of the rod B, the lifting of the lever arm L and of the valve consequently ensues. A tappet R is placed over the trigger N and is keyed on a spindle W supported by the pillar-stand T. This tappet is under governor-control, and according to its position, disengagement is effected sooner or later, upon which the valve is closed. With the downward motion of the trigger N, which takes place owing to the counterweight on B_1, the trigger N falls into gear with the spindle.

The exhaust valves are worked similarly, excepting the trip-gear. The swing-centre Z_1 of the lever KK_1 is also on the pillar-stand T. By the simultaneous rotation of the four cams, the Engine becomes reversed. The former are mounted on the sleeve A_1 of the lay-shaft A; this sleeve is moved by the lever X and cannot slide side-ways on the lay-shaft.

D. Engines fitted with Combined-Valve-gears.

I. Engines working with Main-slide and Expansion-valve.

1. Valve-gears working with the Expansion-valve placed apart from the Main-slide.

a. J. J. Meyer of Mülhausen.

As soon as the advantages of Automatic Variable Expansion gears, presented themselves the Engineering public, many practical men, tried to impart these advantages to the old Engine-pes, which were then merely working with the ordinary slide. In certain cases, these attempts met ith much success, though all the main characteristics of Automatic Variable Expansion-gears could ever be obtained, inasmuch as the long steam-passages with their large clearance spaces could

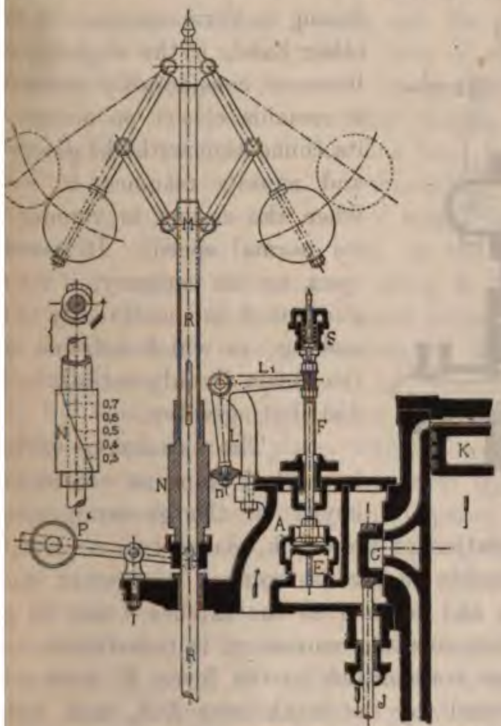


Fig. 313.

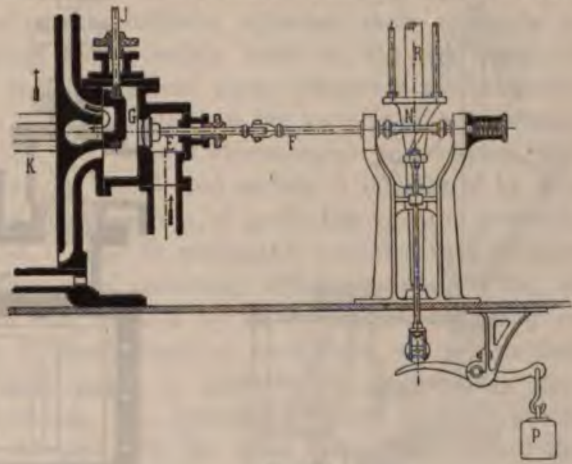


Fig. 312.

not be obviated, so that the simultaneous expansion of the steam in the valve-chest etc. still took place. As all the attempts made in this direction, are more or less based on Meyer's Expansion Valve-gear type, we begin this last section of our "Corliss-engine" Work with the latter, and illustrate the same by Fig. 312.

The piston rod *E*, is moved twice with every crank-revolution by a conical sleeve *N*. This eve rotates with the governor spindle *R*, but has also a vertical slide which effects the variableness of the cut-off. We may conveniently describe the mechanism introduced for this purpose, referring to the *improved* Meyer Valve-gear illustrated in Figs. 313 and 314.

The main-slide G receives its motion from the slide-rod J in the ordinary way from an eccentric, so that following the inscribed arrow, steam is being admitted on the top side of the piston K, expansion due to the slide-motion alone, would only occur towards the stroke-end. The valve-chest A is furnished with an equilibrium valve E placed under control of the governor, so as to effect automatic variable expansion. But as the steam has to be cut-off twice, during each revolution of the crank, the valve E is raised and lowered twice in the corresponding time. This equilibrium valve is driven by the governor-spindle R which rotates at equal speed with the crank-shaft. The lower portion of the collar M has a sleeve N, the weight of which is balanced by the counterweight P. This sleeve N is furnished with cams, set diametrically opposite each other, the form of which is shewn in Fig. 314; the edge of these cams is designed to allow a variable expansion, between a range of 0.25 and of 0.7 stroke. Consequently, with each revolution, the roller r gliding on the cam-surfaces, will be pushed twice forwards and backwards. This motion, transmitted as it is through the bell-crank $L L_1$, causes the valve E to lift and close accordingly. A spring S facilitates the closing movement of this valve. It is evident that a vertical slide of the sleeve N will bring about a variable cut-off, and as the sleeve is worked up and down by the governor, automatic variable expansion is obtained.

b. Umpherstone & Co., Engineers of Leith.

The somewhat peculiar expansion-gear, represented in the annexed Figs. 315 and 316 has been applied by Mr. Wm. Umpherstone even to large sized engines. It consists of a double-piston expansion valve E, which is brought twice on its seatings during each stroke, cutting off steam at a fixed portion of the stroke during uniform speeds. On the other hand, if the engine speed becomes considerably increased, it remains closed on account of its connection with the governor, and merely resumes to work when the engine is running at its normal speed. It remains open, on the contrary, if the engine-speed is continually diminishing, in which extreme case, the steam is only cut-off, by the distributing-valve.

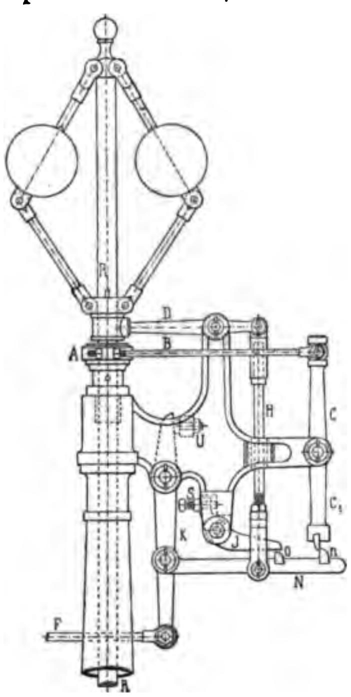


Fig. 315.

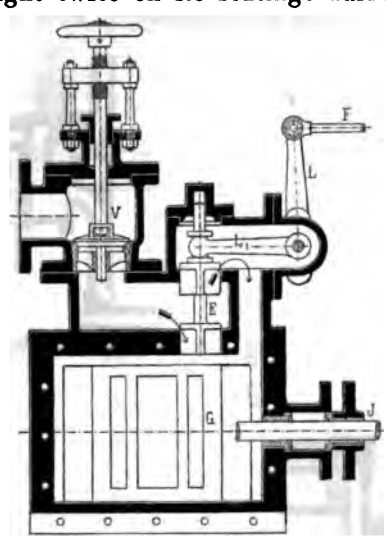


Fig. 316.

The expansion-valve E is worked from an eccentric A, keyed on the governor-spindle R which for every revolution of the crank, makes two revolutions. The eccentric-rod B imparts in the first place, a constant movement to the lever CC_1, and so long as the catches n are in gear with each other, this reciprocating movement is transferred on to the bar N, to be thence transmitted to the lever K with which the double seated expansion valve E is rigidly connected by the crank-lever $L L_1$ and rod F. The placing in and out of gear of the nibs n is controlled by the governor, as the rod N is attached to the lever D leading to the governor collar, by the link H. The high flying of the governor-balls, brings the nibs n clear of each other, which corresponds to a shutting off of the valve E, until the lever N is sufficiently lifted by the governor, as to permit the rocking motion of the lever C to be again transferred to the lever N. If on the other hand, the lever N becomes raised above its central position, then a second nib o, strikes against the catch J, by which it is eventually caught, so preventing the return-movement of the lever or the closing of the valve. The nibs o keep the expansion-valve out of gear when the engine is either going very slow or when it is being started. The catch J is rendered adjustable by the set-screw S. The steam now continues to enter the cylinder till the slide-valve G shuts off the ports, the valve E only again coming into action when so compelled by the governor.

The working of this valve-gear requires very little power from the action of the governor balls nor is the governor subjected to counter-shocks. With comparatively uniform steam-pressures and loads, the link-gear can be so adjusted, that the expansion-valve E may only miss coming into play once during ten or twenty revolutions of the crank.

The Translator may add that the faces of the nibs n_1 were stepped, thus ⌐⌐, to give a variable amount of opening to the cut-off valve, in addition to the full shut and open action. This arrangement of Cut-off gear, has however now been discontinued, Mr. Wm. Umpherston having lately designed a variable action for the expansion valve, providing the latter with a *positive* shutting movement.

c. E. R. & F. Turner, Engineers of Ipswich.

Though the abolition of small boilers and engines has been recently mooted in Engineering circles, a long time will necessarily elapse before this change takes place. It is true the energy with which the Americans are at this present time working out the means of supplying our towns with a common source of power, and the success which has hitherto attended their attempts in the laying down of underground lines of steam piping, may possibly hurry on the era, when all steam users in large cities will obtain their power in a convenient form, whenever and wherever required, at a fixed and reasonable charge, with no other trouble than the turning on of a steam-cock. But even, when all this has been accomplished, the present steam-engine construction will still have to be resorted to, for converting the steam into work, and certain it is, that if by this change, engine and boiler makers might lose one of their sources of profit through the probable dispensation of boiler power, yet, on the other hand, it may be reasonably expected that a larger demand for engines will ensue, owing to the convenience of obtaining driving power. Thus, at the present time, owing to the geat extravagance in coal entailed by small boilers, requiring as they do almost as much attention as large ones to keep them at work, etc., we seldom find very small engines employed; for, where only small power is required, it is generally supplied by human labour, or what is still more common, the operations which require power are transferred to some place, where power can be obtained. On the other hand, let us afford the smallest power-requirer, cheap means of obtaining a constant steam supply, without in any way entailing upon him the trouble and expense of generating steam, and it may be reasonably expected that he will "go in" for a Steam-Engine, where at present he would entertain no such idea; therefore, if our engine makers should be sufferers from an eventual absence of orders for boilers, they may reasonably expect an increase in the demand for their engines. It is likely, that the Future may somewhat qualify this remark, especially if the present efforts that are being made in the conveyance of power from Nature's quiet domains into our busy industrial centres, are allowed to become more economical in their practical application, than our small Steam-engines. It is perhaps needless to observe, that the latter are already receiving much opposition from Gas-motors, owing to the forementioned reasons, but let us hope that this evident competition, will all the more stimulate our Engine-builders, not to be beaten in the race for supremacy. On various occasions, the writer of these lines has discussed the far greater importance which small engines may hold in the Future. As this subject is specially interesting to Steam-engine makers, the

Translator may here briefly recapitulate the views conveyed by him to several of the home and foreign technical journals: It may be taken for granted, that most of the Mill break-downs are attributable to the system, that is at present in vogue for mill driving. If we consider the serious consequences which happen, if the prime motor is disabled from working, we shall find in situations where only one large steam engine is employed for driving purposes, that its disablement carries with it the stoppage of the entire mill. It frequently happens without one word of warning, that a heavy and powerful engine is made, almost in a moment, a complete wreck, the cause of the disaster, being often only a conjecture, and at other times, remaining a complete mystery. To make matters worse, engine break-downs are as common and as disastrous in new mills as in old ones. There are unquestionably many mills, that work on year after year, without almost any stoppage; this would seem to show, that if some errors of construction or arrangement are avoided, safety may be secured. Other objections may be raised, against the prevalent one-engine driving system, inasmuch as much idle needless weight (requiring special heavy fixtures) has to be driven along with the work-performing machinery. Looking at all the "pros and cons" of the question involved, the bold idea suggests itself, whether it would not be more advantageous to have either a number of small engines placed at certain distances, to work an entire mill, or to make one engine drive one or two floors separately. *En passant*, we may observe, that this tendency of becoming more and more independent of one motor is daily gaining ground, for to quote only one example we see that the ponderous Steam-pumps — much resembling the Steam engine in their working, and one of which in former years was made to drain one mine — are being more and more replaced by a number of smaller pumps fed by one or more steam boilers. In fact we need not go farther than our own mills to notice the same tendency; for, what do we now furnish our steam boilers with check-valves for, but to make them independent of each other, so that if damage accrues to one, the remainder may not be affected by such injury, but still continue to work.

Again, it has been rightly observed, that there are many advantages in merely having one Steam-engine to drive a Factory, but generally, it must be so large and heavy, and move such a considerable load, that with a constant risk of breakdowns, if a breakdown happens, it is almost sure to be serious one, though there are sometimes miraculous escapes. There would be many advantages, as well as disadvantages, in having several steam engines instead of one only, as for instance one on each story. At first sight, it might appear, that such a plan would only multiply the chances of breakdowns, but we must remember, that breakdowns of steam-engines are not continually happening in the same mill, and a steam-user — if he is lucky — may only experience one grand smash in his life. When his turn comes, his factory is stopped, at a moderate estimate, for three months, and the expense of stopping, will about equal the expense of his new steam-engine, besides all his hands being thrown out of work, in addition to the responsibility attaching to previous contracts entered into! The breakage of one of the smaller engines, if it were to happen, would be a very trifling matter in comparison. It should be remembered too, that if big steam engines are not necessarily always smashing up, they are continually stopping for one thing or other, perhaps every month for some trifling accident. It may be, that some bearing in the factory has become hot, or that a drum has come loose, or some small wheel on the shafting may have slipped out of gear, or a strap may have lapped; but from whatever reason, the whole factory must stop until it is set to rights. Again, it may happen that some part of the factory may be required to work now and then without the other parts; yet with one engine, all the gearing of the factory has to be turned, however little of it you may want.

In putting forth this suggestion, we must not be understood as implying to place, the engines each in connection with small boilers, for the latter, as is well known, are extremely extravagant in coal, and require almost as much attention as large ones to keep them at work; besides they entail dirt and much inconvenience, so that we should suggest that the present boiler system be retained in the boiler-house, and that steam should be conducted to each engine by a service of well protected pipes. That the engines required need only be of small power may be conjectured when it is remembered that approximately one *nominal* horse-power will drive in a Cotton mill for instance, inclusive of the preparatory frames either 500 mule (60—80's) or 375 self-actors (60's), or 250 throstle (30—40's) spindles, or 16 calico looms. Naturally the more engines are introduced the smaller they need be, though the most economical number from a manufacturers' point of view will necessarily vary in each going-concern. The introduction of small steam engines, into our industrial centres appears therefore to have a future, which will be hastened, the more our small steam-motors are perfected and made to work with greater steam economy!

All the foregoing remarks seem to prove, that the small steam-engine promises to have a larger future demand in store, and the horizontal and vertical arrangements represented by our annexed wood-cuts may with many others described in these pages receive attention at the hands of small steam users, besides recommending themselves as auxiliaries where larger powers are required. Our Fig. 317 give perspective view of the vertical and horizontal arangements of the so-called Gippeswyk engine. A front elevation of the vertical type, with governor attachment shown in section, is represented in our Fig. 318.

Fig. 317.

From these engravings it will be seen, that very little difference exists in the constructive details of the vertical and horizontal engine types, excepting it be, that in the latter, two foundation pedestals are introduced in the place of the one in the vertical arrangement, and that the governor is placed perpendicularly, instead of being in line with the steam inlet valve spindle, working the latter in this case by a lever bracket; the following description of the vertical type will therefore answer in other respects for the horizontal arrangement as well. The steam cylinder is bolted to the end of a fork-shaped cast-iron framing, and thus when erected apart from its boiler is secured to the hollow bed.

The forked frame, has the further advantage of ensuring a perfect concentric boring of the guide slides with the cylinders, which point is so very important for ensuring the truthful and easy working of every engine. The crank-shaft bearings are carried by the prongs of the upright framing, and are also provided with an improved wedge-adjustment. Two separate eccentrics placed on one side of the engine, drive the feed-pump and slide-valve, and the bed-plate holds the engine sufficiently high as to dispense with fly-wheel race, or further bed-packing. The crank-shaft is of wrought iron, and is sufficiently long to carry a pulley at the opposite end of the fly-wheel. Motion to the governor is imparted by bevel gearing from the crank-shaft, and the governor itself is combined with the starting valve, which acts also as an expansion-valve. The ordinary governor-balls, as will be from Fig. 320 seen, are enclosed in a hollow sphere, which rises and falls as the balls expand or contract by increase or diminution of the speed. The rise of the hollow sphere closes the steam inlet valve to the cylinder and checks the speed, while its weight causes it at once to drop and re-open the supply valve at the instant the speed is in the slightest degree diminished. The makers (Messrs. E. R. & F. Turner, of Ipswich), have supplied us with the following more detailed description of this governor: The steam pipe from the boiler is jointed to a small casing containing an equilibrium valve which controls the admission of steam to the cylinder. The spindle of the equilibrium valve just mentioned passes through a stuffing-box at the bottom of its casing, and is connected by a screwed socket and lock nut to another short length of spindle, having a buttonhead at its lower end. It will be noticed that the connecting socket just mentioned, is provided with an arm, which is traversed by a vertical stud on the framing of the engine, the arrangement being such, that the spindle of the equilibrium valve is prevented from rotating, although it is left free to move endways. The button-head just mentioned as being provided at the lower end of the extension of the equilibrium valve spindle, is clipped by a cap as shown, this cap connecting it to the spherical casing, which encloses the governor. Below the spherical casing is a screw and hand-wheel, by which the spherical casing, and with it, of course, the equilibrium valve can be raised or lowered; the parts in our engraving are shown in their highest position, and the equilibrium valve consequently closed and steam shut off from the cylinder. By turning the hand-wheel, the spherical casing can be lowered (and the equilibrium valve consequently opened) until the further descent is arrested, by the top of the spherical casing taking a bearing upon the horns, with which the arms of the governors are provided, as shown in our engraving. When the governor balls rise, these horns raise the spherical casing, and consequently the equilibrium valve, the latter thus effecting automatic cut-off.

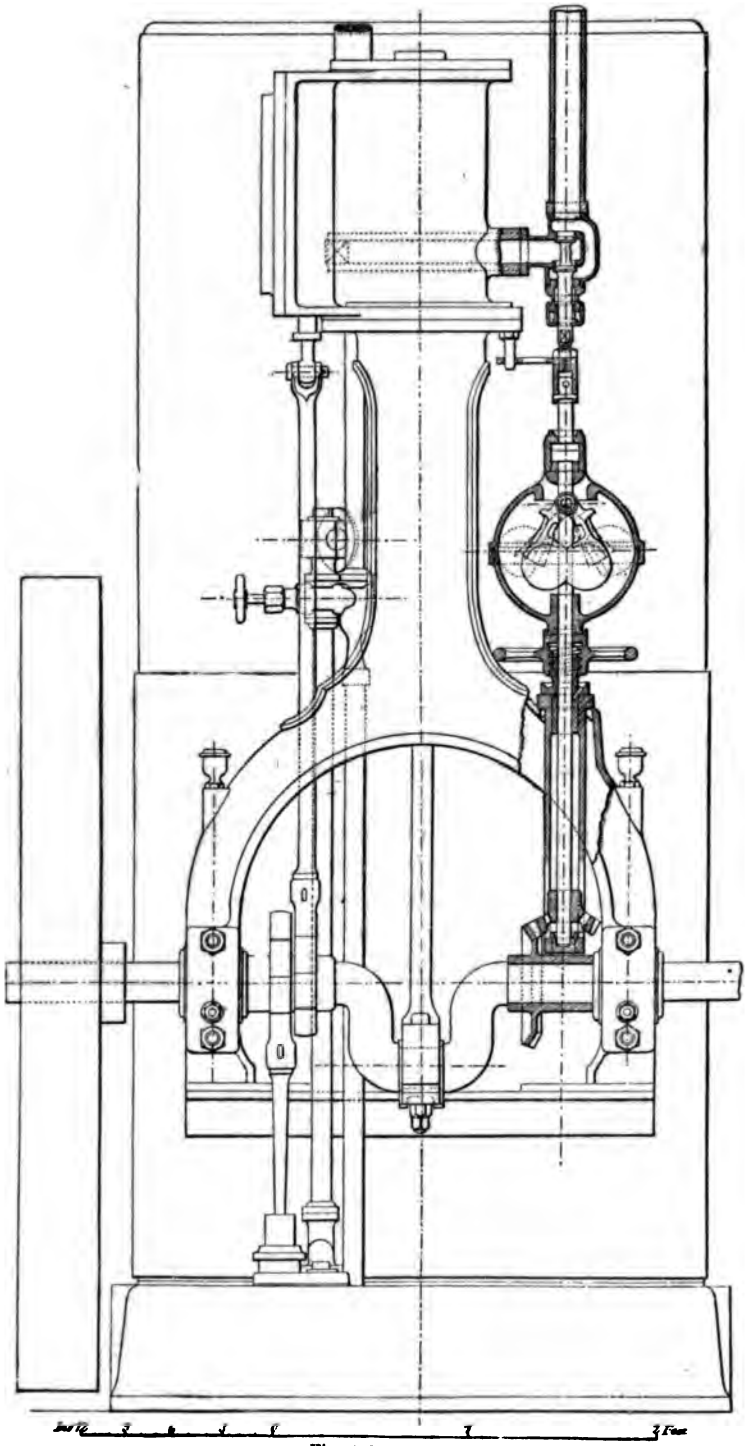


Fig. 318.

In their latest types, Messrs. E. R. & F. Turner have abandoned this governor, and substituted the well known Hartnell governor.

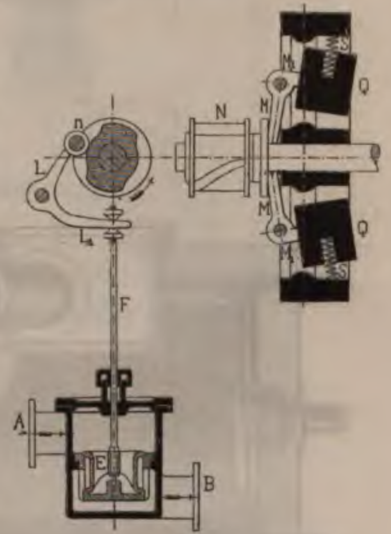
d. Raymond, Engineer of Lüttich.

On Plate XXXIII (Figs. 1 and 2) we illustrate the Expansion-gear of Mr. Raymond of Lüttich, but in order to gain room we have placed the three main parts of the engine closer together. The main slide is driven by one eccentric, whereas the expansion-valve E is worked by a trip-gear arranged under control of the governor. The sudden opening of the expansion-valve E is effected by a cam-disc D mounted on the crank-shaft and fitted with projections $d\ d$ placed diametrically opposite each other. The crank, as represented in our drawing, is on its dead-centre, and simultaneously the trigger N falls into a groove on the slide-block T, to which the rods F and F_1 are attached; by thus falling into gear, the slide block T is prevented from moving either way. The eccentric C, whose dead-centre corresponds with that of the crank, is connected to a forked rod M fitted with tappets $r\,r_1$ moving over the trigger N. The other end of the rod M is linked to a rod R controlled by the governor, which rod R assumes a higher position with rising governor-balls, and vice versa. Consequently, contact between the tappets r and the trigger N will occur at different times, releasing accordingly the trigger N from the slide-block T. The disengagement of the latter, corresponds to a closing of the valve, whence an automatic variable expansion gear is secured. With the commencement of the next stroke, this action is repeated, inasmuch as the trigger N_1 then comes into play, giving the rod M a contrary direction of motion.

e. Maxim & Welch, of New-York.

The Engineering Firm of Messrs. Maxim & Welch of New-York, fit their small Steam-engines with Hiram Maxim's Expansion-gear, illustrated in our Figs. 319 and 320. The governor consists of weights $Q\,Q$ attached to crank-levers $M\,M_1$, arranged inside a belt-fly-pulley. The internal rim of the latter is pressed against, by spiral springs $S\,S_2$ which take up a portion of the centrifugal force exerted by the weights $Q\,Q$. With increase of pulley-speed, the action of the weights on the arm $M\,M_1$ shifts the position of a grooved cam N.

This axial slide reacts in the manner clearly shewn in our drawing on the Expansion-valve E which receives its steam at A, passing it on, through B, into the valve-chest.



Figs. 319 and 320.

f. Briegleb, Hansen & Co., Engineers of Gotha.

We have already become acquainted — refer to pg. 209 — with several Lift-valve gears of Messrs. Briegleb, Hansen & Co., and on Plate XXXIII (Figs. 3 and 4) we illustrate their Combined Slide and Lift valve gears. The arrangement of the latter is the same as those already referred to, excepting that an expansion valve now takes the place of the former admission-valve. The slides are worked by an eccentric mounted on the crank-shaft. The arrangement shewn in Fig. 4, is used in cases where each cylinder-end is furnished with separate slide, and where consequently two expansion-valves and double gearing are rendered necessary.

g. Messrs. Starke & Hoffmann, of Hirschberg (Silesia).

(Type: M. A. Starke.)

The above named Machinists have turned out a variety of Engines fitted either with Automatic Variable Cut-off motion, or with an Expansion-gear, patented by Mr. Starke. According to the special requirements, one or two expansion-valves are used, whereas the distribution of

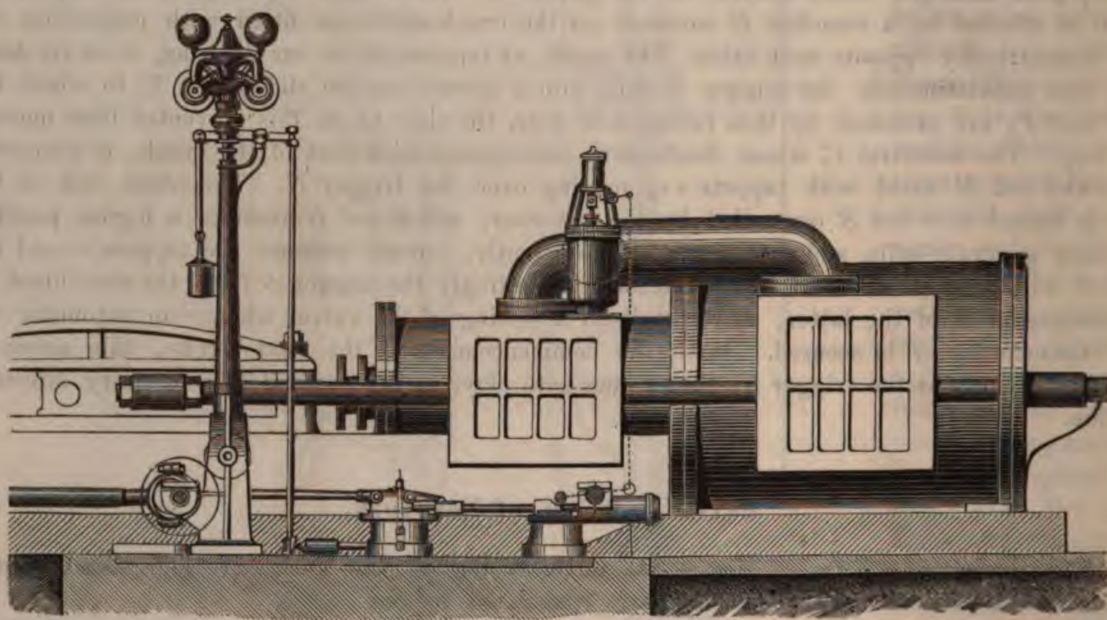


Fig. 321.

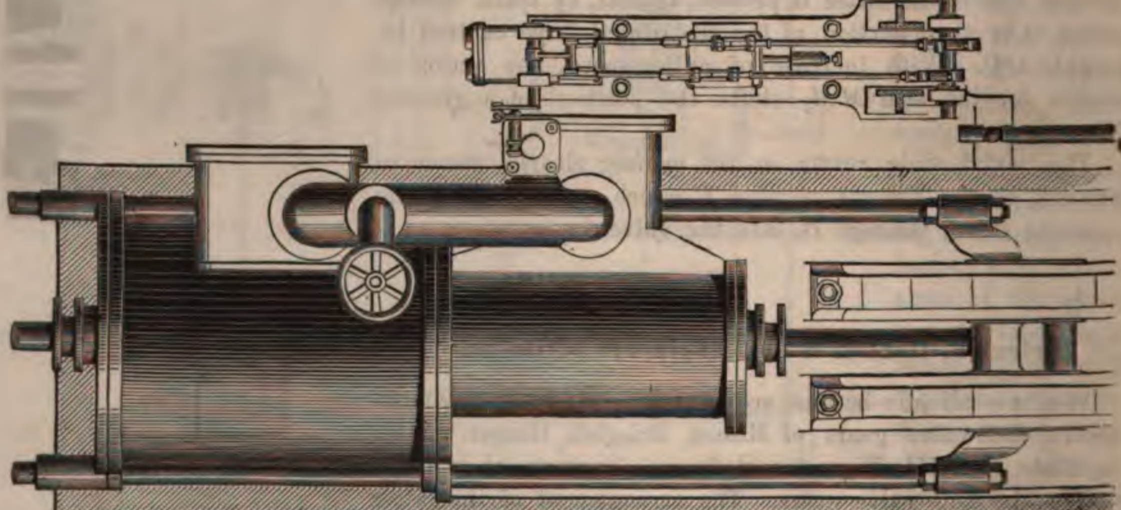


Fig. 322.

steam is effected by separate mechanism. An Engine of the first named type is represented in Figs. 1—4, (Plate 60), working with two separate main-slides fitted in two separate valve-chests placed at the cylinder-side. On the other hand, Figs. 5—9 illustrate what is termed an "Anchor nsion-gear" — owing to the anchor-like form of two catches it contains — for application igines working with one Valve-chest. Mr. John J. Derham, Engineer of Wilpshire (near :burn) who has purchased the patent rights for this country, the Colonies, and for Belgium Holland, has kindly placed some of the following particulars at the Translators disposal:

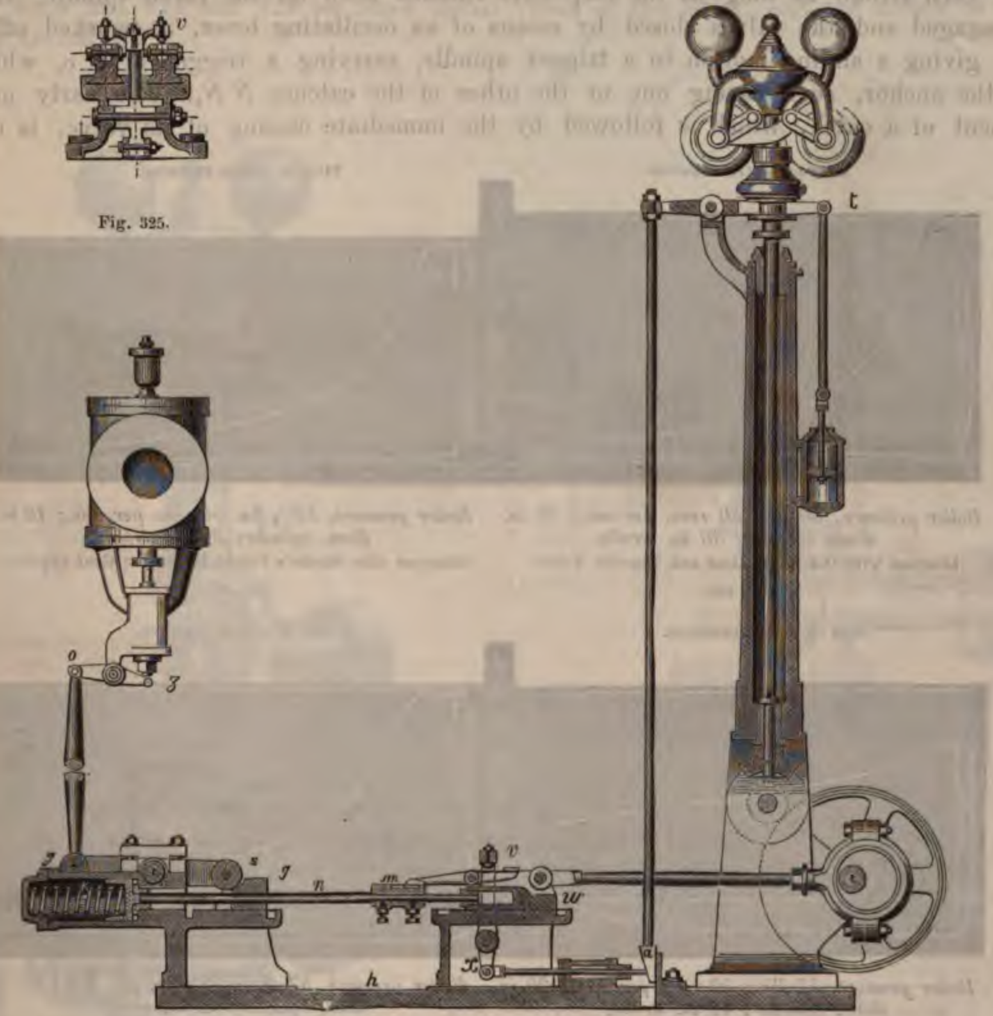


Fig. 325.

Fig. 323.

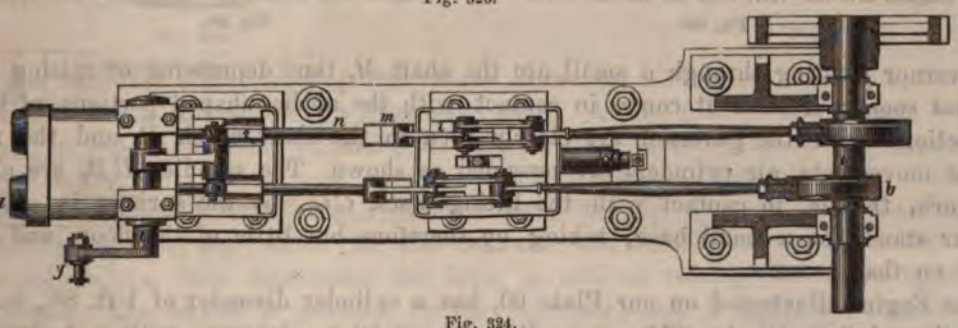
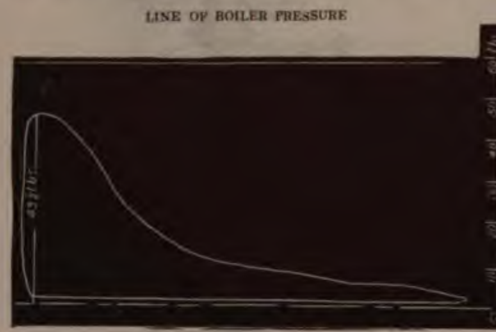
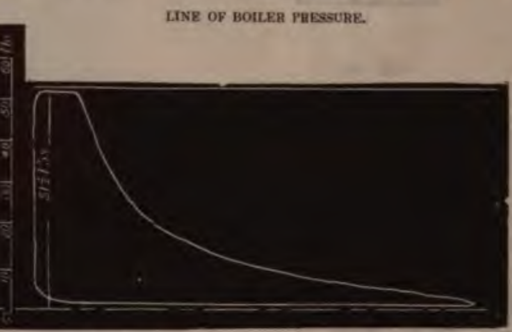


Fig. 324.

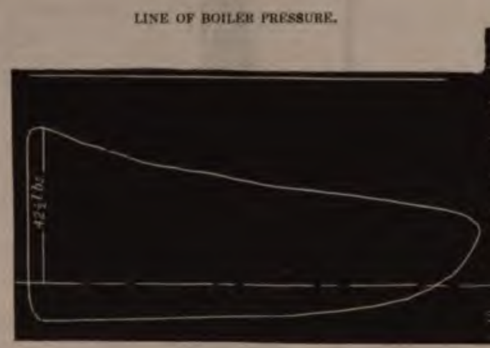
The anchor-gear — Fig. 6 — is worked at the foot of the governor stand by an oscillating or "wrist plate", A, which receives its motion from an eccentric on the engine shaft. On this disc are bolted two plates, or cams, CC_1, which for every stroke, through the medium of the friction rollers attached to BB_1 lift the spindles BB_1, carrying at their upper extremities the two catches NN_1, shaped like anchors. These hang loosely from the lifting levers LL_1. Connection with the admission valves is made by the rods clearly shewn in Fig. 1. The valves remain open for each stroke as long as the respective catches keep up the valve spindle; the catches are disengaged and the valves closed by means of an oscillating lever, J (worked off the main disc A), giving a sliding motion to a trigger spindle, carrying a trigger arm, o, which strikes against the anchor, so releasing one or the other of the catches NN_1. The early or late disengagement of a catch, which is followed by the immediate closing of its valve, is determined



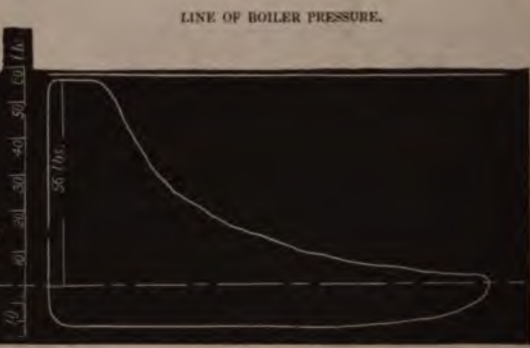
Boiler pressure, 60 lbs.; 50 revs. per min.; 16 in. diam. cylinder; 30 in. stroke.
Diagram with Old Valve Gear and Throttle Valve.
Fig. 326.



Boiler pressure, 52 1/2 lbs. 50 revs. per min.; 16 in. diam. cylinder; 30 in. stroke.
Diagram after Starke's Patent Expansion Gear applied.
Fig. 327.



Boiler pressure, 57 lbs.; 50 revs. per min.; 20 in. diam. cylinder; 42 in. stroke.
Diagram with Old Valve Gear and Throttle Valve.
Fig. 328.



Boiler pressure, 57 lbs.; 50 revs. per min.; 20 in. diam. cylinder; 42 in. stroke.
Diagram after Starke's Patent Expansion Gear applied.
Fig. 329.

by the governor rotating through a small arc the shaft M, thus depressing or raising the trigger arm, so that sooner or later it comes in contact with the anchor-shaped portions of the catches. The connections with the governor are clearly seen in the short crank P, and the rod R. To cushion the movements, air cylinders are provided as shown. The spindles BB_1 are always kept to their work, that is, in contact with the lifting discs, CC_1, by the springs in guide T. The anchor gear stands on a small base, taking up therefore but little of the floor, and it is often convenient on that account.

The Engine illustrated on our Plate 60, has a cylinder diameter of 1 ft. 8 5/8 in. (525 mm.) and a stroke of 3 ft. 1 1/2 in. (950 mm.). Running at 50 revolutions, with a boiler-pressure of 75 lbs. (5 atm.) and a cut-off at 1/4 to 1/3 stroke, it throws off 65—80 horsepowers when non-condensing and 90—105 *HP* when condensing.

A considerable number of compound Beam-engines have been subsequently fitted with an Expansions-gear shewn in the annexed Figs. 321—325 and known as Starke's Horizontal Expansion-gear.

This form of gear, it will be seen from Figs. 321 and 322, can with ease be applied to engines with single valve chests.

In Figs. 323, 324 and 325 we show detail views of the latter, and the action of the mechanism is as follows:

Fig. 330.

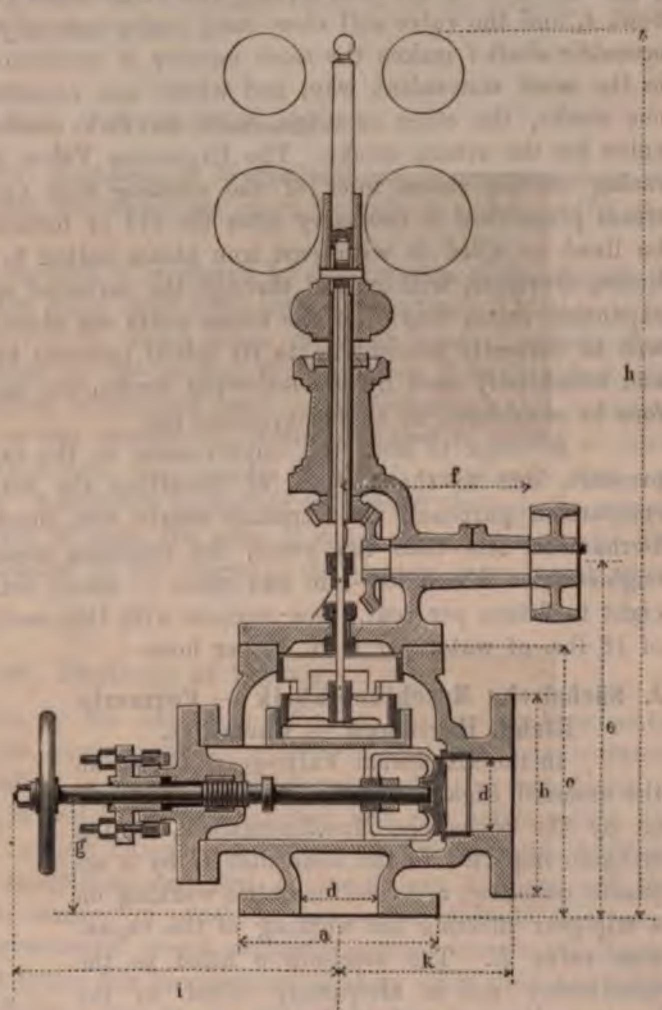


Fig. 331.

In the sectional elevation, Fig. 323 (which shows the sliding arrangement), the sole plate, *h*, carries at one end a column with a Buss governor*). At the foot of this column two bearings are provided, in which revolves the shaft, *i*, carrying two valve exentrics set opposite to each other. These latter work slides, *ww*, carrying catch levers, *ll*, either of which, in its forward stroke dropping against a step at *m*, pushes onward the spindles *nn*. On these spindles are attached lifting blocks, *qq*, which in the forward movement are pushed under the bowls, or friction rollers, *ss*, thus depressing the lever *y*, and so raising the valve spindle *z*, and admitting steam. The cut-off is effected by the governor, and is under its control as follows:

*) Messrs. Schäffer & Budenberg of Manchester are now introducing a more compact arrangement of their Buss's governor, which works with a special throttle valve, as represented in elevation and section in Figs. 330 and 331.

Suppose the speed is too high, and the grade of expansion is to be reduced. The governor balls, in opening beyond their normal amount, lift the lever *t*, and thus, by the connections shown, depresses the wedge, *u*. In this way, by means of the lever *x*, the trigger *v* is moved to the right, and therefore the sooner will it meet with the projection on the catch lever *l*, the right hand end of which it depresses, and so lifting the other end out of the notch at *m*. The spindle *n* is now free, and the spiral spring *k* will send it home, ready for engagement at *m* in the next stroke; and at the same time the block *q* will be shot from under the bowl *s*, and the valve will close itself instantaneously, and so yield the best possible cut-off. The eccentric shaft *i* makes the same number of revolutions as the engine shaft, being driven from it in the most convenient way, and whilst one eccentric works the apparatus to admit steam for one stroke, the other eccentric, with its own catch-slide, moves backwards, ready to work the valve for the return stroke. The Expansion Valve is fixed, as already mentioned, in a separate casing on the steam inlet of the existing slide valve box, and should the latter contain more steam place than is necessary after the old or former expansion valve has been removed, it may be lined or filled in with cast iron pieces bolted to the cover. The steam entering into the cylinder, therefore, will expand through the curtailed spaces of the Valve Box after the close of the expansion valve, and after the steam ports are closed by the Slide Valve (or bottom valve) but will be instantly brought up to its initial pressure by the fresh supply of steam from the Boilers and beneficially used by the following stroke, the curtailed space in the Valve Box cannot therefore be considered as an inconvenient one.

In order to shew the improvement in the expansion-lines and in the higher initial steam pressure, due to the absence of throttling the diagrams Figs. 326—329 are here appended for comparison purposes. In Germany nearly two hundred have been applied by Messrs. Starke & Derham in less than two years, the resulting economy being in condensing and non-condensing engines from fifteen to — in bad cases — about thirty per cent., and in compound engines from eight to fifteen per cent.; new engines with this motion applied are working with an evaporation of 18 lbs. of water per I. H. P. per hour.

h. Sächsische Maschinenfabrik — Formerly Richd. Hartmann — Chemnitz.

In the Expansion Valve-gear, shewn in the annexed Figs. 332 and 333, and constructed by the Sächsische Maschinenfabrik, motion is again imparted to the main-slide *G* by a separate eccentric, a second eccentric working on a trip-gear effecting the working of the expansion valve *E*. The steel-nib *o* fitted to the spindle-slot end is alternately lifted by the triggers NN_1 during each crank revolution,

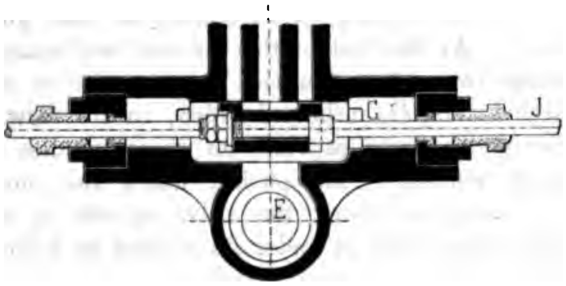


Fig. 332.

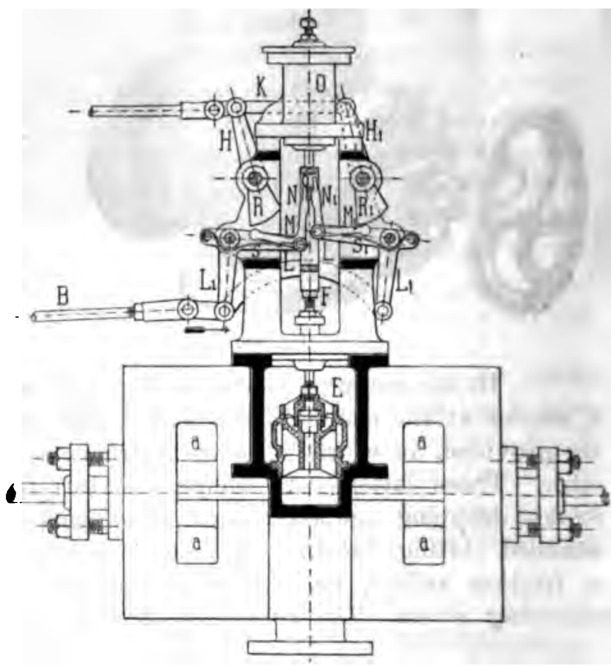


Fig. 333.

owing to the action of the springs $S S_1$. Each trigger is carried on a bell-crank $L L_1$ linked to the eccentric rod B; the triggers $N N_1$ move thereby in opposite directions, so that for example, the one trigger N is facing its maximum ascent, when the other trigger N_1 is just about gearing on to the valve-spindle. These triggers also form bell-cranks, whose horizontal arms $M M_1$ when ascending come in contact, sooner or later, with cams $R R_1$, the positions of which are determined by the governor acting uniformly upon them, through link K and levers $H H_1$. As soon as disengagement ensues, the spring in the small cylinder O presses the expansion-valve E on its seating. To reduce the valve-chest space, its cover is cast as shewn at $a a$.

i. Ed. Hochheim, of Mark-Gladbach.

The Expansion-gear, patented by Edw. Hochheim of Mark-Gladbach, is represented on our Plate XXXII (Figs. 4—6); here front and side elevations are given in Figs. 4 and 5, whilst plan of this arrangement is drawn in Fig. 6.

The double-beat valve E in the valve-chest G is moved by the rotation of the spindle F; it is self-evident that for each revolution, this valve must come into action twice. Motion is imparted to the mechanism by the eccentric rod B, which gears on to the lever C, which along with the lever D is keyed on a spindle carried by the bracket T. The lever D is furnished with the two steel-nibbed triggers N and N_1 which alternately gear on to projections $O O_1$ arranged on a disc A keyed on to the valve-spindle; in this manner the latter is caused to rotate, so opening the valve. During the progress of this action, the triggers N and N_1 gradually sink and come to lie respectively on the tappets $r r_1$. Automatic regulation is effected through the wedge-block K being connected by rod P and lever M with the axis R under governor control. The governor, working almost frictionless, indicates by the finger z, the expansion-grade, at which the engine is working.

k. W. H. Uhland, Engineer of Leipzig.

Mr. W. H. Uhland, who in addition to his able Editorship of the leading Continental Engineering periodical *), ranks amongst the most practical writers of the day, has certainly filled up a most important gap hitherto existing in Engineering Literature, by the compilation of the present work. The practical manner in which he has collated into one entire whole, the contemporaneous mechanical practice of the leading European and American Steam-engine builders, supplementing this practice with examples irregularly scattered in the Patent Archives and Engineering Press of various countries, and the manner in which he has further reduced this incongruous mass of practical ingenuity, into a systematic record, certainly entitles him to the thanks and gratitude of the Engineering profession at large; this the more so, as at no other time, has public attention been more closely and more generally given to the subject he has herewith mastered!

A more fitting place for this well earned eulogy could probably not be found in this Work, than side by side with the Automatic Variable Expansion-gear, illustrated in the annexed Figs. 334—341, which is designed by Mr. Uhland, so proving that he is not merely a talented Engineering writer, but also an actual practical worker.

In addition to its simplicity, this Expansion-gear shares the advantage of easy adaptability to new and old Engines, and is equally applicable to all Valve-gears, no matter whether of the slide-, lift-or rotating-types.

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*) Der practische Maschinen-Constructeur published by Baumgärtner & Co., Leipsig. The large Working-drawings published with each issue on subjects relating to Mechanical Engineering, render this Journal specially useful to practical Machinists.

Our engravings shew this arrangement, as being in direct combination with the governor, arranged on the valve-chest at the side of a horizontal cylinder. As each end of the latter is presumed, in this case, to be furnished with separate admission valves, we find also two expansion valves, the spindles of which are again indicated by FF_1.

A vertical lay-shaft W, which in this example is turned by the governor-spindle R but which could be driven direct, equally well in cases where the governor is otherwise situated, carries a plate A of unequal thickness. To be more exact, the upper border of this plate is raised almost over half its circumference. This swelling is slightly in excess of the requirements of the valve-lift — or expansion slide travel — so that with the lowest position of the valve-spindles FF_1, the projections nn rest on the lower half of the plate. The action of the latter, resolves itself,

Fig. 336.

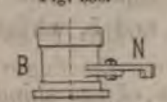


Fig. 337.

Fig. 340.

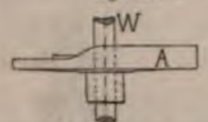


Fig. 341.

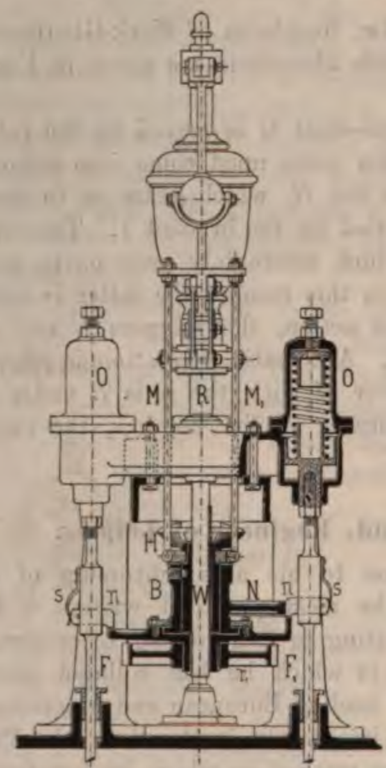


Fig. 334.

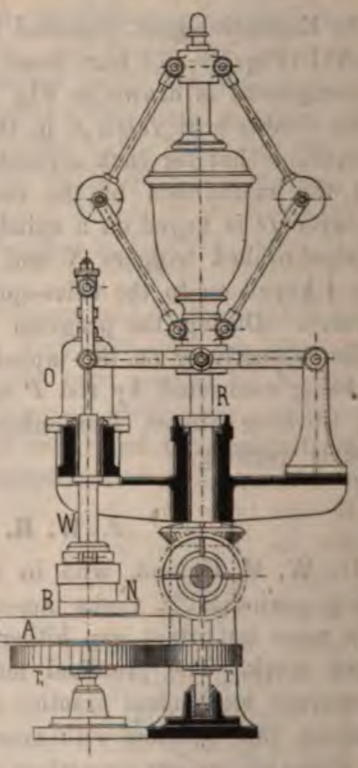


Fig. 335.

Fig. 338.

Fig. 339.

in alternately lifting the valve-spindles FF_1 — corresponding to the opening of the valves or slides — so as to admit steam from 0.0 to 1.0 stroke, if the disengagement mechanism should not previously come into play to close the valves.

The valve-spindles FF_1 which carry springs and buffer-piston at their top-ends in the ordinary manner, are slotted for the purpose of receiving horizontally moving slides nn, which are always kept over and against the plate-border A by the springs ss, so long as no counter-pressure is brought to bear upon them. Inasmuch as the plate A revolves underneath these slides nn_1, its border alternately raises and lowers the valve-spindles FF_1 and would admit of steam being admitted during full-stroke as already observed, if a disengagement gear did not come into play.

For this purpose, a sleeve B is placed over and revolves with the plate A; its form will be seen from Figs. 335 and 336, and its projecting finger N is allowed to protrude beyond the external plate border by about $^1/_{32}$—$^1/_{16}$ in. (1—2 mm.), so that when the latter comes in contact with the slides $n\,n$, it pushes them away from the plate. The moment this occurs, the spring in the dash-pot O comes into action, so closing the corresponding valve. It is evident, that the slide n can be thrown off the border of the plate A at any time, according to the position of the projecting finger N; in other words the range of expansion may be thus determined. For this purpose, it is only necessary to connect the finger N with the governor, so as to obtain in as simple a manner as possible, an Automatic Variable Expansion-gear.

Inside the sleeve B is an additional collar H — Figs. 337 and 338 — revolving with the spindle W and connected with the vertical rods $M M_1$ to the governor. These rods impart to it an additional up and down motion, and as the collar has a groove, into which a pin of the sleeve B gears, it is evident that the rise or fall of the collar H will react on the sleeve B, by turning it either to the left or to the right; this motion naturally implies the earlier or later disengagement of the valve-spindles F or F_1, or what is the same thing, an earlier or later cut-off.

For practical reasons, it appears advisable to make the groove in the collar H as steep as possible, and in the case before us, the total work of the collar would move the finger N to about $^1/_4$ rev. The grade of expansion would therefore lie between 0.0 and 0.5 stroke, which may be taken to suffice in Engines working with Automatic Expansion gears. Still the mechanism allows itself to be applied to later cut-offs, by bolting the finger N to the collar H whereby according to its position, steam may be automatically shut off, between 0.1—0.6, or 0.2—0.7, or 0.25—0.75 stroke etc. if it should appear undesirable to extend the range of expansion, by either prolonging the collar H or by the adoption of other mechanism.

l. Messrs. Pusey, Jones & Co., of Wilmington. (Delaware, U. S.)

(Type: Tremper.)

This Expansion-gear is illustrated in the annexed Figs. 342 and 343. An eccentric-rod is connected with the lever A, which is mounted on the same spindle as the bent lever $B B_1$. The eyes of the latter, form the swing-centre of triggers $N N_1$; the latter alternately raise the piston P owing to the steel plate $o\,o_1$ and as the piston P is rigidly fixed to the valve-spindle F, the valve E is thereby opened. During its rising motion, the trigger-end slides on the wedge M which is kept in position by the governor-spindle R. This wedge forces the trigger off the piston catches P, and relieving the latter, the spindle is free to fall, and to so close the valve. An india-rubber washer O prevents any concussion taking place. As soon as the governor balls have lifted the wedge M to its highest lift, no disengagement takes place, so that the main-slide admits steam up to nearly full stroke.

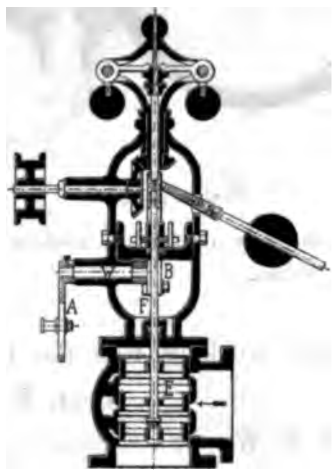


Fig. 342.

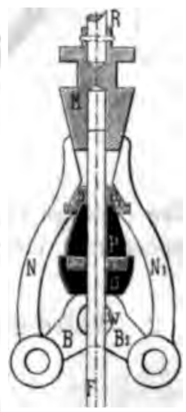
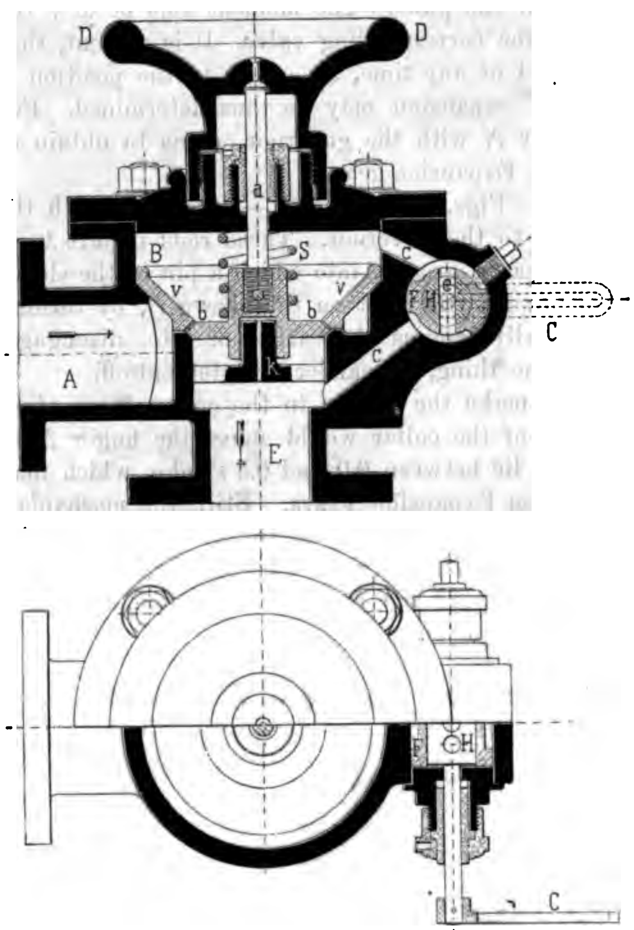


Fig. 343.

m. Rudolf Affeltranger, of Bern.

German Letters Patent were obtained by Rudolf Affeltranger, for the peculiar Expansion-gear shewn in section and in part plan in Figs. 344 and 345.

The apparatus is attached to the valve-chest. The passage of the steam, is indicated by the inscribed arrows. The valve-chest contains a double-seated valve $v\,v$, and the rigid casing F of the cock H. The rod a is screwed fast into the valve v; k is a small piston fitting into this valve.



Figs. 344 and 345.

To start the engine, the hand-wheel *D* has to be turned in order to lift the valve off its seating. The steam in the pipe-connection *A*, thereupon enters the valve, and passes through *E* into the valve-chest. Simultaneously, the steam also comes to play on the upper part of the valve by passing through the passages *b b*, the channel *c*, and cock-way *e*. As these steam-ways are comparatively small in comparison to the steam-pipe, the progress of the steam in them will be gradual, that is to say the pressure of the steam on the top side of the valve will only gradually exert the same amount of pressure as that on the underside. When equal pressures are established, the spiral spring *S* presses the valve on to its seating. In consequence of the communication existing between the inner portion of the valve chest and the capacity *B*, the steam expands in both places.

This arrangement is controlled by contracting or extending, the forementioned steam-channel *c c* through the cock *H*. The latter is moved by the lever *C* placed either in communication with the governor or controlled by hand for a certain expansion-grade. At times of starting with the governor-balls in their lowest position the passage *c c* is fully open, but somewhat contracted when the engine is working at its normal speed and vice versa.

2. Valve-gears, working with the Expansion-valve placed inside the Main-slide chest.

a. Prof. R. R. Werner of Darmstadt.

Prof. R. R. Werner's Expansion-gear is drawn in our Figs. 346—348 and it may be said to share the main advantage over the preceding types, that the additional expansion of the steam in the valve-chest is partially removed, inasmuch as the valve may lie close on or near to the main-slide. This advantage calls forth the constructive difficulty, that the valve is obliged to participate in the movement of the slide, in addition to its own motion.

The governor collar *N* rotates with its two cams, at equal speed with the crank-shaft. The rod *C* has a friction roller *n*, which is kept constantly against this cam-surface, by the spring *S* in the cylinder *O*. But as the rod *C* is connected to the expansion valve spindle *F* by lever *D*, oscillating movement is given to the expansion valve-spindle *F*. The latter carries a lever *L* which opens and shuts the expansion-valve at the bidding of the governor, simultaneously allowing the expansion-valve to follow the motion of the main-slide. Running at 44 revs. the governor allows the latest, whilst the earliest automatic cut-off takes place with 45 revs. of the crank-shaft; hence it is evident, that the range of automatic expansion is confined to a small limit.

b. J. Reusing, of Mülheim on the Rhine.

The Expansion-gear of Mr. Reusing, illustrated in Figs. 349—352 must be regarded as an advantageous solution, of a judicious arrangement of the expansion-valve inside the main-slide.

An eccentric works the main-slide *A*. Admission-motion is imparted to the expansion-valve supported by the main-slide, either by a second eccentric (keyed to the same lead angle δ — Fig. 352 — as the main-slide eccentric), in which case the travel of the expansion-valve is reduced to the extent of the main-slide travel. Or the expansion-valve is worked off the same eccentric, with a travel correspondingly reduced by a combination of levers.

The casing *D* is fixed fast to the main-slide rod by the sleeve *d*, and is guided in the bracket *T*.

The triggers $n\,n_1$ swing on the centres $f\,f_1$ carried by the bar *g*. These triggers are either worked by a separate eccentric, or by the main-slide eccentric by reduced leverages.

By coming in contact with the governor-block *M*, the trigger nibs $n\,n_1$ are knocked out of gear, and the corresponding

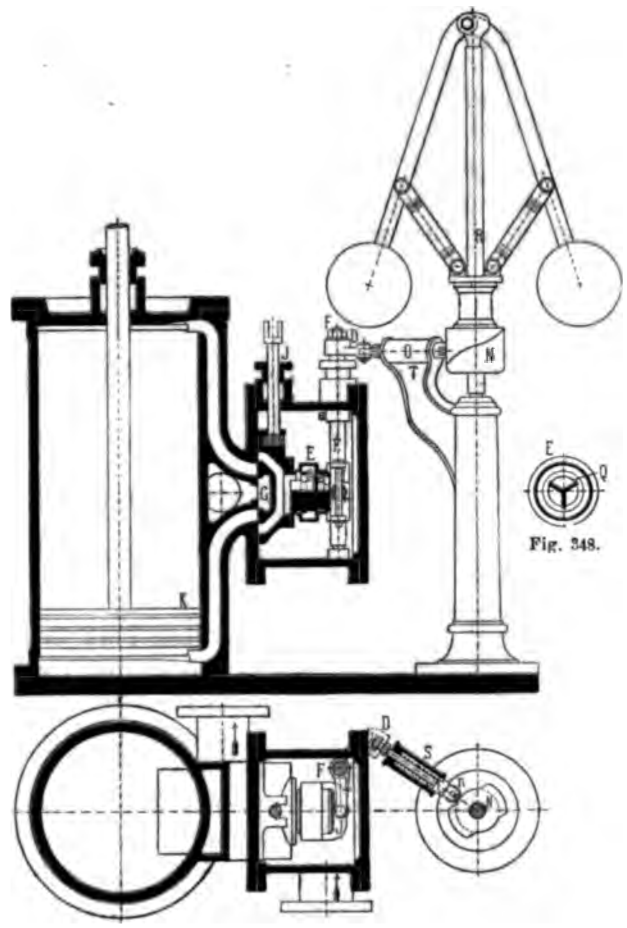
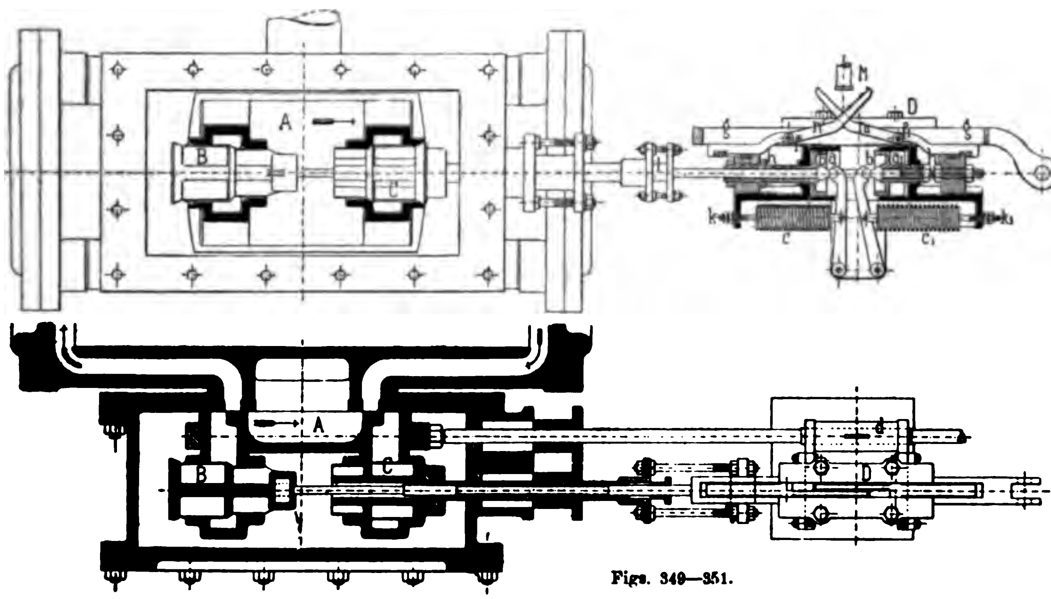


Fig. 348.

Figs. 346 and 347.



Figs. 349—351.

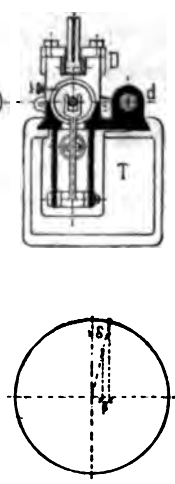


Fig. 352

valves closed. If we assume the slide to be moving in the direction of the inscribed arrow, with the left admission port about to open, then the trigger n_1 has fallen in gear with the catch h_1 attached to the valve B_1 and opened the latter to the extent of β — Fig. 352 —. This opening as well as the compression of the spring c_1 continually increase till the piston has travelled to its other end, provided that the block M has not effected disengagement in the interim. The same action is repeated with the trigger n owing the return-stroke and so on.

Air-cylinders $a\,a_1$ prevent any jarring taking place, and the set screws $k\,k_1$ serve for tightening up the springs $c\,c_1$.

II. Steam-engines, working with four separate valves.

1. Valve-gears with two Admission- and two Exhaust-Valves.

A. Admission-valves, arranged at the side of the Cylinder.

a. Washington Iron-Works, Newburgh (U. S.).

(Type: Wright.)

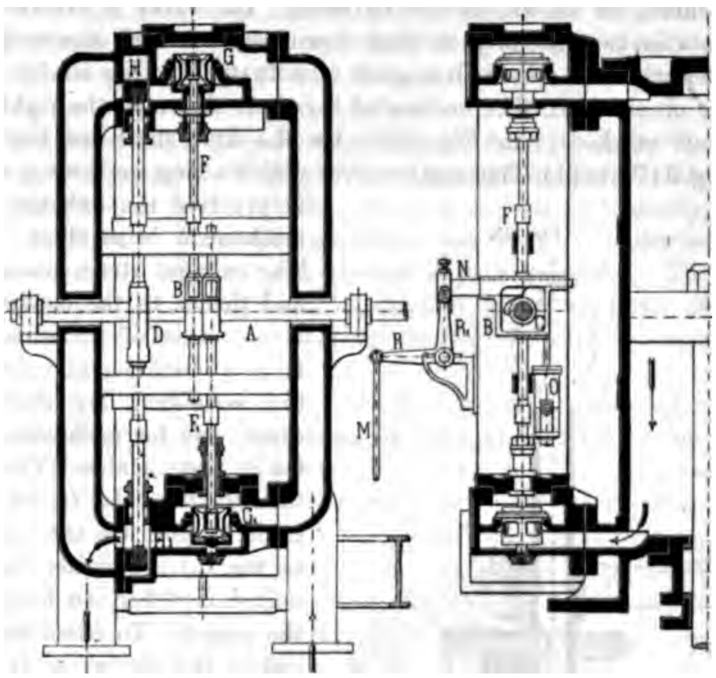
At an Exhibition held at New-York in 1867, an Engine fitted with Wright's Valve-gear, by the Washington Iron-Works, Newburgh received the first prize, as being the best American Engine. Figs. 6 and 7 (Plate 47) shew the general arrangement, whilst Figs. 8—10 illustrate the details of the valve-gear. Two equilibrium valves are arranged at the cylinder-side, working parallel to the cylinder-axis. The exhaust-valves of the grid-iron form, are arranged to the bottom of the cylinder, and receive a continuous motion from a lay-shaft, whereas the admission valves are worked through the hollow spindle M driven by bevel-gear off the shaft A. This spindle has two cam-pairs $e\,e_1$ and $i\,i_1$, the former working the valve-spindle a, and the latter the valve-spindle a_1; these two spindles revolve at $1/2$ crank-shaft speed. The teeth fitted to the internal sides of these cams, gear on to a very broad wheel r keyed on the rod n and revolving inside the hollow spindle M. The upper end of the rod n is connected with the governor, in such a manner at s that it is worked up and down by rise or fall of the governor-balls. The lower end of the rod n is fitted with a grooved cylinder on which the nut p slides up and down. The rod n is thereby made to rotate along with the toothed wheel r; consequently the cam will be brought up closer or further away from the valve-spindle ends. When these cams have glided off the latter, the valves close, owing to the steam-pressure exerted upon them.

The above named Engineering Firm constructs Engines in this type in various sizes ranging from 15 to 1200 *HP*.

b. John Rowan & Sons (Lim.), Engineers of Belfast.

For driving the machinery of a Flax Mill, Messrs. John Rowan & Sons (Lim.), Engineers of Belfast, put down an Engine working with three cylinders independent of each other, though having condenser and air-pump common to all three. This arrangement was adopted with a view of obtaining as steady a speed as possible. The vertical cylinders were worked with a valve-gear corresponding to that represented in Figs. 353 and 354, though the port clearance is shewn greatly exaggerated; the cranks driving these cylinders are set at 120° apart.

The horizontal lay-shaft A extends over the three cylinders and is connected by bevel-gear with the vertical shaft, similarly driven from the crank-shaft. A cam D works the two exhaust-valves $H\,H_1$ the action of the steam pressing the latter on their seatings. Each of the inlet-valves $G G_1$ is driven from a cam-disc C, which rotating with the lay-shaft lifts a frame B as well as the valve spindle F. In order to vary the time of contact between cam-disc C and valve-spindle F, a bolt N is inserted between the spindle and the frame. This bolt is connected with the governor by means of the bell-crank $R R_1$ and rod M, whence it is pushed forwards or backwards. If, therefore the governor has attained its highest position, the bolt M is pulled so far back out of the forementioned frame, that it is scarcely touched by the cam C, consequently the inlet-valve is already closed with the beginning of the stroke. In order to obtain an easy silent working of the valve-gear, dash-pots O are applied and filled with water.



Figs. 353 and 354.

Each of the three cylinders was $22^1/_2$ in. (570 mm.) in bore, and of 4 ft. (1220 mm.) stroke. Beginning to work at 5 atm. pressure cutting off at $^1/_{10}$th stroke, and running at 46 revolutions per min. — equal to a piston speed of 6.1 ft. per sec. — the engine developed 300 *HP*.

c. Hartford Foundry & Machine Co. Hartford (Conn. U. S.).

(Type: Woodruff.)

Figs. 4 and 5 (Plate 47) shews the Engine exhibited at the Centennial Exhibition by the Hartford Foundry and Machine Co., as fitted with the Woodruff Valve-gear. It bears great resemblance in its internal gear to Wright's Valve-motion.

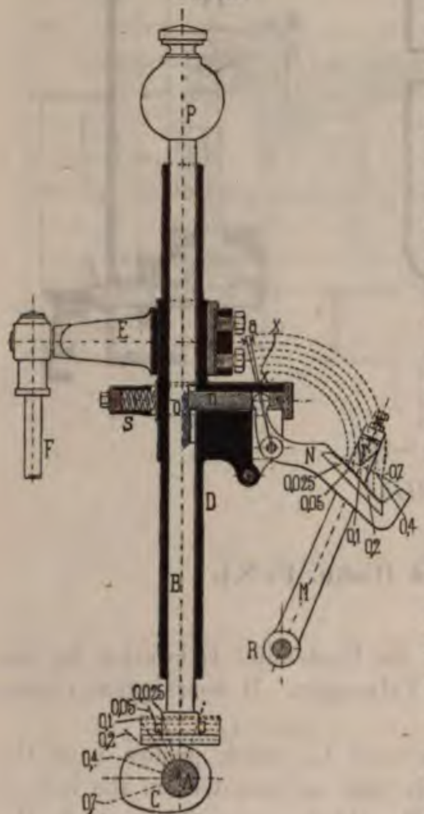
But the admission-valves are now worked off one eccentric C, which pushes back the valve-spindles $F F_1$, so opening the corresponding valves. This cam is mounted on the hollow governor spindle, and rotates at equal speed with the crank. To obtain a variable cut-off, the lead-angle of this eccentric is changed. The return travel of the slides is due to the steam-pressure. The expansion valves are of the grid-iron type, and they are worked by an eccentric mounted on a transverse shaft under the slide-bars.

The very simple and solid appearance of this Engine, is at once apparent from our drawings, which are taken from a 40 *HP* (nominal) engine of 1 ft. (305 mm.) cylinder-bore and 3 ft. (914 mm.) stroke — three times the diam. — Running at 65 revs. per min. the mean piston-speed amounts to nearly $6^1/_2$ ft. (2 m.) per sec.

d. Chr. Nolet, Engineer of Ghent (Belgium).

In 1872—1873, Mr. Nolet's Valve-gear was much discussed by the Engineering press, as it undoubtedly attracted general attention, and still belongs to the most important modern Steam-engine constructions. On Plate 61, we represent a 350 *HP* Horizontal Condensing Engine, constructed by Mr. Ch. Nolet. There are separate exhaust and admission valves at each end of the cylinder. The valve boxes are placed in communication by a pipe, to which the steam pipe is jointed. The exhaust valve consists of a gridiron plate, sliding on the upper surface of a plate secured, as shown, to the cylinder. The valve is driven by a rod, passing through two vertical slots in two blocks projecting downwards through the seat, in a way best seen, perhaps, in Fig. 3. The whole of the valve gear is actuated by lay shafts driven by two equal bevel wheels from the crank shaft. The horizontal lay-shaft shewn to the right in Fig. 3 (Plate 61) drives a second short shaft marked *A* in Fig. 355. On the first shaft are keyed two cams, one of which is shown in Fig. 3 (Plate 61). This cam revolves within a ring on the top of a lever turning on a pin. To this lever is pivotted the exhaust-valve rod. The action of this piece of mechanism is so clear, that no further description is necessary. The exhaust steam passes off to a feed heater in the engine bed and thence to the condenser.

Fig. 355.



One of the steam valves is shown in Fig. 3 (Plate 61). It is a double-beat valve of large diameter and small lift. On the secondary lay shaft *A* — Fig. 355 — are keyed two cams, one for each steam valve; one of these is shewn at *C*. On it rests a shoe. This shoe carries a rod *B* which passes up through the tube *D*, which rod moves up and down in two suitable guides. On the tube is fixed the arm *E*, which is secured to the valve spindle. So long as the tube *D* and the rod *B* are united together, so long will the valve derive its motion from the cam *C*. To effect this union the detent *n* is employed. The end of this detent is drawn into a notch *o* excavated in the side of *D* by a coiled spring, which works within a kind of stirrup, the foot-piece of which rests on the head of *n*. The lever moves bodily up and down with *D* in a way easily understood. It is obvious that if the long end of the lever were forced down, the short end would pull the detent out of the notch *o* in *D*; but *N* will be forced down if, while its fulcrum is rising with *D*, something comes in contact with it. This something is the touching piece — or "taquette," to use the expressive French name — *r* on the end of an arm *M* which is actuated directly by the governor as clearly shewn in Fig. 3 (Plate 61). According to the position assumed by this arm, so will the cut-off take place later or earlier.

Fig. 356.

The action of the gear is as follows: The detent *n* being lodged in the notch, *o* as the cam rotates it will lift *B* and with it *D* and *N*, until *N* comes against *r*; then, as *D* continues to rise, *n* is withdrawn from the rod, and the valve drops, and steam is cut off. The shock is taken up by an air dash-pot, a second dash pot being used to steady the governor. At the moment contact is made between *r* and *N* the valve will not close, because a little delay must take place, while *n* is being pulled out of the notch. Therefore, for a cut-off at one-fifth, the contact between *r* and *N* must occur a little too soon. Bearing this in mind, it is very easy to draw the curves marked with fractions 0.025, 04, etc. etc., and thus to proportion the governor gear.

The upper end of the lever *N* is shaped as shown, in order that if a belt broke or other accident occurred, which might set the engine racing, on the governor flying open, *r* would at once force down *N*, and so totally cut-off all steam from the cylinder. On the other hand, if the governor gear failed, then r would fall down till it caught the raised end of N, and would in the same way hold it down, and prevent the admission of steam to the cylinder.

We may state that M. Nolet uses sliding valves for the exhaust, because he finds that they will not score; for high-pressures he uses double-beat valves, which remain tight for two years and often much more, and which can be made tight at any time in a couple of hours by grinding.

This description borrowed from "The Engineer"*) may be supplemented with the following additions: The form of the cam D has been so chosen, as to cause the valve to lift very rapidly up to about 0.3 stroke; from this piston-position up to $^7/_{10}$ stroke, the rod B lifts but slowly, though sufficient to allow the governor to engage. The curve xx above the lever N, indicates the valve lifts, corresponding to the positions of the trigger r for various expansion-grades. The valve-lift, which must take place during the gliding off of n and o, — i. e. when the lever N is held fast by the trigger r, — is similarly indicated for various expansion-grades, by the arcs included by the angle marked a.

The Engine illustrated on Plate 61 has a cylinder-bore of 2 ft. 8 in. (815 mm.) and a stroke of 5 ft. (1525 mm.). The steam-pipe is $8^5/_8$ in. (220 mm.) diam. or $^1/_{13\cdot7}$ part of the piston-area; the pipe leading to the condenser is 11 in. (280 mm.) diam. or $^1/_{8\cdot4}$th of the piston in area.

The Condenser and the Air-pump merit further attention. Prior to the spent steam entering the condenser, it passes through a horizontal cylinder to heat the feed-water, circulating for this purpose through a pipe-coil in this cylinder; by these means, the feed-water is raised to double the pump temperature. This feed pump is $4^3/_4$ in. (120 mm.) diam. and has a stroke of $11^1/_8$ in. (283.5 mm.). The vertical single acting air-pump is driven by a bell-crank and separate connecting rod off the crank-pin; its diam. is 1 ft. $10^1/_2$ in. (570 mm.) and its stroke is 2 ft. $3^3/_4$ in. (704 mm.) consequently its capacity stands to that of the steam-cylinder in the proportion 1:4.4.

The slide-bar casting, of ⊨ section, is bolted both to the cylinder-cover and to the crank-shaft pedestal. The connecting rod is made five times as long as the crank, and the Engine is placed under the control of an ordinary Watt's Governor.

B. With Admission-valves, placed over the cylinder.

a. Em. Walschaerts, Engineer of Brussels.

The Firm of Em. Walschaerts was represented by a 30—40 *HP* (nominal) Horizontal Engine at the Paris Exhibition of 1878, the general arrangement of which we represent in elevation and in end-view in Figs. 357 and 358. It was used at Paris, for driving the machinery in the Belgian section.

Following the description given by "Engineering"**) the special feature about this type of engine, which is of simple and straightforward design, is its steam-distributing apparatus. The cylinder is jacketed, steam passing through the jacket on its way to two admission valves, which are of the double-beat type, placed on the top of the cylinder. These valves are opened by eccentrics upon a revolving longitudinal lay-shaft by the action of a catch forming part of the eccentric rod, upon a small plate attached to the outer end of a horizontal lever, whose inner end lifts the valve. By the intervention of the simple gear, shown in Fig. 358 the position of the eccentric rod is determined by the governor, and the different parts of the gear are so proportioned, that

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*) d. 28 March 1879, pg. 229.

**) d. 10 Jan. 1879, pg. 29.

any change in this position, affects only the time of disengagement, and not that of admission. As soon as the catch is tripped, the valve is shut by a spring in the usual way. It will be seen that the whole gear very closely resembles the Sulzer gear in its original form, though it is somewhat simplified. Instead, however, of using similar valves for the exhaust, M. Walschaerts employs grid-iron slides, placed below the cylinder, and connected together and worked simultaneously by a single spindle (Fig. 357). These valves receive motion only towards each end of the piston's stroke, remaining stationary in one or other of two positions during the rest of the time. On the underside of the piston-rod head are formed two inclined planes, one of which, at each end of the stroke, comes in contact with and presses down a roller upon the end of a rocking lever, which is in the fashion shown in Fig. 357, connected to the valve spindle. The gear is arranged so as to work at any cut-off between 0.0 and 0.85 of the stroke. There is a special connexion with the governor provided, which at once cuts off steam in the event of the governor ceasing to act through any cause.

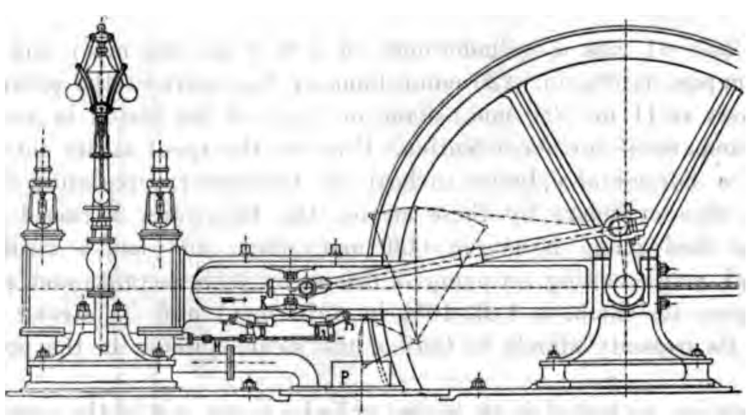
Fig. 357.

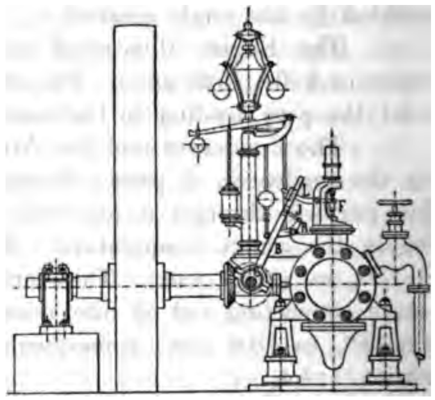
Fig. 358.

The condenser and air pump are placed below the bed-plate. The pump is single-acting, worked from the crank-pin through the system of levers, whose centre lines are shown in Fig. 357. The vacuum attained is said to be very good.

M. Walschaerts has supplied a number of engines contructed upon the system illustrated to manufacturing firms in Belgium. The largest size made has been 200 horse power, and trials upon this engine have, we are informed, shown its consumption to have been only 0.82 kilos. (1.8 lb.) of common coal per indicated horse power per hour, including all fuel burnt during stoppages. We have before us, however, only the broad results of these trials, and not the particulars of them. The ratio of brake to indicated horse power was over 90 per cent. Considerable pains seem to have been taken in designing the engine to make all the parts accessible and easily removable, in the event of any change being required.

b. Socin & Wick, Engineers of Bâle.

The Engineering Firm of Socin & Wick, also exhibited a Horizontal Engine at the Paris International Exhibition of 1878, the admission valves of which were of the Sulzer-type, whilst Nolet's arrangement of Exhaust-valves was adopted. Plate 62 represents this Engine.

The crank-shaft drives a horizontal lay-shaft at equal speed with itself by a pair of bevel-wheels. As in Nolet's arrangement, this lay-shaft moves a secondary lay-shaft by equal spur-gearing. Four eccentrics are mounted on this shaft *A* — Fig. 7 — which work the four-valves. The opening of an admission valve, follows with the downward motion of its corresponding eccentric-rod *B*, whereby a steel plate *n* fastened to the upper-end of *B* presses down the short arm *D* of a bell-crank DK — vide Fig. 5 —. The long arm of the latter carries a friction-roller r which presses on the steel-plate u of the valve-spindle lever LL_1. The surface of this steel-plate u is peculiar, inasmuch as its outer end is inclined to the friction roller, whilst its remaining curved-surface has its centre coinciding with the swing centre of the bell-crank DK. Therefore, as soon as the friction-roller r begins to glide over the steel-plate u, the lever-arm L is pressed down, the valve continues to lift, till the friction-roller rolls on the cylindrical surface of this plate u. When this occurs, the valve will naturally remain stationary, till disengagement ensues between the eccentric rod B and the lever arm D, whereupon the admission valve will rapidly close. The closing of the valve is effected by a spiral-spring, which has been previously compressed by the ascending motion of the valve-spindle. On referring to Fig. 3, it will be seen that the spring is compressed both from its top and its bottom. The pressure exerted on the spring bottom, ceases to increase however as the friction roller has glided on to the cylindrical surface of the plate u. The disengagement between eccentric rod and lever arm D is effected by the governor, inasmuch as it determines the distance of the admission eccentric-rod from the lever-arm D so that at a certain time the edge of n — which as Fig. 7 shews describes an elliptical curve — may be relieved from the lever arm D. The distance can be varied, owing to the connecting link J between the rod B, and an eccentric M keyed on the expansion-shaft R under governor-control.

The peculiar form of the steel-plate — called "Transporteur" by the makers — is due to the hitherto ignored defect of most Engines, namely that the admission-passages corresponding to high and low expansion-grades are made too large or too small. This defect is remedied by this valve-spindle motion-transmitting apparatus, inasmuch as with early cut-offs from 0.0—0.15 stroke, the valve is continuously rapidly lifted, whereas during later cut-offs the valve remains in a certain position, the lift of which, corresponding to the valve diameter, gives exactly the required steam-passage area. The double compression of the spiral spring before alluded to, meets another objection, namely that the pressure on the springs increases to too great an extent with late cut-offs, so that the beat of the valve is far greater with late than with early cut-offs. In the present arrangement, on the other hand, the spring is only compressed from both ends up to 0.15 stroke, after which the lower pressure ceases entirely leaving only the upper pressure to come into play; in addition the top and bottom of the spring-boxes act as air-cushions, so ensuring a steady motion. The exhaust valve eccentrics, are worked by interposed eccentric, as the ordinary lever arrangement would not look so well, on account of the small distance of the exhaust valves from the cylinder centre.

The Engine exhibited was of $14^3/_4$ in. (375 mm.) diam. and 2' $11^1/_2$ in. (900 mm.) stroke; it ran at 65 revs. per min. so yielding a mean piston-speed of about $6^1/_2$ ft. (1.95 m.) per sec. The cylinder is composed of several parts, as shewn in Figs. 3 and 4, it is jacketed and lagged. The fly-wheel is arranged for rope-driving, and a cosine-governor controls the Engine-speed.

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2. Valve-gears, shewing two differently combined Admission and Exhaust-valves.

a. Bolzano, Tedesco & Co. of Schlan (Bohemia).

(Type: Regnier.)

Regnier's Valve-gear motion, as applied by Messrs. Bolzano. Tedesco & Co. of Schlan, is exemplified on Plate 63.

A horizontal lay-shaft is here driven at double crank-shaft speed by bevel-wheels off the latter; this lay-shaft drives, the vertical governor-spindle, by a pair of equal bevel-wheels. The latter imparts equal crank-shaft speed to two lay-shafts arranged transversely over and under the cylinder. The admission valves are of the piston-type, and are worked from the upper transverse shaft.

The mechanism will be best explained by Fig. 6, where it will be seen that the upper shaft carries a crank *C*, which can revolve inside the frame *B*; the latter can only slide horizontally whilst its internal slide *D* may in addition move up and down. The slide *D* carries catch-plates OO_1 at each side, which with the slide, describe a circular pathe qual in radius to the crank-length. The spindles FF_1 of the piston-valves GG_1 are swelled, so that the pressure of the steam tends to push them in the direction of the inscribed arrows *pp*. The shoe of each valve-spindle, is furnished with a vertical slide NN_1 to which the additional catches nn_1 are fitted; these slides NN_1 are under governor control through the rods MM_1.

The valve-gear is shewn in its central position, whilst the crank *K* is still, to the extent of its lead-angle δ away from its dead-centre. In this position, and in the indicated direction of motion, the catch *o* is pushing the plate *n* in front of it, whereby the piston-valve *G* will open the port *E* after travelling to the extent of its lap. But as the edge of the catch *o* describes the circular path, shewn in dotted lines, and the motion of *n* is confined to a horizontal movement, at a certain time, the edge of *o* will glide off the catch *n*. The piston-valve *G* then follows the direction of the steam-pressure *pp* and closes the port. Simultaneously the slide *D* continuing its motion, brings the catch o_1 in gear with n_1, to repeat the foregoing action on the piston valve G_1 during the next stroke. In the position the catch-plates nn_1 are drawn in our engraving disengagement or cut-off would take place at $\frac{1}{4}$ stroke. If on the other hand, the plates *n* and n_1 are pushed up to *x* and x_1 by the action of the governor, then *n* and *o* no longer come in contact, and the cut-off = 0. The more *n* and n_1 are raised or lowered, the longer does engagement last, consequently the valve will close later. The shifting of the plates nn_1 can naturally also be done by hand. The constructive details of this part of the mechanism will be seen from Fig. 7. The prolonged ends of the valve-spindles are furnished with air-buffers, the arrangement of which is fully shewn in Fig. 1, and this remark also holds good, with regards to the grid formed exhaust-valves worked off a heart-cam (cardioide).

The cylinder-bore of this Engine was $12^1/_2$ in. (320 mm.); its stroke 2 ft. $7^1/_2$ in. (800 mm.). The steam supply pipe enters the cylinder from the side; its diameter was $3^1/_8$ in. (80 mm.) or $^1/_{16}$ the cylinder cross-area. The exhaust pipe, joining one of the cylinder-legs is 4 in. (100 mm.) in bore or $^1/_{10}$ the cylinder bore-area. The piston construction is shewn in Fig 8, and Fig. 7 shews the constructive details of the valve-gear. The piston-valve — where two ports — exist may also be arranged as drawn in Fig. 9. The crank-shaft pedestal is illustrated in Fig. 7. The fly-wheel was 8 ft. 10 in. (2.7 m.) diam. and $15^3/_4$ in. (400 mm.) on the face. A parabolic governor is used; a later improved construction of the latter is drawn in our Fig. 5. Attention may also be given to the lubricating plan adopted for the lower lay-shaft; for we find that a wrought iron ring in the middle of the bearing is made to dip in oil, so ensuring constant lubrication whilst running.

b. Hick, Hargreaves & Co., Engineers of Bolton.

An original arrangement of the steam-cylinder-valves, reminding one of the Bède & Farcot type*), designed with the special purpose of reducing clearance-spaces, is drawn in our Fig. 359. Admission of the steam to the cylinder is effected by ordinary Corliss-valves, whereas flat stamper valves are used for the exhaust. This arrangement has been patented**) by Messrs. Wm. Hargreaves & Wm. Inglis, both of the above mentioned Firm, and will no doubt be found most advantageous, in cases where the steam in the cylinder, is allowed to expand close up to at-

*) See pg. 76.
**) Blue-Book Specification No. 3340. A.D. 1877.

mospheric pressure, as the opening of the stamper valve will then offer the least resistance owing to the reduced steam pressure on its inner face. This Valve-gear has been successfully applied to Engines working at 75 revs. per min., though higher speeds are probably equally available, because the flat stamper-valve may be quietly and slowly opened and quietly and slowly shut, whilst the motion in the interval may be as quick as desired. Were the stamper-valve used for the steam-inlet, it would on the contrary be compelled to shut quickly, and this would necessarily limit the Engine-speed.

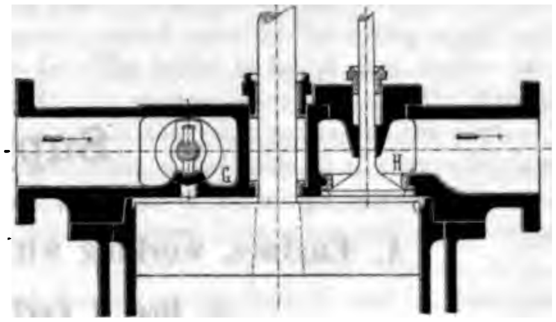


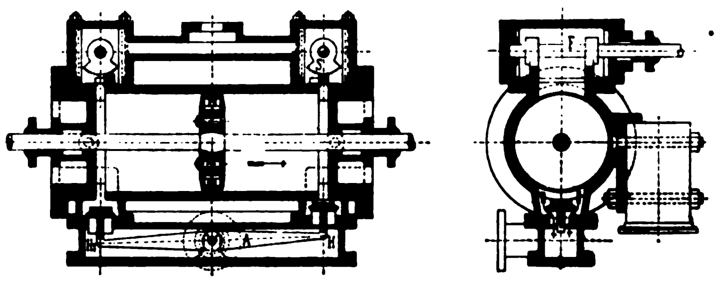
Fig. 359.

c. Fr. Schmid, Engineer of Neustadt-Magdeburg.

In Figs. 360 and 361, we represent what Mr. Fr. Schmid, its Patentee, is pleased to call an "improved Corliss Valve-gear", inasmuch as the attempt has here been made of obtaining a quicker exhaust than is otherwise obtained, by employing two self-acting exhaust-valves $H H_1$. The fresh steam entering the cylinder, closes the exhaust valve on the steam admitting cylinder side. As the two exhaust valves are connected together by an oscillating beam A, the other emission valve is simultaneously lifted, so that the steam may escape from the other cylinder-end.

The patent lays further claim to regulating the steam-supply by flat-slides, worked off toothed segments S keyed on the valve-spindle F. The reader will remember, that we met a similar arrangement in Nemelka's Valve-gear which we described on pg. 176 and illustrated on Plate XXIII.

The admission-valves may be worked by any trip-gear mechanism.



Figs. 360 and 361.

It is very questionable, whether the forementioned automatic action of the Exhaust really is an improvement, for no doubt a waste in the simultaneous discharge of fresh steam must take place with each stroke. Apart from this consideration, which in itself will probably outweigh any advantage gained, no compression can take place, hence this valuable factor for obtaining quiet running etc. is also entirely lost.

Supplement.

A. Engines, working with Corliss-valves and Trip-gear.

a. Geo. H. Corliss, Providence (U. S.).

New as the two last Valve-gears of Mr. Geo. H. Corliss, may be to many our readers, still they are not the latest improved constructions of this genial inventor. He lately patented a modified valve-gear, the main advantage of which, is the avoiding of the uneq expansion of the steam, on the two cylinder-piston sides. That, Corliss is not the only one, has solved this problem, may appear superfluous to add, for in discussing various valve-gears,

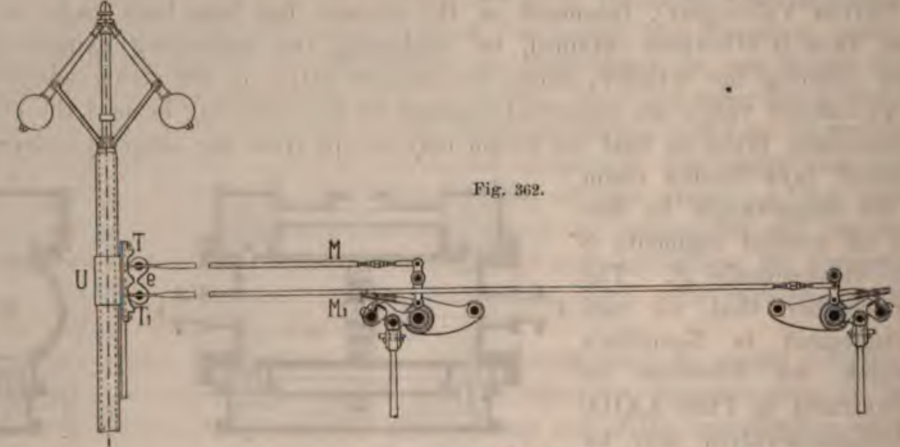


Fig. 362.

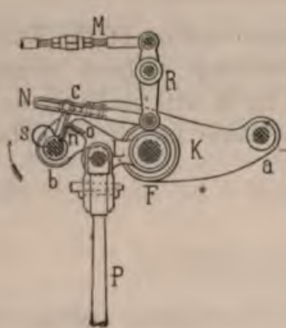


Fig. 363.

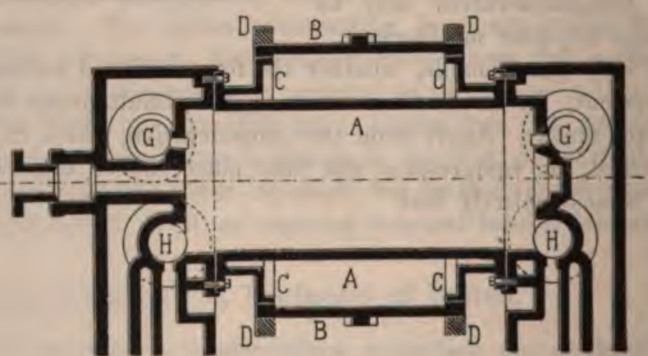


Fig. 364.

have already observed, that regard has been paid to this question by several Engineers. A rule, the unequal piston-motions were compensated for, by giving different forms to the gover knocker-offs, so that the two admission valves on each cylinder-side, shut-off steam, when piston was exactly at equal distance, from one stroke end as it was from the other.

In the latest Corliss-valve gear, patented last year (1879), and which we illustrate Figs. 362—364, we similarly find a uniform steam-supply obtained by unequal governor knock off gear. In Fig. 363, *F* is the valve-spindle carrying the lever *K* loose, the eye *a* of which connected in the usual manner, by a rod to the rocking plate. Consequently, the lever K oscillates; when the lever-eye b is in its lowest position, its trigger n acted upon by the spring s will come to lie under the steel-catch o of the stationary lever L. The latter is keyed fast to the valve-spindle, and can be pulled down by the dash-pot rod P. If, motion takes place in the direction of the inscribed arrow, the lever L is turned accordingly, and the valve opens out the port.

Simultaneously the eye C of the trigger n, glides in the closed slide of the lever N; when the end of this slide is reached, the continued motion of the lever K brings about a change in the position of the trigger, which ultimately causes disengagement between n and o, whereupon the valve closes in the ordinary way.

Variable expansion is obtained, by a horizontal shifting of the slide N, and for this reason the latter is linked to the double lever R placed under governor-control, owing to its connection with the governor-rod M; automatic disengagement therefore ensues, when the governor reacts on the trigger n through the last mentioned mechanism. But in order to equalise the unequal piston travels, the governor-collar U carries two unequal cams $T\,T_1$ with which the forementioned rods $M\,M_1$ of the opposite cylinder-end are in contact. These ends are flattened, and slide at e in small guides. No special mechanism is required to keep the rods M or M_1 in contact with T or T_1, for this is already secured by the power required for disengagement purposes.

Respecting the machinery parts, likewise patented by Mr. Corliss, we may note the new cylinder, longitudinal section of which, is drawn in our Fig. 364. It consists of the actual cylinder A and its separately cast jacket B. The flanges of the cylinder are cast with rectangular formed rings $C\,C$, to which the jacket is bolted. These rectangular rings serve the purpose, of meeting the radial and axial expansion of the cylinder. $D\,D$ are two contraction rings placed outside, and the rectangular rings $C\,C$ similarly allow the steam-jacket to expand in the direction of the whole length of the cylinder.

With regards to the valve-chest G and H, our woodcut shews that Bède & Farcot's arrangement has been here re-introduced.

On Plate 64 we publish drawings of a Compound Pumping Engine designed and constructed with this Valve-gear, for the Water-works at Pawtucket, Rhode Island (U. S. A.) by Mr. George H. Corliss, of Providence. In addition to its Valve-gear, this construction presents many interesting details. The two horizontal cylinders are 15 in. (380 mm.) and 30 in. (762 mm.) bore, and have each a stroke of 2 ft. 6 in. (762 mm.). The governor, common to both, runs the engine at 52 revolutions per min. which corresponds to a mean piston speed of 4 ft. 4 in. (1.32 m.) per sec.

The pumps are double acting plunger-pumps, with the plungers attached to the prolonged piston-rod; their diameter is 10$^1/_2$ in. (267 mm.), and the piston-rod is 2$^1/_2$ in. (63 mm.) diam. The suction and delivery pipes are 15 in (380 mm.) diam. The end of the piston rod is connected by a short rod to a peculiarly formed rocking lever. The lower portion of this lever consists of a cast-iron segment, whereas its upper part is enclosed by four wrought iron rods. They are coupled with the cranks on the ends of the fly-wheel shaft by connecting rods. The fly-wheel shaft rests on bearings carried by the pump castings. The fly-wheel is 18 ft. (5.48 m.) in diameter. The construction of the fly-wheel is also patented, and consists of six equal parts, each forming a part of the boss, wheel-arm and a segment of the rim. These parts are connected by screw-bolts, working in radial flanges.

The air pump, which is 20 in. (508 mm.) diam. and of 7$^1/_2$ in. (190 mm.) stroke, is arranged vertically under the engine-floor, and is driven by a rod linked to the side of the forementioned cast-lever.

Some additional interesting particulars of this Engine or rather of working-results obtained, were published, towards the end of last year by Engineering*) though our contemporary, is evi-

*) d. 5 Sept. 1879 et seq.

dently in error, when it states that this Engine is fitted with valve-gear ot the *same pattern* as Mr. Corliss applied to his large engine at the Philadelphia Centennial Exhibition of 1876. As an example of American go-aheadism, the present engine is said to cover no less than thirteen different patents!

b. Pr. Van den Kerchove, of Ghent.

These Engineers were the first, to introduce Corliss engines into Belgium and Holland. They have constructed many of these Engines — amongst which are some very powerful constructions — chiefly of the earlier Corliss-types. Of late years, they have however, adopted the VI Corliss valve-gear with some modifications, as illustrated on Plate 64, by a pair of Beam-engines.

A glance at these drawings will shew, that this Engine merely differs in certain minor details from the original Corliss-engine of the Philadelphia Exhibition — vide Plate 1 —; the valve gear, has however been altered to our designs Figs. 7—10.

The rocking-plate, placed somewhat to the side of the cylinder centre, is of peculiar form. For admission purposes, it gives motion to the cast iron double levers $B B_1$ which do not oscillate on the valve-spindles but on a special stud. To its shorter arm B, a flat bar C is suspended the lower end of which, rests on a cross-piece H of equal thickness. Both parts can slide freely in a slot of the dash-pot piston Q. The same stud of the lever B, also carries a flat rod J, the lower end of which, is fitted with a projecting steel nib n, gearing on to a steel catch plate rigidly fixed behind the buffer-piston, a flat spring being applied as usual. The lever L mounted on the valve-spindle is rigidly connected with the dash-pot piston Q by the rod P. The valve-spindle bracket has another stud on which the lever R is mounted; the latter is connected with the governor by the rod M, whilst it carries a pin r about its middle, which at proper times comes in contact with the forementioned rod J, and causes disengagement to ensue. To understand the action of these mechanical details, let us look to the position of the mechanism represented in Fig. 10. The valve has here closed the steam-port, the spiral spring S in the dash-pot is in its expanded state, and the lever B as well as the flat rods C and J are in their highest positions. With the downward movement, the spiral spring S becomes compressed by the cross-piece H and rod C, whilst n and o are approaching to each other, ultimately engaging themselves; our Fig. 9 corresponds to this position.

The ascending movement of the lever B simultaneously raises the dash-pot piston, and consequently also the lever L, so turning the valve. When the rod J becomes disengaged, the dash-pot piston Q falls, — because the spiral spring is pressing against its bottom — and pulls the valve round to its closed position.

This valve-gear differs therefore from the VI Corliss-valve-gear, that in the place of a vacuum, spiral pressure is again employed, spring-compression taking place during the return travel of the mechanism. This arrangement is specially valuable, on account of the spring being always uniformly tensioned, or always working with equal force, independent of the cut-off.

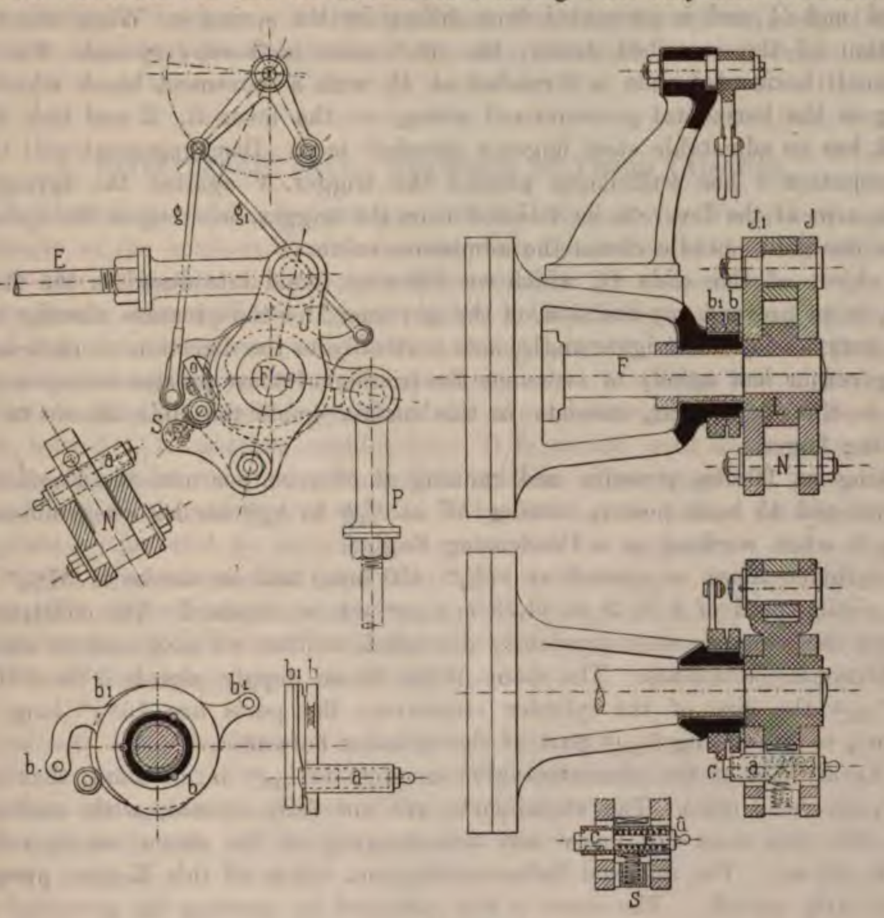
The cylinders illustrated on Plate 64 are each 3 ft. 10 in. (1170 mm.) bore and of 10 ft. (3050 mm.) stroke. The cranks run at 30 revs. per min., so giving off a mean piston-speed equal to 9 ft. 10 in. (3 m.) per sec.

The steam-cylinders are not jacketed. The valves are arranged as in the horizontal type, and in addition a capital practical hit has been obtained in the exhaust portion, inasmuch as during the half-motion of the valve, a double passage is offered to the spent steam, as our Figs. 6 and 7 clearly shew.

The crank-shaft, of Krupp steel, is 1 ft. 11 in. (583 mm.) in diam. swelled to 1 ft. 9 in. (533 mm.) at its bearings. It carries a toothed fly-wheel in the middle, the rim of which is composed of ten segments. The arms are bolted to the rim, and firmly wedged in the wheel-boss. The fly-wheel ft. (9.144 m.) in diam. and weighs about $108^1/_5$ tons (110.000 kg.). Its maximum power is at 3000 *HP*, which is transferred on to a mortice wheel of 9 ft. 10 in. (3 m.) diam.

c. J. Joseph Leon Farcot of Paris.

Mr. Farcot has taken out a German Patent for a new disengagement-gear, allowing a of expansion between 0.0 and 0.8 stroke for working with only one eccentric.



Figs. 365—371.

As the complicated nature of this mechanism, will probably present its further application ntent ourselves here by illustrating the same in Figs. 365—371. It serves as an additional of the zeal displayed in attempting to extend the range of automatic expansion, available *one* eccentric.

ngerhauser Actien-Maschinenfabrik und Eisengiesserei — Formerly Messrs. Hornung & Rabe — of Sangerhausen.

(Type: Kliebisch.)

We described on pg. 69 Kliebrich's Automatic Variable Expansion-gear, and as in a quent application to a 45 *HP* Horizontal Engine, the same Valve-gear has received such d improvement, we feel called upon to illustrate the latter on Plate 66.

The same principle has been retained, and this remark applies equally to the general design as our Fig. 1—3 (Plate 65) conclusively prove. It is the disengagement-gear however, which has assumed quite a different form as our Fig. 6 indicates. As in the first named arrangement, a transverse lay-shaft carries three eccentrics, one of which drives the two exhaust valves, whilst the other two each drive one admission valve.

The admission eccentric-rod A is linked to a cranked lever B; the other steel-armoured arm of the latter gears on the wedge formed trigger N, which articulates in a slot of the dash-pot piston-rod end C, and is prevented from falling by the spring s. When the eccentric moves in the direction of the inscribed arrow, the inlet valve is thereby opened. For disengagement purposes, a small horizontal slide is furnished at D, with a movement block which slides to and fro, according as the horizontal governor-rod acting on the lever R_1 R and link E, desires it to do; this block has an adjustable steel finger r attached to it. Disengagement will therefore ensue, when this projection r has sufficiently pressed the trigger N against the spring-pressure s, to cause the free arm of the lever to be relieved from the trigger, whereupon the spring in the dash-pot acting on the valve-spindle closes the admission valve.

The object of the slide D, which we likewise found introduced in the Marky & Schulz Valve-gear *), is to prevent any reaction on the governor; for the pressure already largely reduced through the acuteness of the trigger-angle, acts vertically to the direction of motion of the fingers so that the governor has merely to overcome the friction of these pressure-components. The chief improvement in this Valve-gear, consists in this certain guide the slide affords to the block and to its projecting finger.

Working at 90 lbs. pressure and running at 55 revs. per min. the Engine drawn on our Plate 65, developed 45 horse-power, cutting off at $^1/_4$th to $^1/_5$th stroke when non-condensing, and at $^1/_8$th to $^1/_{10}$th when working as a Condensing Engine.

The cylinder diam. is quoted at $17^3/_4$" (450 mm.) and its stroke is $37^1/_2$" (950 mm.), so that a mean piston-speed of 5 ft. 9 in. (1.75 m.) per sec. is obtained. The constructive details of these parts are the same as were previously discussed, so that we may content ourselves by adding a few additional particulars. The diam. of the steam supply pipe is 5 in. (125 mm.) so that its bore is $^1/_{13}$th the size of the cylinder cross-area; the ports are $16^1/_8$" long $\times$ 1 in. wide (410×23 mm.), so presenting $^1/_{17}$th part of the cylinder bore-area.

The lineal lead of the admission-valve amounts to $^1/_{16}$th in. (2 mm.); that of the exhaust-valve $^3/_{16}$—$^1/_4$ in. (5—6 mm.). The steam-ports are not fully opened, with earlier cut-offs than $^1/_4$th stroke, still this does not cause any wire-drawing of the steam, as its velocity does not exceed 195 ft. (30 m.). The annexed Indicator-diagram, taken off this Engine, proves its superior working with early cut-offs. The curve a was obtained by pressing the governor done by hand, when the Engine was running at 80 revolutions per min. with a boiler-pressure equal to 4.4 atm. (66 lbs.). When merely driving the shafting, the steam expanded below atmospheric pressure, as shewn by curve b; in this case the pressure in the boiler was 4.65 atm. and the number of revs. 60. The waved portion of these curves is due to the vibration of the indicator-spring. The range of expansion is limited to $^3/_4$ stroke. The exhaust pipe is 6 in. (150 mm.) diam $= ^1/_9$ cylinder cross-area; the exhaust passages are $16^1/_8$ in. long $\times 1^3/_8$ in. wide (410×34 mm.) and stand thus in the proportion of $^1/_{11\cdot5}$ to the cylinder bore-area.

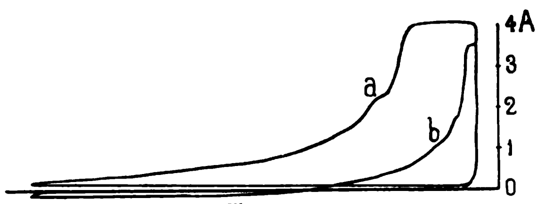


Fig. 372.

*) see pg. 66.

The connecting rod is 8 ft. $1\frac{1}{2}$ in. (2480 mm.) long or 5.22 times the crank-length; it is ıade strongest at about $\frac{1}{3}$ of its length from the crank-pin end. Crank-shaft is 9 in. (230 mm.) diam. and slightly reduced where it fits in the crank. It carries a flywheel of 13 ft. (4 m.) in am. mounted in two parts, and of $16\frac{1}{8}$ in. (410 mm.) on its face. The power is taken off, by a tton-belt $11\frac{7}{8}$ in. (300 mm.) wide.

The valve-gear motion rods are all made adjustable by screw-joints. The Pröell governor driven at 107 revs.

This Engine-type, displays a well thought-out design, and may unquestionably be classed ıongst the most important constructions of the day, controlled by automatic variable expanon gear.

e. Berger André & Co., Engineers of Thaun (Alsatia).

In their patented Corliss-engine arrangement, this Engineering Firm, have sought to comne the advantages of the ordinary Corliss-engine, with the merits of the Wheelock engine-type, far as regards the external motion of the admission from the exhaust-valves.

We have drawn one of Messrs. Berger André & Co's Valve-gears on Plate 64.

The tail-end of an eccentric, articulates a treble lever A, which is mounted on a hollow indle forming the prolongation of the valve spindle bracket T — Fig. 4 —. The lever L carried the exhaust-valve spindle is rocked by a stud on the oscilating lever A. The arm B of the ter is linked by rod C to another rocking-lever D furnished with the trigger N for working admission-valve, and also mounted on a hollow spindle. This trigger N gears on to a discgment G keyed fast on the inlet-valve spindle. The last named hollow spindle or stud, carries loose finger-plate r connected by suitable link-gear, with the governor. As soon as the catchate o of the trigger, comes in contact with the finger r, the trigger becomes raised, and disengement ensues. The shut-off action is effected by the previously described Corliss vacuum piston. ould the strap driving the governor break, by some mishap or other, a second finger r_1 comes contact with another catch portion of the plate, so equally raising the trigger, and shutting steam.

The third arm H of the lever A is connected with the other exhaust valve lever — of nilar design to the preceding A —, where the same mechanism is repeated.

Though this arrangement dispenses with one wrist-plate, and only uses three motion-rods peculiarly complicated form of the levers, renders the external valve far more intricate than Wheelock-gear.

B. Engines working with Rotary-valves.

a. Waldemar Fritsche of Breslau.

The special advantage of the Rocking-valve gear designed by Mr. Waldemar Fritsche of eslau, consists in its allowing a higher Engine-speed than most of the other rocking-, lifting- or ding-valve gears permit.

As the annexed Figs. 373—375 shew, this arrangements consists of two admission and o exhaust valves, placed in regards to the cylinder, similar to the Corliss-style. The revolving lves are cylindrical in form, and are each fitted with three steam-passages. The pressure of the am, merely presses the valve against its somewhat protruding part-seating, and with each relution of the valve the corresponding steam-port is opened and shut three times; consequently valve need only make $\frac{1}{3}$ revolution to every crank-revolution. The lay-shaft A parallel with the piston-rod, is driven by bevel-wheels off the crank-shaft, and it works the four-valve-spin by skew-gear as shewn in Fig. 373.

The expansion-valves are placed inside the admission-valves, and though they fit close to the latter, still they do not revolve, but are merely rocked to and fro at be bidding of governor with which they are indirectly connected; in this manner an automatic variable cut is obtained. The connection with the governor is effected off the small-crank D and linked the governor-collar.

As the power required for shifting the expansion-valves may at times vary considera the moving of the latter is obtained indirectly off the governor, by the insertion of an in mediate mechanism, illustrated in section in Fig. 375. As this mechanism follows the rise fall of the governor, the action of the latter on this mechanism remains the same for positions.

The collar of the ordinary governor, has a double friction-cone *a* attached to it, so th the latter is compelled to revolve, and rise and fall with the governor-collar. The top and low portions of this friction-cone, are furnished with hollow-cones, to which the bevel wheels *b* and *c* are bolted, the latter gear on to the bevel-wheel *d*. These three wheels are kept in their proper positions by the casing *f*, which is made to rest on the bevel-wheel *c*. The governor-pillar enables this casing *f*, to slide vertically, though it is prevented from turning. The boss of the lower wheel *c*, is extended to form a screw for a nut to work on; this nut is rigidly fixed to the governor-pillar. Consequently this threaded boss carries the

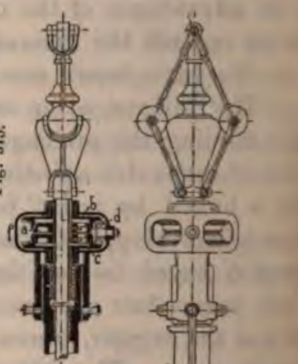


Fig. 375.

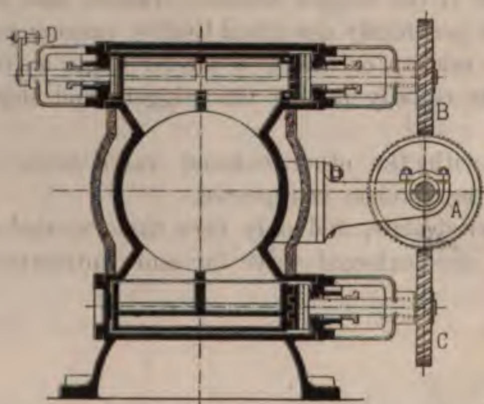


Fig. 373.

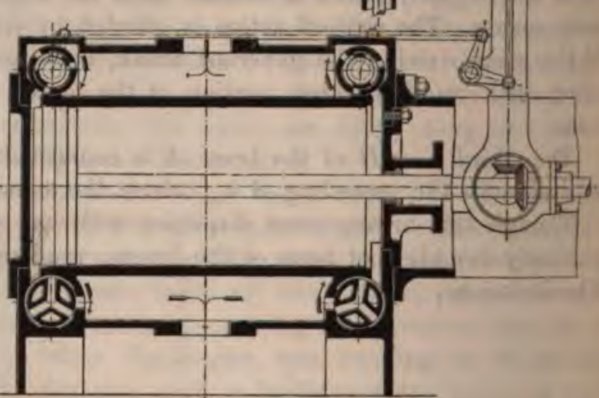


Fig. 374.

three bevel wheels as well as the casing. According as the revolving governor holds the frictio cone *a* out of gear with both, or in gear with the upper or lower hollow cone, so the bevel whee *c* will either be stationary or be turned to the right or to the left. But at these rotations of th bevel wheel *c*, cause the wheel boss to screw out and in of the nut, the casing becomes thereb lifted or sunk, which will be seen to correspond to the governor-balls rising or falling.

This mechanism consequently follows exactly the vertical motions of the governor-colla it secures equilibrium of the governor during the various declensions, and gives off certain grade of expansion according to the positions of the governor.

b. Camin & Neumann, of Frankfort on the Oder.

The balanced Rotary-valve of Camin & Neumann is arranged with automatic adjustment, imilarly adapts itself to high-speed Engines, on account of its continuous revolving motion lf the crank-shaft revolution number. Two pairs of bevel wheels, and an intermediate shaft motion to the valve-gear.

Fig. 378.

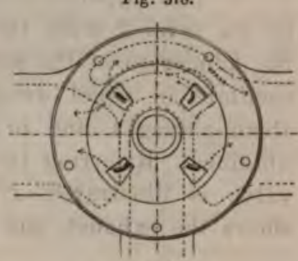


Fig. 379.

vood-cut Fig. 376, shews a udinal section, a trans- section through the cylin- nd valve-chest being repre- l in Fig. 377.

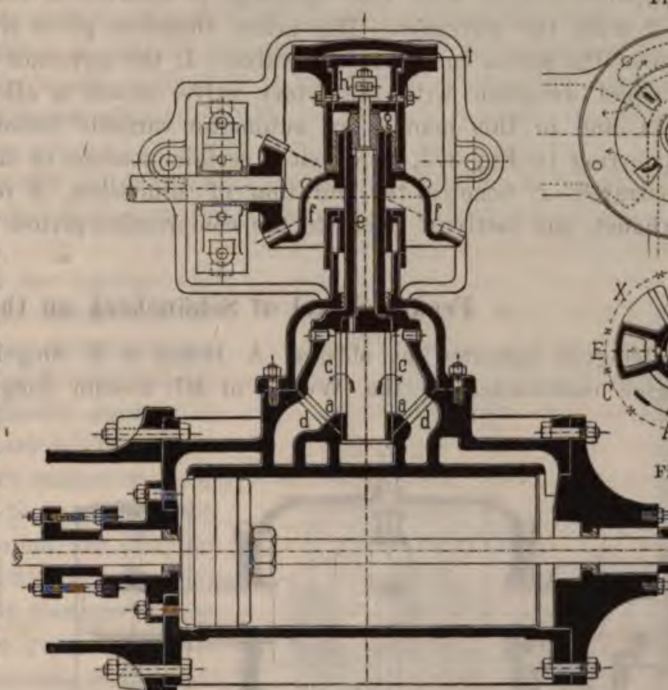


Fig. 376.

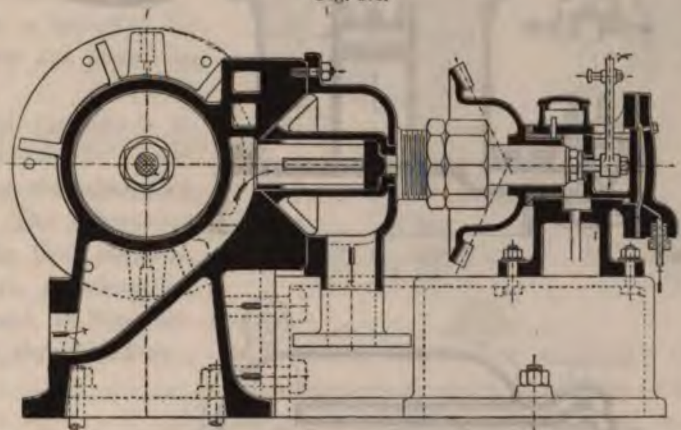


Fig. 377.

A steep-inclined cone a, ving on a corresponding -seating (shewn in plan in 378) receives fresh steam gh two opposite steam-pas- c; it gives the steam off into one of the cylinder- through two openings d, are also diametrically ar- d in the conical slide-sur- The latter is moreover hed with cover-surfaces for ompression and expansion steam, which surfaces are ally arranged symmetrically e two admission-passages.

The openings of the co- slide-surface, limited by lges of the expansion and ession-surfaces, allow the steam to enter the valve- to pass out again in the air or into the condenser. prolonged valve-spindle e s through the valve-chest g-box, and it has the bevel- f keyed on for working alve, and it rests on a gland g which simultane- serves as packing and a for inner expansion-valve le. A hollow cylinder h, de to lie on the gland g, and it is so supported as to be only able to move axially to the of $^1/_5$ in. (5 mm.). The outer surface of this cylinder rests against an india rubber plate l with hemp, on which the boiler pressure is made to act — see Fig. 377. —

The tendency of the fresh steam on the rotary-valve, is to force the latter away from its g, and this pressure is transmitted on to the gland g and thence on to the india rubber plate i

to be here counteracted by the boiler-steam pressure. According as the pressure-surface of the india-rubber plate is large or small, the rotary valve will be more or less balanced; if the plate pressure surface is therefore made of the correct size, it is evident that the valve must sit close on its seating, till a wear and tear of $^1/_5$th in. (5 mm.) has taken place in the valve seating-surfaces. Consequently this rotary valve design not merely balanced, but adjusts itself automatically so long as the prescribed limit of wear and tear is not exceeded.

An expansion-valve with four openings is inserted in the rotary valve, and is connected by its lever *k* with the governor. The latter therefore gives it a rocking motion so regulating the admission of the steam to the rotary valve. If the governor causes the expansion valve to oscillate in equal direction with the rotary valve, steam is allowed to pass longer through the steam-passages, and in this manner an automatic variable cut-off between 0.0 and 0.4 stroke is obtained. Referring to Fig. 377, in which a certain position of the expansion valve to the rotary valve is illustrated, *E* denotes the duration of admission, *X* indicates the expansion-period, *A* shews the exhaust, and lastly *C* refers to the compression-period.

c. Feodor Siegel of Schönebeck on the Elbe.

A valve-gear patented by Messrs. A. Behne & F. Siegel is usually fitted to the Three-cylinder Engine constructed at the Works of Mr. Feodor Siegel. We represent one of these

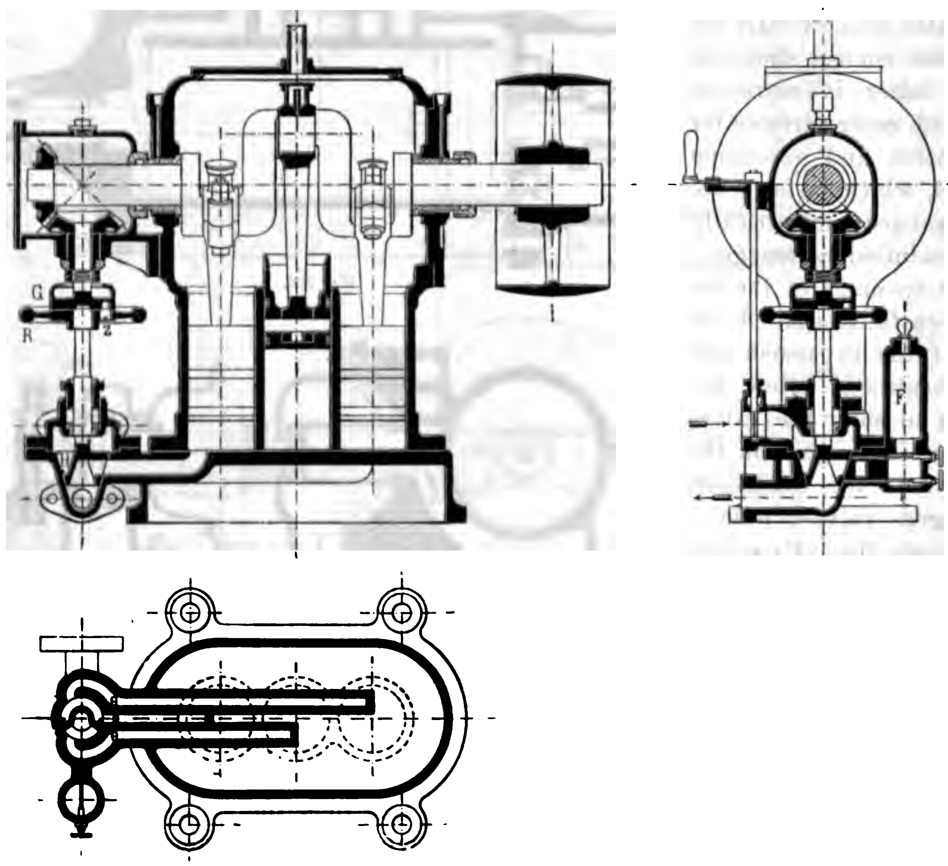


Fig. 380—382.

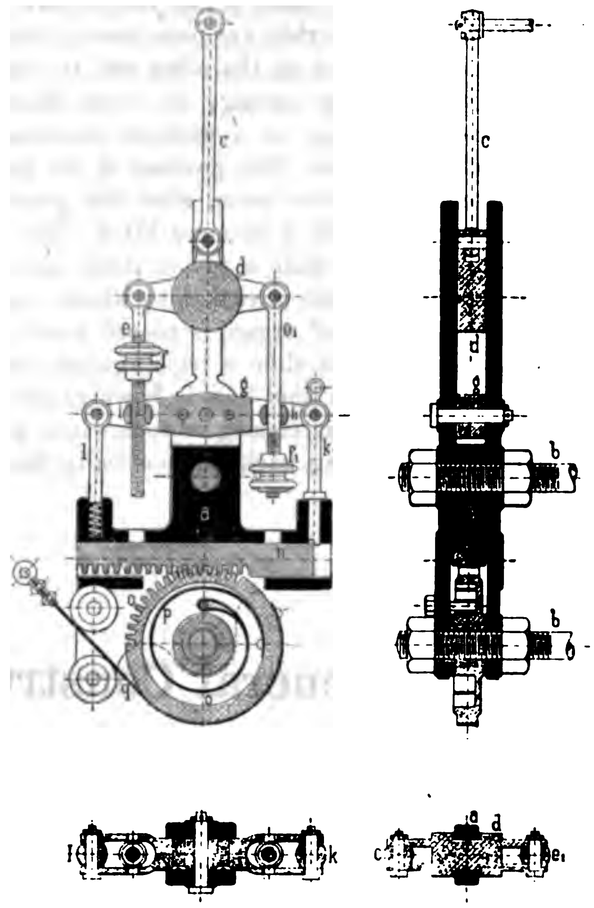
single acting Engines in our annexed Figs. 380—382. The three cylinders are placed close to each other, in vertical positions, with their axes in one plane. These cylinders are left open towards their crank-shaft ends, and the cranks are set at 120° to each other. The crank-shaft is supported by a cylindrical casing completely boxed in, excepting that its top carries a small pipe communicating with the atmosphere. The interior of this casing consequently also communicates with the open cylinder-ends; any steam-leakage therefore escapes through the formentioned pipe.

These steam-cylinders being single-acting, the piston-rods are merely in compression, during the whole of their work. The three steam-passages *s*, as well as the steam supply and exhaust pipes, abut in the valve chest *H*. The main-valve driven by a pair of bevel-wheels and a disc *G* which carries the hand-wheel *R* along with it owing to the protruding stud *z*, works in such a manner as to place the working pistons in communication with the steam-supply pipe, whilst the returning idle pistons are in communication with the exhaust. The proper distribution of the steam through the ordinary rotary valve — shewn in plan in Fig. 382. — is obtained by placing the outlets of the three passages in the valve-chest at 120° apart.

The Engine is reversed by turning the valve by the hand-wheel *R*. The latter has the pin *z* fixed to it, to gear in a concentric groove the disc *G*, which permits the hand-wheel to be turned round 180°. The main-spindle consists of two parts; namely the upper part with the disc *G* keyed fast, and the lower part connected with the valve. If the Engine is to be reversed, the shut-off valve is closed, whereupon the Engine comes to a stand-still; the hand-wheel is then turned in the same direction as it was previously running, and as far round as the groove permits. The shut-off valve is then re-opened, whereupon the engine moves in a contrary direction.

As this type of Engines is intended for high-speeds, all the moving parts are boxed in, so as to prevent accidents.

The lubricating method still remains to be described and the manner in which the valve and as well as the three cylinders are lubricated, is as peculiar as it is practical. The lubricator-cup *F* delivers the lubricant in the first instance, through two passages, to the valve, so oiling the latter. Any excess of the lubricant, is then carried by the steam uniformly into the cylinders.



Figs. 383—386.

C. Automatic Engine-stop apparatus.

By M. A. Starke of Hirschberg (Silesia).

To prevent the "running-away" of Engines at any time, the automatic Engine stop-apparatus, illustrated in Figs. 383—386, has been designed and patented in Germany by M. A. Starke of Hirschberg (Silesia). At allows itself to be applied to any Engine, and is specially adapted to Motors working with automatic Variable Expansion gears.

The cause "running away" of an Engine may either be caused by breakage of the governor-driving mechanism, or by the steam-supplying valves refusing to shut. To compensate for both of these causes, the present Apparatus has been devised: An independent shut-off valve is placed between the steam-cylinder and the ordinary stop-valve. Before starting the Engine, the tenter opens the former, and it remains thus open during the usual running of the Engine, as it is acted upon by a brake mechanism. The stop-apparatus then comes into action, when the governor assumes either its highest lift or greatest fall for then the governor releases the brake-mechanism employed in the keeping open of this extra stop-valve.

The cast-iron bracket *a* is bolted to the governor-pillar by the bolts *b b*, and the rod *c* is connected with the governor-links. The lever-block *d* moving vertically in a planed slide, is carried by the rod *c*; the arms of the former have rods $e\,e_1$ suspended from them, and carry double set-screws $f\,f_1$. These rods $e\,e_1$ pass loosely through a cross-beam *g*, which at one end is linked to the pressure bolt *l*, and at the other end to the escapement-bolt *k*.

With ordinary runnig, the cross-beam *g* remains in horizontal position, inasmuch as the escape-bolt *k* rests on *a* with its shoulder, whilst a lightly compressed spring presses the pressure-bolt *l* upwards. The position of the double-nuts ff_1 is so chosen, that they may merely come in contact with the beam, when the governor is in either of its extreme positions; when contact occurs the bolt *k* becomes lifted. The lower end of the latter is in the form of a tooth, in order to allow the slide *n* to lay itself against it. This slide is carried in a horizontal guide, and its under side forms a rack into which a partly toothed wheel *o* gears. A steel band *q* connected with the shut-off organ, is placed round the circumference of this wheel *o*.

As long as the slide *n* trips against the bolt *k*, and is thus kept stationary, the shut off valve remains open; if this bolt is however lifted, then the closing of the valve ensues, as can be readily imagined. This closing motion winds up a light spring *p*, placed inside this wheel *o* for the purpose of bringing back automatically the slide *n* when the stop-valve is again opened.

General Constructive-principles.

1. Of the Valve-gears.

If we look back on the various valve-gears, which have formed the subject-matter of the preceding pages, we shall find that in each of the chief groupes of rocking-, and slide and lift valve-gears, external mechanisms recur which not only bear great similarity to each other, but which in certain cases are exactly alike in principle. In order to form an opinion respecting the general constructive-principles of the various Valve-gears motions it matters little, even from a theoretical stand-point whether any of the valves are worked by this or that external mechanism. The grouping of the valve-gears according to the steam-distributing organs, has merely been adopted from a practical point of view, because this treatment offers itself as the best, and readist way of shewing-up these characteristics most suited to the requirements of "actual practice". The careful reader will not have missed observing the inner relationships existing amongst many of the preceding mechanisms, and no doubt he will have derived greater satisfaction in this respect, the more he has penetrated into the objects of the constituent organs, and the more he has compared the valve and the advantages of the latter, amongst each other.

We may appropriately give a short resumé of the different proposals made for the purpose of placing our modern Valve-gears in certain groupes or divisions.

Emil Blaha in his "Steuerungen der Maschinen" divides Corliss valve-gears, according to a proposal emanating from F. Wellner & Prof. G. Schmidt, inasmuch as he terms that portion of the mechanism receiving its motion direct from the engine, the "active transmitter" whereas the remaining portion connected with the steam-distributing organs, he calls the "passive transmitter". In this manner four groupes are obtained as the active or passive transmitter is disengaged or altered by the governor. The greater part of valve-gear motions, belong to one of these two divisions, and in fact we may add that it is the trip-gears where the active transmitter is disengaged, and the lift-valve gears where the passive transmitter is displaced.

Müller-Melchior in a paper contributed to Dingler's Polytechn-Journal, divides all the valve-gears extant, into two groupes, namely Positive valve-gear motions, and secondly into Expansion-gears (according to von Reiche) which again may be subdivided into such as offer isochronous (equal timed) in contra-distinction to those which offer allochronous disengagements (cut-offs). With Expansion-gears working with isochronous disengagements, the steam-distributing organ, advances in the same degree as the disengagement gear, that is to say, the co-operating borders of the admission become larger in the same proportion as the distance between the co-operating edges of the disengagement-gear becomes reduced. Amongst this class trip-gears figure conspicuously.

On the other hand, an allochronous expansion gear may be said to present itself, when the formentioned simultaneous "going-together" of the external and internal valve-gear, no longer takes place, but where instead the longitudinal and transverse motions of an eccentric-rod are used, for acting respectively on the valve-opening, and on the distance between the „striking" edges. In these valve-gears, the steam-distributing organ may still become disengaged during its return, so allowing a range of expansion, between 0.0 and 1.0 stroke. The latest Valve-gears of Sulzer, Quillacq, Trappen, Kuchenbecker, Teichmann etc. belong hereto, and which are classed as "Valve-gears with positive opening and negative closing of the inlet-valves".

Fine and ingenious as such divisions appear, and however well they may adapt themselves to theoretical investigatives, still they are of little use to the practical machinist, inasmuch as the latter will always classify an Engine, according to its clearly visible external characteristics. Acting up to this practical view, a classification has been adopted in the preceding pages, which pays regard to the types of steam-distributing organs, employed, as well as to their position on the cylinder, and which similarly takes into question the constituent parts of the external valve-mechanism — whether working with or without trip-gears. We now propose to inquire more minutely into the various valve-gear-motions, and their application to the three steam-distributing organs, such as they present themselves in the rotary or rocking valve, the slide valve, and the lift-valve!

It is said that an American mechanic, named Fr. E. Sickels first invented a trip-gear in connection with a valve-gear, which he patented about 1841. This mechanism was applied by the Engineering Firm Hogg of New-York to the Steamer named "South America". The governor was not already used to act on the valve-gear. To Zachariah Allen the merit is however due of having already invented in 1834, an Expansion-gear which was already depending on the governor. The first party, who allowed the governor to act on a trip-gear was George H. Corliss, who as we have already observed applied it to this purpose about the year 1849.

The characteristics of a Corliss-valve gear, consists in the four separate steam distributing organs, and the resulting diminution of the clearance or waste spaces; then again in the disengagement of the external mechanism by the governor at the end of the steam-admission periods, whereby the work done by the Engine is regulated and constantly performed under the boiler-steam pressure. No throttling of the steam takes place, however early the cut-off ensues, because the steam-ports always open in the same manner no matter whether the steam is cut-off early or late, whilst the exhaust, with suitable lead and moderate compression, remains constant during all ranges of expansion. These advantaves, producing the smallest consumption of steam and consequently also of fuel, are nevertheless attended with the disadvantage of causing a complicated valve-gear mechanism. Naturally a certain time must elapse for what we may term the negative closing of a steam-port, thence the greater the Engine-speed the more inaccurate will the closing of the port become; for this reason where such a negative valve-motion is resorted to, the number of revolutions of an Engine are limited. Probably 70 to 80 revolutions per minute is in these cases the maximum engine-speed, though Engines working with rotary-valves may for example run easily at over 100 revs. per min. Again Corliss valve gears adapt themselves chiefly to large power-purposes, and presume that a careful tentering of the Engine is available where they are used. We therefore find these Corliss-gears largely confined to extensive power-requirements, whereas the simple cock-valve (rocking or rotary types) is judiciously employed for the small-steam motors, and for intermediate larger sizes we generally find some combination of the ordinary slide-valve gears.

In the design of an ordinary trip-gear in which all the four distributing organs are driven off one eccentric, care must be taken to limit the range of expansion to about 0.4 stroke. The larger the lead-angle is chosen, the more is this limit reduced, and consequently the lead-angle of the eccentric is generally accepted smaller than with slide-valve-gears; from 10° to 20° is found ample in this respect to secure a sufficient lineal opening in addition, and no lap of the exhaust working valve edges is required, or in other words, when the valve-gear is in its middle position, these exhaust working edges coincide with each other.

The motion-rods, as well as the links connected with the trip-gear and with the exhaust organs, should always be made adjustable, as this allows the valve-gears to be worked with great accuracy. Thus, if the lineal lead requires altering, all that then becomes necessary is to alter the length of the motion rod, because the lap of the valve becomes thereby altered, and an earlier or later admission ensues. As a rule, the eccentric rod is not linked to the wrist-plate direct, but indirectly by the intervention of an adjustable intermediate lever.

If, on the contrary, two eccentrics are used, then it becomes an easy matter to extend the forementioned range of expansion, by a suitable mounting or keying of the admission-eccentric. But so that the valve-opening may ensue when the eccentric is moving quick, the negative lead-angle is chosen at 20° to 30°, that is to say the admission-eccentric is keyed 70° to 60° in front or behind the crank. In this manner a range of automatic expansion is obtained between 0.0 and 0.65 and 0.8 stroke.

With regards to the diameters of these Valves, the reader will find the various sizes in the annexed Table *A*. Taking the average, we find that cylinder-diameter equals $3^1/_2$ times the valve-diameter. Hlubeck's engine type forms however an exception hereto, as the valve-diameter is there half the cylinder-diameter. The width of the steam-passages is comparatively small, as the length of the latter is made as large as possible, so as to obtain a sufficiently large passage even when the steam-port is not fully opened out, such as happens, for instance, with early cut-offs.

Care must also be taken in constructing trip-gears, that their gearing on to the stationary parts, should take place as centrally as possible, for a one-sided gearing often causes — through eventual wear, — the gear to refuse to work. The success attained by the Spencer & Inglis Valve-gear may be largely attributed to the attention it has received in this respect.

Amongst the valve-gears working without Trip-gears, we may class a great number of rocking-valve mechanisms. The work of the oscillating valve, may be easily referred to the simple slide action, for according as the lap, and the arrangement of the co-operating working edges of the steam-distributing valve and of its seating, are chosen we similarly obtain any expansion-grade as would also be obtained by a slide-valve gear working with one slide.

The balanced and non-balanced rocking-valve types, have of late received much application when non-balanced, their form is naturally very simple. They are chiefly worked by an eccentric or counter-crank.

But if it is desired to obtain a *variable* expansion, then the edge of the valve which cuts-off the steam, must journey over a different travel to the rest of the edges: this is only possible by reducing the steam-distributing organ into two parts. Whilst the one valve is continually oscillating and so regulating the beginning of the admission and of the exhaust periods, the expansion valve under hand or governor control is specially worked to shut-off quickly.

If in using this oscillating valve, it is desired to approach the Corliss-type, then a separate steam-distributing organ is chosen for each of the four working edges; the small Engine of Fenby serves as a good example in this latter respect.

Rotary-valves may be said to form a class by themselves. Though at the Paris Exhibition of 1878, this arrangement was only shewn applied to small motors, it would be wrong to conclude that owing to the various constructive difficulties inherent to this valve-gear, it will not be able to hold its own ground. On the contrary, the advantages of this type, consist in its perfect balanced qualities, enabling it to be used at very high steam pressures and piston-speeds. All the oscillating parts of the other valve-gears, as well as their link-combinations, are here dispensed with, because continuous rotary motion merely takes place. Again, the wear is slight on account of the reduced speed of the steam-distributing valve; thus in Radinger's, Musil's and Ehrhardt's valve-gears, we noticed that the valve rotated at only half the crank-shaft speed, whereas this speed was further reduced to one third in Waldemar's Fritsche's Valve-gear. We have already seen, that with these valve-gears, expansion is obtained by a special expansion-valve; the latter was made to rotate inside the other in Radinger's design, whereas in Musil, Ehrhardt's or Fritche's Valve-gears, the expansion-valve is fixed, and only moved by the governor. On account of the very favorable results obtained with Engines so fitted — provided higher speeds and working-pressures continue, to increase in favour — it is probable, that the Rotary Valve-gears may become serious competitors of the present highly favored trip-gear types!

The principle involved in "positive motion as applied to slide-valves" is placed beyond the province of the Work for reason that this subject has already largely appeared in print.

Referring to lift-valve gears with fixed expansions, they are often worked by an eccentric, or still oftener by cams, the form of which determine the duration of admission and exhaust. With this class, it is easier to obtain variable expansions, for reason that the admission valve can be worked independently of the exhaust-valve. This fact, is utilised to the best advantage by a number of machinists, inasmuch as they employ a number of differently formed cams, each answering to a certain degree of expansion, whereby variable expansion it is obtained; these cams are often united into one piece, which is then pushed by hand or by the governor under the valve-spindle lever.

In the way of combining the slide-valve as steam-distributing organ, with the Lift-valve for the expansion-medium, we met with a number of constructions, each of which could only be singly treated, and which therefore offer no reason for a general treatment here. Still it may be observed, that as in most of these cases, the expansion-valve is worked off a distinct organ, their principle admits of the high range of expansion of 0.0 to 1.0 stroke.

In the various Valve-gears, which we have just generalized, the strict Corliss principle is more or less imperfectly rendered, inasmuch as either the instantaneous steam cut-off, or the separated arrangement of the valves is found wanting.

On the other hand, the entire conditions of the Corliss-principle are fulfilled to the letter by the Lift or Double-beat Valve-gears, which we might conveniently ground so as being of the Sulzer-type. These Valve-gears deserve the greatest attention, because they permit a quick-steam admission and an unlimited range of expansion.

For opening the inlet valve, half of the forward or return stroke of the eccentric is used, which travel corresponds to the full piston stroke. The disengagement of the eccentric rod, also takes place with the return of the eccentric. In most cases, even when no disengagement takes place the valve closes the steam-port at stroke-end, consequently Engines fitted with these valve-gears can be worked non-expansively.

The external mechanism of this valve-gear type, can be constructed in such a simple way, as hardly seems attainable with trip-gear constructions. We will for instance remind the reader to the Valve-gears of Kuchenbecker, Trappen, and Teichmann which all bear a great similarity to each other. It is questionable whether anything more simple can be devised for the purpose, than a steel nibbed eccentric-rod, or an eccentric strap, pushing a rod (connected with the valve-spindle) in front of it, whilst this rod is simultaneously guided or held in certain positions by the governor.

If additional conditions have to be fulfilled by the valve-gear type, be it that it should adapt itself to reversing or to high-speed purposes, then the mechanism naturally becomes more complicated as we noticed in the latest Sulzer-engine type, or in the Winding-engine of Quillacq etc.

The lift valve-gears with positive-motion throughout, deserve special attention, as the only two representatives of this type, Collmann and Brown have lately been joined by the ingenious gear of Mr. Hartung. It is not to be desired, that with high-speeds, this type offers certain advantages, inasmuch as with the latter, the closing of a valve cannot be retarded through stuffing-box friction in case the dash-pot fails to act.

When discribing the various valve-gears, with negative (free) disengagement, we have invariably stated the closing of the valve to be instantaneous (momentary); it is however self-evident that a certain time must necessarily elapse for the closing of the valve on its seating. Were it desired to obtain a valve-lift diagram direct from the engine, the closing line of the diagram would intersect the horizontal line representing the piston-travel not vertically but in a slightly inclined direction. Nevertheless, careful indicator-trials have amply proved that a diminution of pressure at the end of the admission does not take place. Much as this "negative motion" answers to these conditions, it also permits the reverse to take place. For many-machinists do not like to see sharp corners in indicator-diagrams, but prefer to see these nicely rounded off. By adjusting the dash-pot valves, a slow or a later cut-off, may be obtained, as we have already shewn.

As the preceding remarks shew, though an *instantaneous* cut-off is not attainable, still a positive movement of the external mechanism embodying the closing of the valve, may nevertheless yield diagrams which for practical purposes are taken to be *"perfect"* by some Machinists. Still the correctness of this idea is much disputed, for public Engineering opinion is largely divided on this question. It may therefore be advisable to leave the decision an open question, and to merely refer those parties who are disirous of gaining more information on this subject to the pamphlets respectly published by Messrs. Sulzer and replied to by Mr. Collmann, who as can be easily imagined take up different points of view according to the opposite principles of the Valve-gears advocated by these two Engineers.

II. Constructive-principles of the Steam-engine.

In order to shew up the general constructive-principles adopted in the preceeding pages, in as short and yet as comprehensive a manner as practicable, we have tabulated the chief dimensions of the most important types, in the Tables here annexed. The steam-engines are again grouped according to their steam-distributing organs, and to facilitate reference-purpose, the number of the page on which any particular Engine is described, or the number of the Plate on which it is illustrated, has been included in these Tables. In cases, where it was subsequently found hat certain important dimensions had been omitted from the Plates, these have been similarly aken up in the Tables though dimensions which seemed doubtful have been again omitted. As he conversion of the metrical system into English equivalents, is in many cases extremely tedious, n extra Table has been added where the metric measures are accordingly reduced, as it is thought hat it will not only prove highly expeditious for those using the Working-drawings, but will lso serve as a check to the English dimensions inserted in the preceding pages.

It is beyond our object to enter into the theoretical calculations of the Steam-engine, in o far as it is not depending on the type of valve-gear used. On the other hand, we have sought o give certain numerical ratios existing between the various engine-parts referred to and calulated from our Tables.

In the first instance it is important to know, the proportion existing between the cylinderliameter and its stroke. In horizontal single-cylinder Engines a long stroke predominates and:

$$\frac{\text{Piston-stroke}}{\text{Cylinder - diameter}} = 1.37 \text{ to } 3.$$

The greatest stroke-ratio (3) is mostly confined to American Engines, whereas the Engine ot Messrs. Marcinelle & Couillet shews the smallest corresponding value (1.37). The average value resulting from all the Engines enumerated is however:

$$\frac{\text{Piston-stroke}}{\text{Cylinder - diameter}} = 2.12.$$

In Woolf or Compound-engines the diameter of the High-pressure cylinder is generally $^1/_3$ piston-stroke; that of the Low pressure cylinder is from $^1/_{1\cdot5}$ to $^1/_2$ piston-stroke (Sulzer, Escher, Wyss etc.). On the other hand the Compound-engines of Messrs. Douglas & Grant and of Messrs. Claparède & Co. shew a peculiar similarity, inasmuch as in the two, the ratio affecting the High-pressure cylinder is 1.8, whilst that of the Low-pressure cylinder calculates itself to only about 1.08.

No average-value can be obtained respecting the piston-speed, — i. e. number of revolutions — as this depends on the Valve-type adopted. Still attention may be drawn to the maximum and minimum number of revolutions per minute recorded at 125 and 30 in our Tables; the mean piston-speeds vary accordingly from $3^3/_4$ ft. — 8 ft. 2 in. (1.0 to 2.5 m.) per sec. Quite isolated in this respect is the high-average piston-speed of the Corliss Beam-engine exhibited at the Centennial Exhibition, which is quoted at 12 ft. (3.66 m.) per sec.

The size of the steam-passages are depending on the piston-speed, and according to Radinger

$$\frac{\text{Steam-port area}}{\text{Cylinder bore-area}} = \text{Constant} \times \text{Piston-speed} = \frac{f_1}{f} = Cv$$

whereby the constant C is the reciprocal value of the average steam-velocity; the latter was determined by Radinger after many experiments to equal 30 Metres (hence $C = {}^1/_{30}$) in Engines where the curved steam-passages and varying port-areas, shewed no appreciable pressure-reduction in the diagrams. This steam-velocity $C = \frac{f_1}{f}\, v$ is calculated for each Engine included in our Tables.

The steam-pressures at which these Engines are worked lie mostly between 4 and 6 atm. (60—90 lbs.). The mean pressure may therefore be taken at 5 atm. (75 lbs.). Higher pressures are used with Compound-engines, still the high working pressure, that was for example adopted by Dingler's Engine, (10 atm. = 150 lbs.) has not again been resorted to in later Engine-designs.

The Column referring to the proportion existing between the connecting rod and the crank, displays that on an average the former is made five times the length of the crank; but there is a tendency visible in the latest Engine-constructions, to make the connecting rod somewhat longer. The maximum as yet attained in this respect is

connecting rod length = 6 crank-lengths.

Another Column of our Tables, devotes itself to the proportions existing between the radii of the fly-wheels and of their respective cranks. The flywheel is mostly used for giving off the engine-power direct, by gear, belting or roping. The latter is the most recent innovation of these three methods, and where it is adopted the face of the wheel is made somewhat wider, in order to take from 6 and 12 ropes or less or more according to requirements. The hemp-ropes used for driving purposes are about $1^1/_2$ in. (40 mm.) diam.

As practical data, concerning the clearance or waste spaces cannot fail to be interesting, we may now refer to them. If V represents the space actually travelled over by the piston, and V_0 the clearance space at one cylinder-end, then the coefficient of the clearance space will be equal to $\frac{V_0}{V}$ which we will term $= m$.

This coefficient in regard to Corliss-engines, is quoted by the majority of text-books $= 0.015$. This value probably merely allows a very small play or rather space (perhaps $^1/_5$ in. $= 5$ mm.) between piston and cylinder cover; on the other hand if this space is extended to $^5/_{16}$ in. (8 mm.) as is commonly done then $m = 0.02$ to 0.025.

In Hlubek's Engine $m = 0.025$. Steam-motors working with long steam-passages have $m = 0.05$, and the same remark applies to Engines with the valves placed on the side of the cylinder. If the four valves are arranged separately $m = 0.3$. With Engines of the Sulzer-type m lies between the wider limits of 0.026 and 0.045.

Lastly, in the combined Valve-gear of the Engine described as constructed by Messrs. Bolzano, Tedesco & Co. (Plate 63) $m = 0.035$, whilst in Messrs. Socin & Wick's Engine, illustrated on Plate 62, $m = 0.028$.

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e-gears.

Plate.	Valve-gear Type:	Engineers.	W	rnor.		Fly-wheel.						Slides.		Cross-head pin.		Crank-pin.		Crank-pedestal.			Air-pump.			Remarks:
				Revolutions p. Min.	Collar-slide.	Diameter. ft.	Width of Rim. in.	Fly-wheel radius / Crank-radius.	Connecting-rod length / Crank-Radius.	Piston height in inches. in.	Piston-rod Diameter. in.	Length. in.	Width. in.	Diameter. in.	Length. in.	Diameter. in.	Length. in.	Bore. in.	Length. in.	Crank-shaft maximum diam. in.	Diameter. in.	Stroke. in.	Air-pump capacity / Cylinder capacity.	
1	Corliss-Original.	G. H. Corliss.	Prov	—	—	29.7	24	2,96	4,8	10	6 21	—	—	—	—	8	10	17	27	18	33.9	24	1/5	Fly-wheel, 21 Teeth 5¼ in pitch.
IV	,, ,,	,,	,, (	—	—	18	32.29	4,5	5,5	—	3.19	16.34	5.7	5	6.3	5	6.3	11.0	17.7	11	—	—	—	Working since 1860.
2-3	Corliss 1862.	O. H. Müller.	Buda	10	4.72	23	16.73	4,1	5	7	4.91	18.9	13.30	5.7	8.26	7.28	8.85	11.81	17.72	15.75	—	—	—	The high press cylinder is her merely taken in to account.
I	,, ,,	Wilhelmshütte.	Spr	85	5.11	15.4	—	5,1	5,3	5.5	2.68	11.26	3.07	2.36	4	3.15	4.09	—	—	—	12.28	11.81	1/5,7	Fly-wheel as Belt-pulley.
4	Harris-Corliss.	W. A. Harris.	Provid.	—	—	—	—	—	—	5.5	2.36	—	—	1.97	2.76	—	—	—	—	—	—	—	—	
II	,, ,,	R. Wetherill & Co.	Chester	—	—	7.8	15.75	3,93	5,5	—	1.69	8.07	3.15	2.78	3	2.28	3	4 91	8.85	4.91	—	—	—	
V	,, ,,	Gräfl. Stolberg-Wernig. Fact.	Ilse	—	—	12.7	9,84	4,87	5	—	2.68	14.37	5.31	2.56	3.54	3.15	3.94	7.87	12.2	7.87	7.87	31.5	1/8,8	Belt-pulley attached to fly wheel.
5	Corliss 1867.	Erste Brünner Maschinenfabr. Actiengesellsch.	B	—	—	12.5	13.58	4,00	5	4.91	2.60	11.41	7.55	3 62	4.32	3.62	4.32	6.37	15.35	7.47	9.68	9.33	1/10	
VI	,, ,,	J. Körösi.	An	—	—	—	—	—	—	4.95	2.60	—	—	—	—	3.35	3.94	—	—	—	—	—	—	
6-7	,, ,,	Weise & Monski.	Hal	00	2.36	12	11.81	4,42	4,9	6.29	2.28	11.81	4.72	2.36	3.15	2.56	3.15	6.1	10.23	6.29	—	—	—	
9—10	,, ,,	Hick, Hargreaves & Co.	Bo	00	3.76	22	16.38	4,39	6	7.95	5.92	—	—	—	—	—	—	17.17	20.08	19.45	—	—	—	
12-13	Spencer-Inglis.	L. Poillon.	I	70	3.35	10.5	5.51	3,5	5,5	4.95	2.13	13.39	5.90	2.76	3.94	3.74	4.32	7.87	9.45	7.87	7.09	14.96	1,98 doub.	
14-15	,, ,,	G. Sigl.	Vi	44	3.94	15	11.02	3,83	5	7.67	2.76	—	—	—	—	—	—	9.45	11.81	11.81	8.26	47.2	1/5,6 doub.	
II	,, ,,	Escher, Wyss & Co.	Zi	—	—	22	13,78	4,97	5	—	3.54	16.54	7.08	4.13	6.69	5.70	6.88	11.02	16.5	—	17.32	23.6	1/4 sing.	
—	,, ,,	Socin & Wick.	B	—	—	10.5	—	—	—	—	2.17	11.81	5.11	2.95	3.54	2.95	3.94	5.90	10.23	—	—	—	—	Mortice Fly-wheel 168 cogs
16	Douglas & Grant.	Douglas & Grant.	Kirk	—	3.19	20	24	3,34	5,5	6.49	6.49	—	—	—	—	10	10	16	24	20	—	—	—	Toothed Fly wheel, pitch 4.44 in.
16	,, ,,	,, ,,		—	3.19	16			5,5	10	6.49	—	—	—	—	10	10	16	24		20.04	30	1/5,7	
17	Jer. Wheelock.	J. Wheelock.	Wo (U.	—	—	16	25.59	4,0	6	7.08	2.68	12.01	4.72	3.15	3.35	3.15	4.32	8.26	16.14	9.05	—	—	—	Fly-wheel be 21.6 in wide. 0.30 in thick.
IX	Märky & Schulz.	Carolinenthaler Maschinenbau-Actiengesellsch.	Pr	—	—	13	—	4,2	6	—	2.76	9.45	6.29	3.15	5.11	3.74	4.72	5.90	11.81	5.9	—	—	—	Fly-wheel weight 4.7 ton
19	Steiner.	Crimmitschauer Dampfmaschfbr.	Cri sc	—	1.46	—	—	—	—	5.90	2.36	—	—	—	—	—	—	—	—	—	—	—	—	
20	Carl Kliebisch.	Sangerhauser Act.-Maschfabr.	Sa ha	298	2.76	12.75	7.87	4,53	5,26	5.90	2.32	9.84	6.88	2.95	3.94	3.15	3.94	6.88	12.2	6.88	—	—	—	
66	,,	,,		107	2.76	13	16.14	4,2	5,22	6.29	3.07	12.60	8.85	3.94	4.72	4.32	5.11	9.05	14.57	9 05	—	—	—	
21	Wannieck-Köppner.	Fr. Wannieck.	Bi	170	3.62	13.5	9.84	4,31	4,5	5.90	2.64	18.5	5.90	2.76	3.94	3.74	5.19	6.69	12.00	7.87	12.2	12.4	1/6	
22	Bède & Farcot.	Houget & Teston, Bède & Co.	Ver	45	—	15	15.75	4,5	5,3	7,67	2.95	16.93	11.02	2.36	3 54	4.52	5.9	7.47	12.99	8.66	6.29	39.4	1/8	Fly-wheel weight 5.9 ton
64	Corliss.	P. Van den Kerkhove.	Gh	—	—	30	32.09	3,0	4,69	—	7	—	—	—	—	—	—	—	—	23.04	—	—	—	

NB. The proportions used in thes

Page.	Plate.	Plate.	Valve-gear type.	Engineers.	heel. Face-width. in.	Fly-wheel-radius. / Crank-radius.	Connecting-rod length. / Crank-radius.	Piston hight above floor line. in.	Piston-rod-Diam. in.	Slide-bars. Length. in.	Slide-bars. Width. in.	Cross-head pin. Diameter. in.	Cross-head pin. Length. in.	Crank-pin. Diameter. in.	Crank-pin. Length. in.	Crank pedestal. Bore. in.	Crank pedestal. Length. in.	Maxim. Diam. of crank-shaft. in.	Air-pump. Diameter. in.	Air-pump. Stroke. in.	Air-pump-capacity. / Cylinder-capacity.	Remarks.
86	—	12	—	Ed. P. Allis & Co.	.87	6,0	5,3	—	3	8.07	5.90	2.56	3.94	2.95	3.94	6.29	$11._{81}$	$6._{29}$	—	—	—	
89	25	—	—	Weise & Monski.	.72	5,23	4,5	3.54	1.38	6.69	3.15	1.38	1.97	1.97	2.76	3.94	6.49	3_{94}	—	—	—	
100	26	—	P. Hlubek.	Maschinen- u. Waggonfabrik-Act.-Gesellsch.	2.6	3,49	4,46	12_{20}	1.97	3.94	3.94	1.81	2.60	3.15	3.15	3.94	3.94	$5._{11}$	—	—	—	
103	—	15	L. Ehrhardt.	Dinglersche Maschinenfabr.	.47	3,20	—	—	1.58 1.18	8.26	5.70	—	3.15	—	3.35	4.32	8.66	$4._{32}$	$6._{69}$	$31._{50}$	1/11	2.7 lbs. of coal and 2 gallons of water (104° F) per HP.
104	27	—	A. Musil.	Hüttenberger Eisenwerk-Gesellschaft.	—	3,27	5,09	4.80	1.77	—	—	—	—	2.36	3.15	—	7.28	$4._{72}$	—	—	—	
115	29	—	—	H. Berchtold.	.84	4,50	—	—	1.73	$11._{81}$	9.84	2 Side-pins 1.77	2.56	3.15	4.32	4.91	8.66	$5._{90}$	$4._{91}$	$15._{75}$	1/12	Fly-wheel weight 1.7 ton.

;ears.

Page.	Plate.	Plate.	Valve-gear type.	Engineers.	eel. Face-width. n.	Fly-wheel-radius. / Crank-radius.	Connecting-rod length. / Crank-radius.	Piston hight above floor line. in.	Piston-rod-Diam. in.	Slide-bars. Length. in.	Slide-bars. Width. in.	Cross-head pin. Diameter. in.	Cross-head pin. Length. in.	Crank-pin. Diameter. in.	Crank-pin. Length. in.	Crank pedestal. Bore. in.	Crank pedestal. Length. in.	Maxim. Diam. of crank-shaft. in.	Air-pump. Diameter. in.	Air-pump. Stroke. in.	Air-pump-capacity. / Cylinder-capacity.	Remarks.
31	—	18	F. Wellner.	E. Skoda.	.84	4,0	5,2	4.72	2.05	7.87	6.29	$1._{97}$	3.15	2.56	3.54	4.91	8.66	5.90	—	—	—	
66 69	34 33	—	Wannieck-Köppner.	Fr. Wannieck.	.19	4,39	5,0	5.19	1.93	$12._{20}$	4.95	$2._{32}$	3.39	2.83	3.90	4.91	9.84	7.87	—	—	—	Cutting off at 1/5 stroke and non condensing.
70	—	22	Dautzenberg.	Prager Masch.-bau-Actien-Gesellschaft.	.54	4,00	5,5	5.90	2.60	$12._{40}$	10_{35}	$2._{87}$	4.13	3.39	4.72	6.29	$11._{81}$	6.69	13	12.44	doub. 1/6	Fly-wheel as belt-pulley Piston of air-pump 5.7 in.
73	—	20	—	Goldie & Mc. Culloch.	.11	4,97	6,0	—	2.28	9.84	327 × 0.08	$3._{15}$	3.94	3.35	3.94	5.51	$11._{02}$	5.51	—	—	—	
78	36	—	—	C. H. Brown & Co.	.08	3,94	5,6	—	2.24	$11._{81}$	4.32	—	3.15	3.54	3.94	6.29	$13._{78}$	6.29	—	—	—	
7	38	—	B. Lebrun.	B. Lebrun & Co.	.08	4,44	5,0	5.90	2.17	$13._{78}$	—	—	—	—	—	—	—	8.66	4.94	35.43	doub. 1/6	
9	39	—	Wannieck-Köppner.	Fr. Wannieck.	55	4,00	5,0	7.28	2.83	$15._{51}$	6.29	$3._{94}$	5.51	3.94	6.21	8.03	$16._{07}$	9.56	10_{90}	14.57	1/8,7	Cutting of at 1/5 stroke and non-condensing.
9	29	—	—	H. Berchtold.	.51	4,11	5,5	5.90	2.56	$13._{78}$	9.84	$2._{56}$	5.51	3.94	6.29	6.69	$11._{81}$	6.69	6.69	23.62	doub. 1/8,3	
1	40	—	C. Smrezka.	J. C. Bernard.	-	—	6,0	4.72	2.36	$13._{78}$	8.26	$2._{56}$	3.94	3.15	3.94	5.90	9.84	5.90	—	—	—	
3	41	—	W. Theis.	J. & V. Florio & Co.	-	5,00	5,0	4.72	1.97	9.84	—	$1._{97}$	—	4.72	3.94	4.72	5.90	4.72	6.88	9.84	sin. 1/7	
5	—	25	—	M. Kuchenbecker.	.81	4,00	—	4.72	—	$11._{81}$	6.29	$2._{56}$	5.70	3.54	3.74	5.90	10_{23}	6.29	5.51	27.56	1/5,2	
5	37	—	Zimmermann-Waldmann.	Maschfab. der königl. ung. Staatsbahnen.	.85	3,7	5,0	6.29	3.74	$13._{78}$	9.45	$3._{94}$	7.87	5.31	6.29	8.66	$12._{60}$	10_{63}	15_{75}	19.69	1/4,9	Fly-wheel filled with wooden cogs 8.89 in long and 3.15'' pitch.
95	—	26	—	Cail, Halot & Co.	.79	4,0	5,0	—	2 56	$13._{39}$	9.45	$3._{35}$	5.58	3.74	5.58	6.69	$10._{63}$	8.26	—	—	—	

gears.

Plate.	Plate.	Valve-gear type.	Engineers.	Work	Crank-radius.	Piston-hight. in.	Piston-rod-Diam. in.	Slide-bars. Length. in.	Slide-bars. Width. in.	Cross-head pin. Diameter. in.	Cross-head pin. Length. in.	Crank-pin. Diameter. in.	Crank-pin. Length. in.	Crank-pedestal. Bore. in.	Crank-pedestal. Length. in.	Maxim. Diam. of crank-shaft. in.	Air-pump. Diameter. in.	Air-pump. Stroke. in.	Air-pump-capacity / Cylinder-capacity.	Remarks.
45	—	—	Maschinenbau-Actieng. form. Klett & Co.	Nürnb		10.63	2.76	15.75	7.08	2.95	6.69	5.31	6.29	7.08	12.99	9.84	8.26	35.43	1/5,6 doub.	Toothed fly-wheel.
—	27	—	Cölnische Maschinenfabrik.	Colog		8.26	4.13	14.57	9.84 × 0.08	4.13	5.90	4.09	6.29	9.25	12.99	12.60	—	—	—	Flywheel: wooden cogs of 4½ in pitch.
—	27	—	F. W. Köttgen.	Barm	9	7.87	5.11	14.17	7.08 0.08	4.72	6.88	5.90	11_{02}	11_{81}	15.75	15.75	—	—	—	Winding-engine with 2 drums, Dimensions of which are given in Flywheel column.
47	—	—	Putnam Machine Co.	Fitchb		—	1.97	8.66	1.97 0.08	1.89	2.48	2.36	2.95	4.91	10.04	4.91	—	—	—	
Figs.	274 275	Valve gear 1867.	Gebr. Sulzer.	Winter		4.72	2.17	11.02	7.47	2.76	4.13	3.94	4.52	7.08	11.41	7.08	11.81	12.60	1/4,4 single	Flywheel = 190 teeth of 2.36 in pitch.
49	—	Valve gear 1873.	" "	"		5.31	2.60	13.39	9.05	3.15	4 91	3.94	5.11	7.87	14.17	9.45	7.08	41.34	1/6 doub.	Flywheel = 240 teeth 2½ in pitch.
50	—	Valve gear 1878.	" "	"		6.69— 4.32	2.76 3.35	15.75	7.87	3.15	4.72	4.13	4.72	8.66	12.60	9.84	11.02	11.81	1/13	Flywheel channelled for 6 rops.
51	—	Sulzer 1873.	Maschinenfabr. Augsburg.	Augsb		5.29	2.76	13.39	8.66	3.54	5.90	4.32	5.90	7.87	15.75	11.02	16 34	7.08	1/9	200e HP cutting off at 1/10 stroke; 300e maximum.
52	—	Trappen.	Märkische Maschinenb.-Anst.	Wetter Ruh		5.11	2.36	10.28	6.29	2.60	3.62	3.03	4.09	6.29	9.25	7.08	—	—	—	Flywheel for 12r.
52	—	"	" "	"		6.69 3.15	4.32 2.05	10.63	4.72 × 0.08	5.11	6.92	5.66	7.24	11_{81}	15.75	13.78	—	—	—	Rolling-mill Engine.
54	—	—	Escher, Wyss & Co.	Züric		4.72	2.36	9.05	5.90	2.36	4.13	3.54	4.32	5.90	9.84	6.69	6.88	13.78	1/9 doub.	Flywheel channelled for 6 rop.
55	—	Collmann.	Görlitzer Maschinenfabr.	Görli	2	6.69	2.76	6.69	10.63	3.35	6.69	4.32	5.11	7.08	12.99	7.08	7.87	37.40	1/6 doub.	
56	—	Brown.	Schweizerische Maschinen- & Lokomotiv-Fab.	Winter	5	5.90	2.76	2.76	8 66	5.11	3.94	7.08	9.84	6.29	11.81	6.29	11.02 × 0.08	7.47	1/3,75 single	Flywheel toothed.
57	—	—	Sächsische Maschinenfabr.	Chemn		6.29	3.54	11.81	11.02	3.94	5.51	4.95	6.14	9.84	16.54	11.61	13.39	21.56	1/6,8 doub.	Blowing-engine.
53	—	—	Marcinelle & Couillet.	Belgiu	—	—	—	—	—	—	—	—	7.08	—	13.78	11.41	—	—	—	Dim. of fan given in flywh. column.
43	—	J. Baird.	Pusey. Jones & Co.	New-Y	16	7.99	6.10	23.97 × 0.08	12.99	7.24	7.99 × 0.08	12_{90}	15_{99}	15_{43}	26.97	—	29.92	17.99	1/10 doub.	Marine-Engine.
58	—	Hartung.	Harzer Actien-Gesellschaft.	Nordha	80	5.90— 6.49	3.94	18.11	9.84	4.32	9.84	5.51	6.29	11_{81}	16.54	13.39	9.05	49.21	1/9,5 doub.	Rolling-Mill Engine. Flywheel weight about 5 tons.
—	—	"	"	"	—	4.32	2.56	13.78	7.08	2.95	4.87	3.94	5.11	7.08	11.81	—	—	—	—	
48	—	—	Compagnie de l'Horme.	St. Ju	50	4.72	2.17	11.81	7.87	2.76	5.11	—	—	—	—	—	—	—	—	Pumping engine.

ars.

Plate.	Plate.	Valve-gear type.	Engineers.	Works.	Fly-wheel. Face in inches.	Fly-wheel. Flywheel-radius / Crank-radius.	Connecting-rod length / Crank-radius.	Hight of piston above floor inch.	Piston-rod Diameter. in.	Slide-bars. Length. in.	Slide-bars. Width. in.	Cross-head-pin. Diameter. in.	Cross-head-pin. Length. in.	Crank pin. Diameter. in.	Crank pin. Length. in.	Crank-pedestal. Bore. in.	Crank-pedestal. Length. in.	Maximum main-shaft Diam. in.	Air-pump. Diameter. in.	Air-pump. Stroke. in.	Pump-capacity / Cylinder-capacity.	Remarks.
50	—	M. A. Starke.	Starke & Hoffmann.	Hirschberg	—	—	5,34	4·80	2·76	—	7·87	2.95	6.49	—	5.70	8.19	14.17	8.19	—	—	—	
—	—	" "	"	"	.87	4,5	5,34	3·78	1·77	7·87	4·32	1.38	1.97 × 0.08	2.17	3.15	4.32	7.08	4.52	—	—	—	One Slide and one Expansion-valve.
—	—	" "	"	"	.48	4,5	5,34	5·43	3·15	8·46	9·29	2.76	3.31	4.05	5.27	8.74	14.57	8.66	—	—	—	
47	—	Woodruff	Hartford Foundry Machine& C.	Hartford.	.08	3,6	5,00	5·90	2·44	9·25	1·97 × 0·08	2.68	× 0.08 3.94	2.68	3.86	6.88	10.82	7.71	—	—	—	
61	—	—	Ch. Nolet.	Genth.	—	4,5	5,00	8·26	4·52	8·51	—	—	—	3.74	7.87	11·02	21.27	11_{81}	22.45	27.72	1/4,4 single	Expansion-valve inside the Slide.
62	—	—	Socin & Wick.	Bâsle.	3·39	3,93	5,50	5·11	2·36	13·78	5·90	2.76	4.52	3.94	4.32	6.76	11.41	8.46	7.28	35.43	1/4,1 single	
63	—	Regnier.	Bolzano Tedesco & Co.	Schlan-Prag	5·75	3,30	5,00	4·72	1·97	11·02	4·72	1.97	4.13	2.76	4.13	5.51	11.02	5.90	—	—	—	Flywheel channelled for 5 ropes.

Millimetres in Inche a Foot.

Mm.	0	1	2	3
0	—	0.04	0 08	0.12
10	0.39	0.43	0.47	0.51
20	0.79	0.83	0.87	0.91
30	1.18	1.22	1.26	1.30
40	1.53	1.61	1.65	1.69
50	1.97	2.01	2.05	2.09
60	2.36	2.40	2.44	2.48
70	2.76	2.80	2.83	2.87
80	3.15	3.19	3.23	3.27
90	3.54	3.58	3.62	3.66

m	ft.	m	ft.	m	ft.	m	ft.
61	200.13	71	232.94	81	265.75	91	298 56
62	203.41	72	236.22	82	269.03	92	301.84
63	206.69	73	239.50	83	272.31	93	305.12
64	209.97	74	242.78	84	275.59	94	308.40
65	213.25	75	246.06	85	278.87	95	311.68
66	216.53	76	249.13	86	282.15	96	314.96
67	219.82	77	252.62	87	285.43	97	318.24
68	223.10	78	255.90	88	288.71	98	321.52
69	226.38	79	259 19	89	291.99	99	324.80
70	229.66	80	262.47	90	295.27	100	328.08

Square Centimetres in squar

Sq. Ct.	0	1	2	3
0	0.000	0.016	0.030	0.047
1	0.155	0.171	0.186	0.202
2	0.310	0.326	0.341	0.357
3	0.465	0.481	0.496	0.512
4	0 620	0.636	0.651	0.667
5	0.775	0.791	0.806	0.822
6	0.930	0.946	0.961	0.977
7	1.085	1.101	1.116	1.132
8	1.240	1.256	1.271	1.287
9	1.395	1.411	1.426	1.442

Fractions.

Dec.	in.	Dec.	in.	Dec.	in.	Dec.	in.
0.61	39/64	0.71	45/64 +	0.81	13/16 —	0.91	29/32 +
0.62	5/8 —	0.72	23/32 +	0.82	13/16	0.92	59/64 —
0.63	5/8	0.73	47/64 —	0.83	53/64	0.93	59/64
0.64	41/64	0.74	47/64 +	0.84	27/32 —	0.94	15/16
0.65	21/32 —	0.75	3/4	0.85	27/32	0.95	61/64 —
0.66	21/32	0.76	49/64 +	0.86	55/64	0.96	61/64 +
0.67	43/64	0.77	49/64	0.87	7/8 —	0.97	31/32 +
0.68	11/16 —	0.78	25/32 —	0.88	7/8	0.98	63/64 +
0.69	11/16 +	0.79	51/65 +	0.89	57/64	0.99	1 —
0.70	45/64 —	0.80	51/64	0.90	29/32 —	1.00	1

Kilogrammes in Pounds

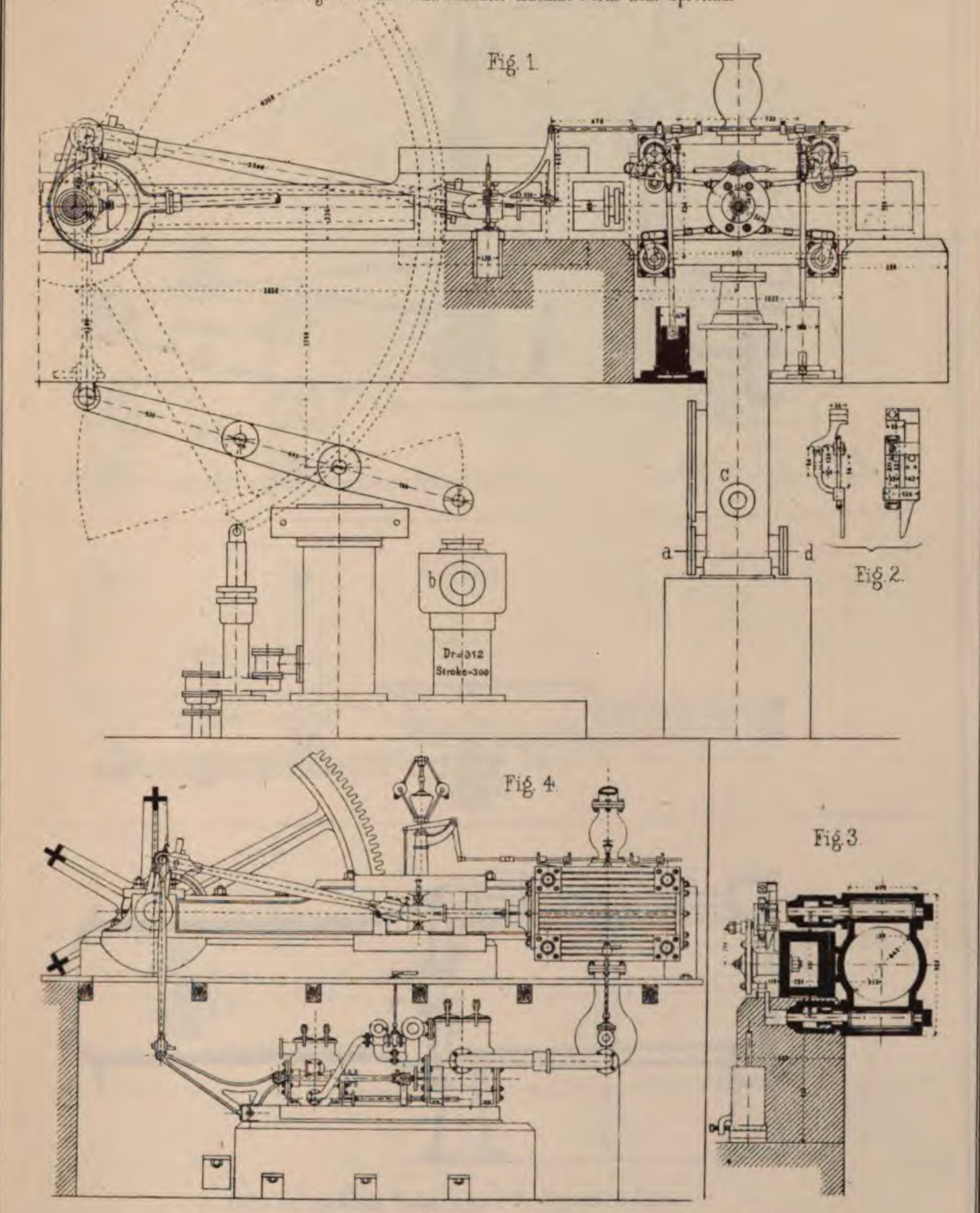
Kilog.	0	1	2	3	
0	—	0.220	0.441	0.661	C
1	2.205	2.425	2.646	2.866	3
2	4.409	4.630	4.850	5.071	5
3	6.614	6.834	7.055	7.275	7
4	8.818	9.039	9.259	9.480	9
5	11.023	11.243	11.464	11.684	11
6	13.228	13.448	13.669	13.889	14
7	15.432	15.653	15.873	16.094	16
8	17.637	17.857	18.078	18.298	18
9	19.841	20.062	20.282	20.503	20

square inch.

inch high) = 0.491163.

. . = 0.01934.

Corliss-Engine of the Wilhelmshütte Machine-works near Sprottau.



Corliss-Engine of the Hamburg-Magdeburg Steam. navigation Company, Buckau-Magdeburg.

E. & J. N. Spon, London & New-York. H. Springer, Leipsic.

Corliss-Engine constructed by Messrs. Robert Wetherill & Co. of Chester P., U. S.

Fig. 1.

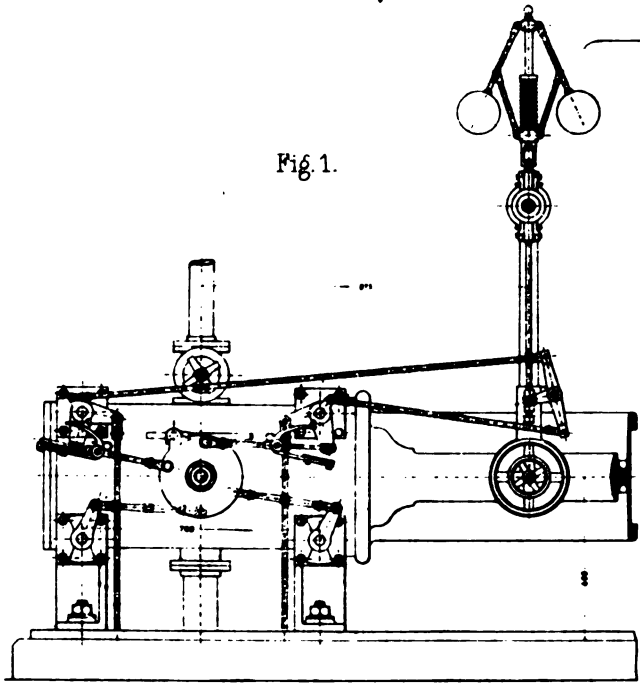


Fig. 2.

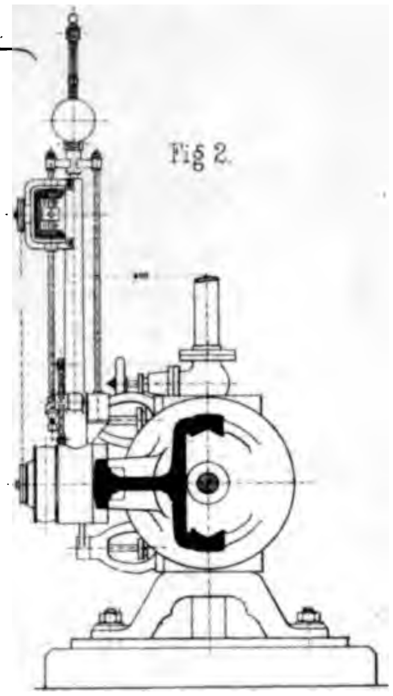


Fig. 3.

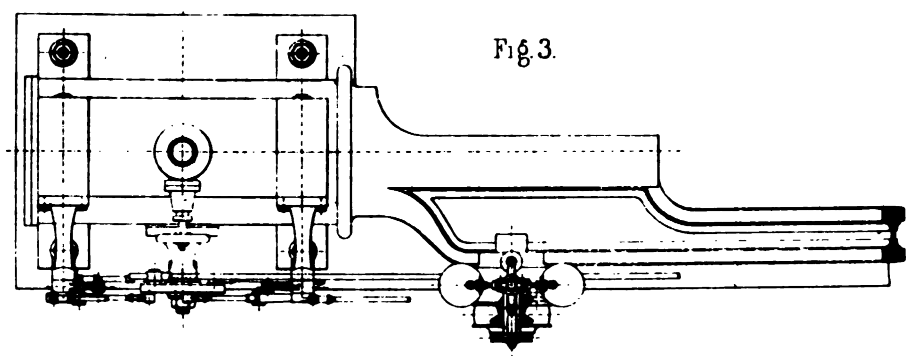
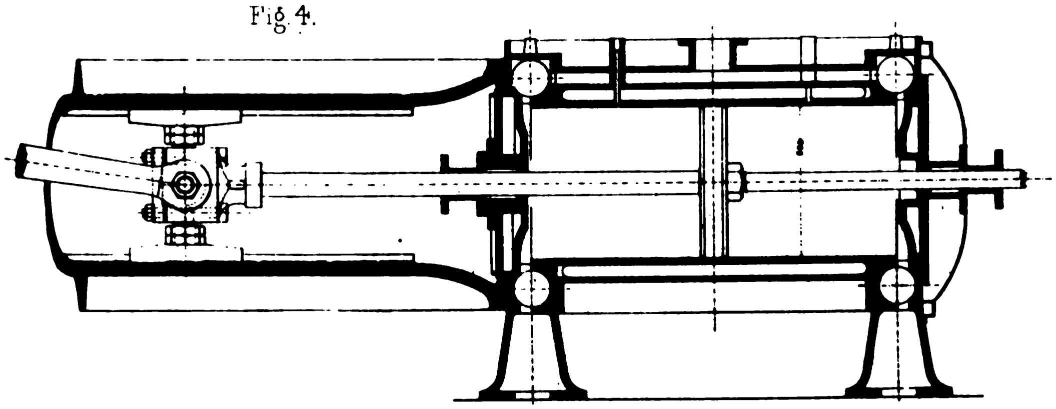
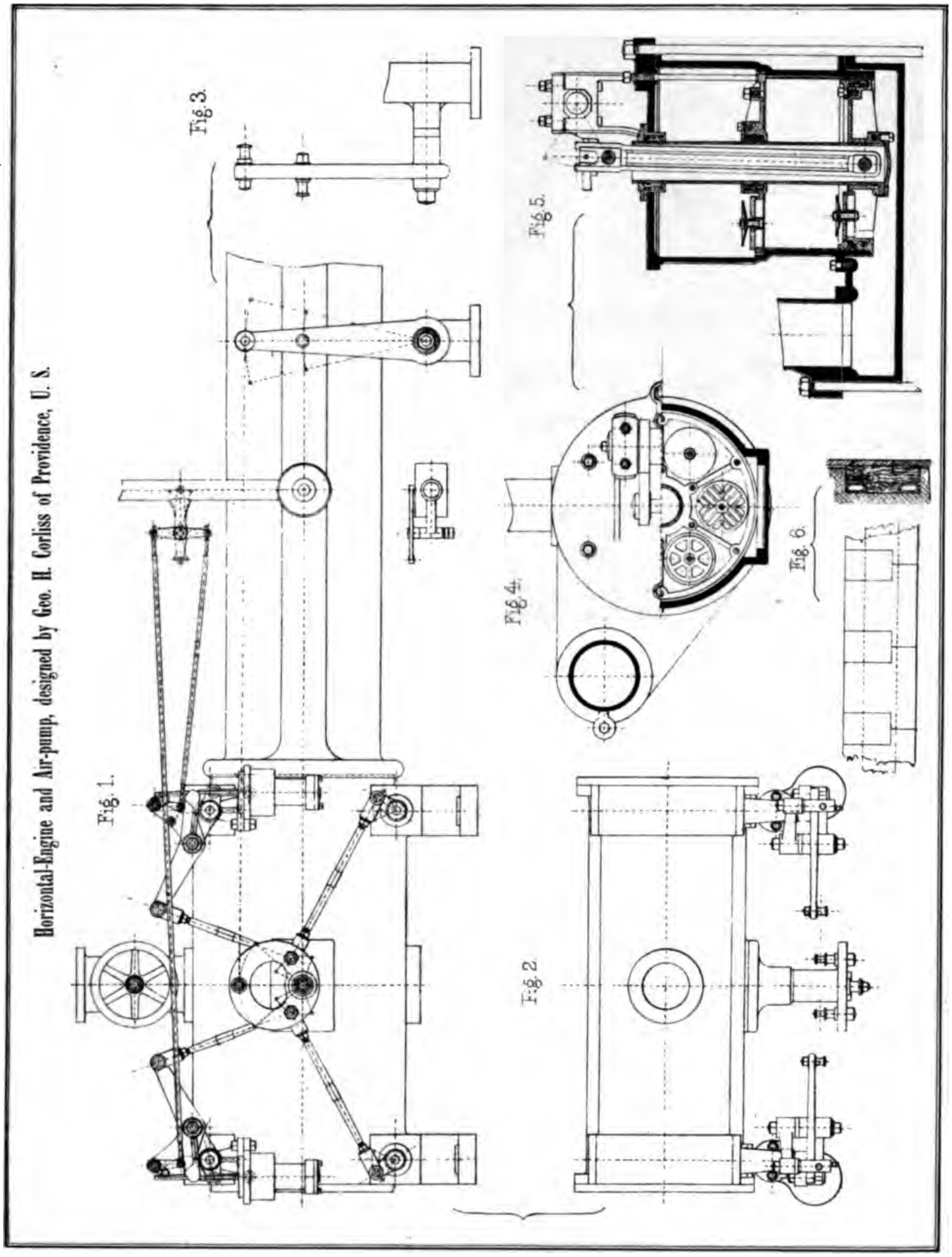


Fig. 4.



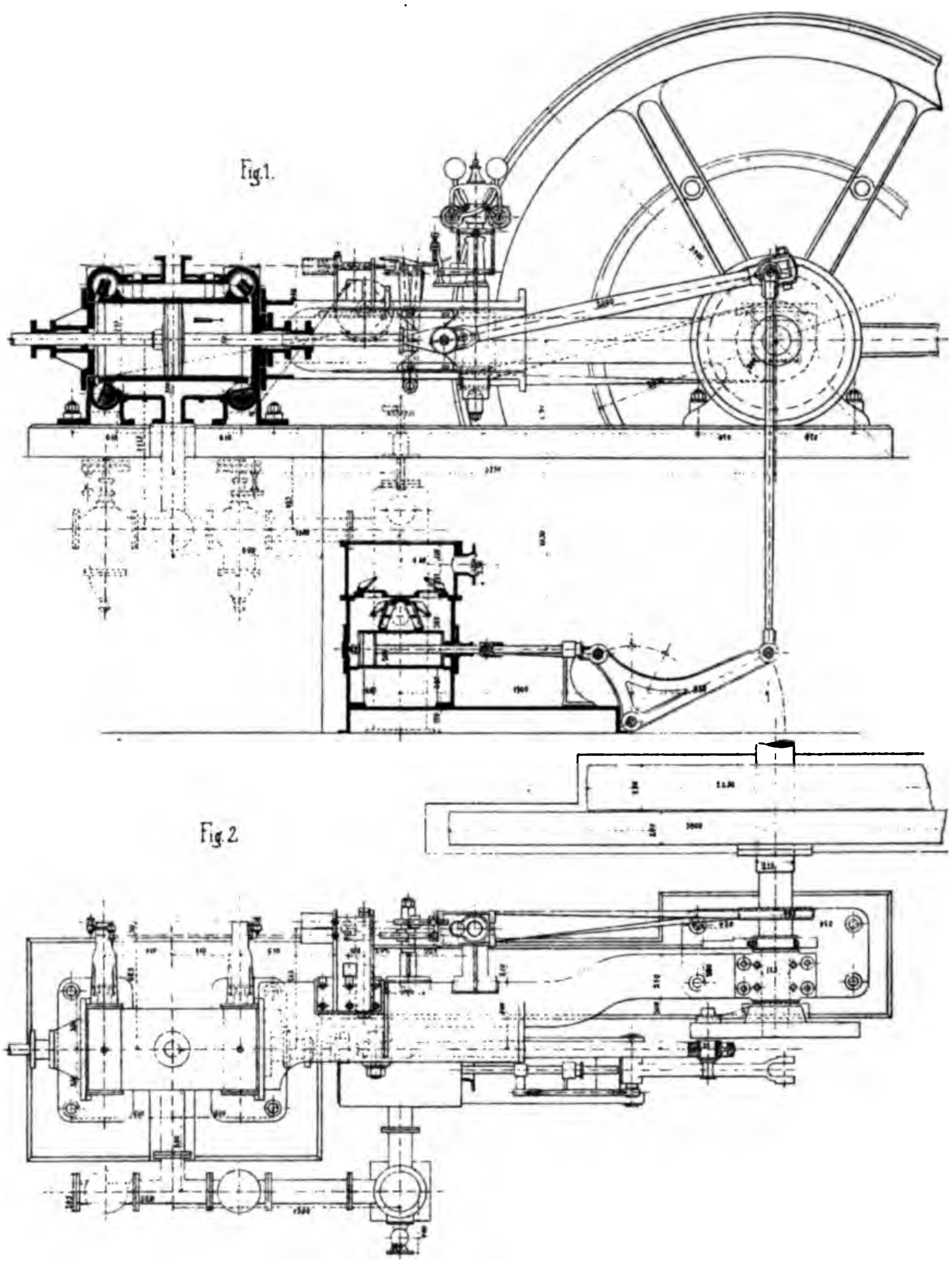
Corliss-Engines Messrs. Escher, Wyss & Co. Engineers of Zürich.

E. & J. N. Spon, London & New-York. H. Springer, Leipsic.

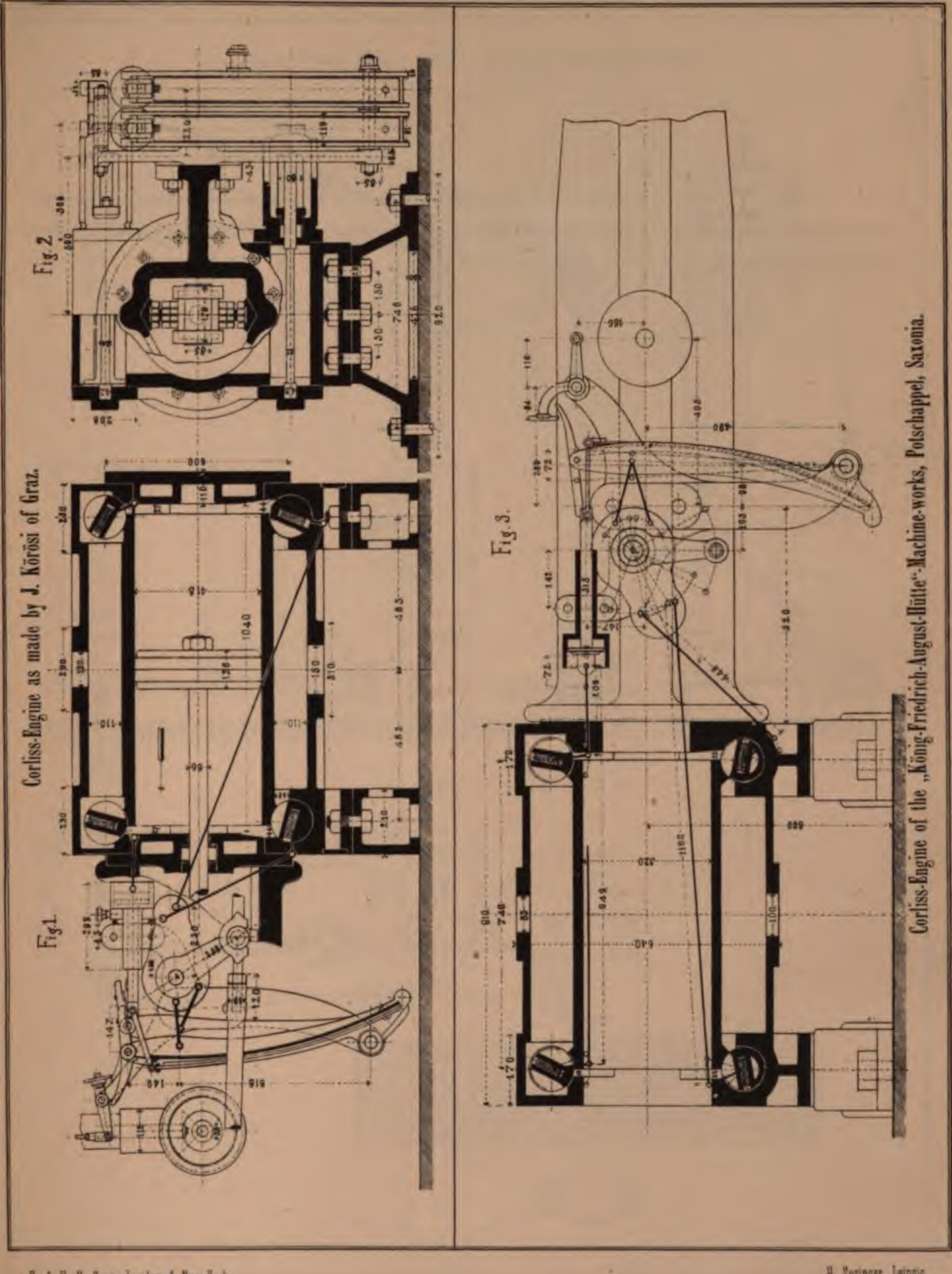


E. & J. N. Spon, London & New-York. H. Springer, Leipsic.

Corliss-Engine of the Stollberg-Machine-works, Ilsenburg.



E. & F. N. Spon, London & New-York. H. Springer, Leipsic.



Corliss-Engine as made by J. Körösi of Graz.

Corliss-Engine of the „König-Friedrich-August-Hütte"-Machine-works, Potschappel, Saxonia.

E. & F. N. Spon, London & New-York. H. Springer, Leipsic.

Corliss-Engine constructed by Messrs. Robert Wetherill & Co. of Chester P., U. S.

Fig. 1. Fig. 2. Fig. 3.

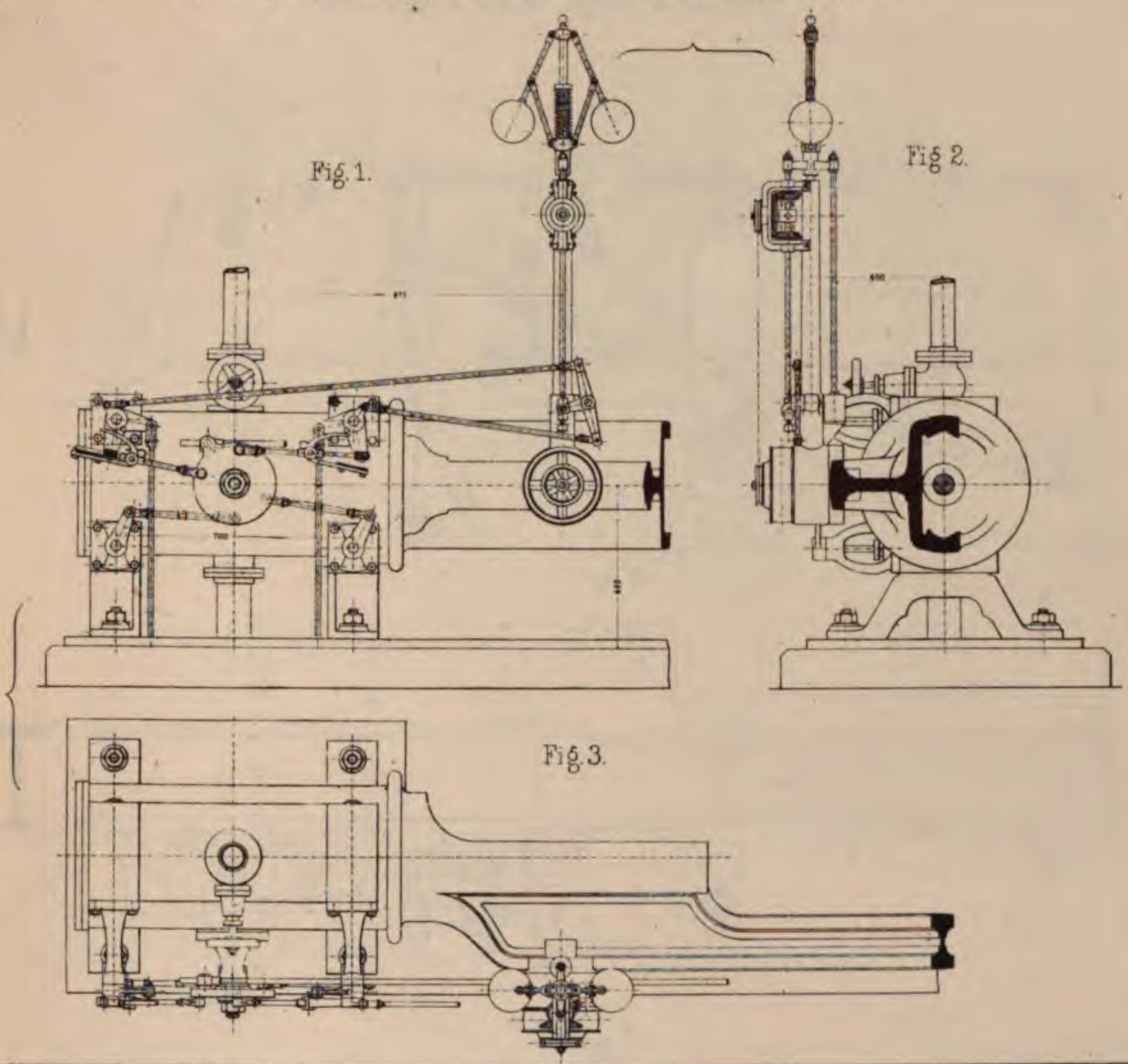
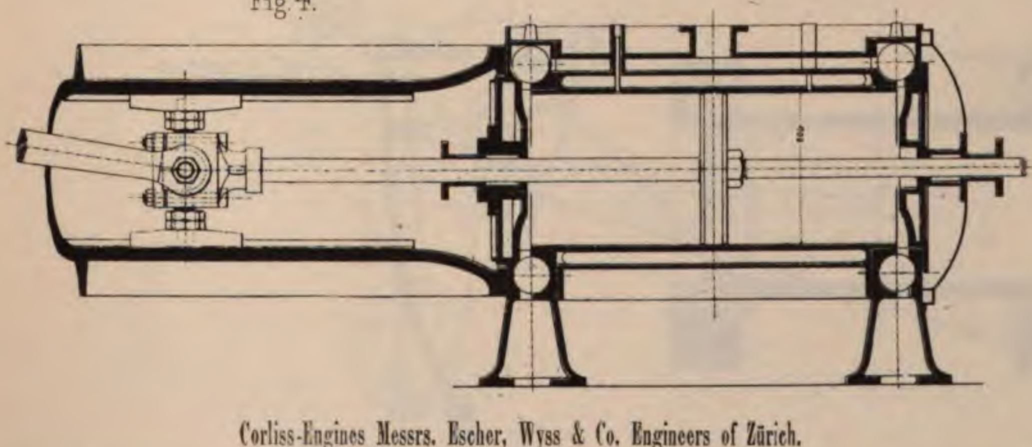


Fig. 4.



Corliss-Engines Messrs. Escher, Wyss & Co. Engineers of Zürich.

E. & J. N. Spon, London & New-York. H. Springer, Leipsic.

Corliss-Engine E. Reinicke, Engineer of Königsberg.

Fig. 1.

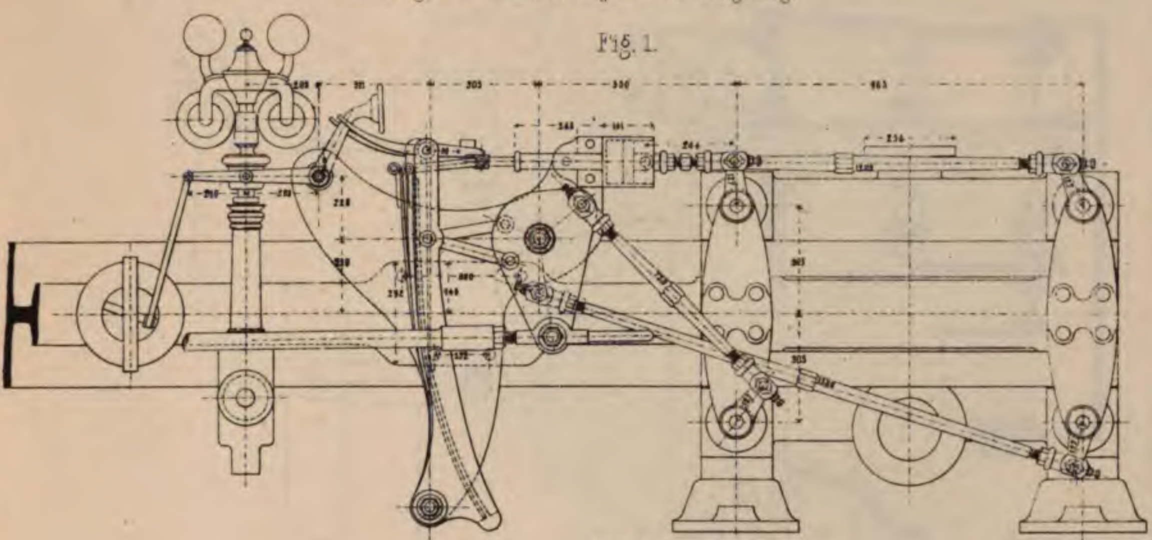


Fig. 2.

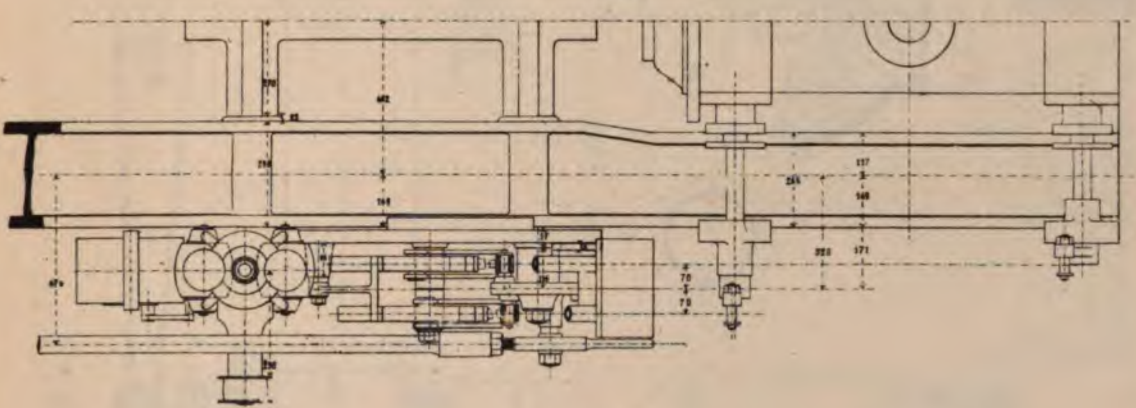
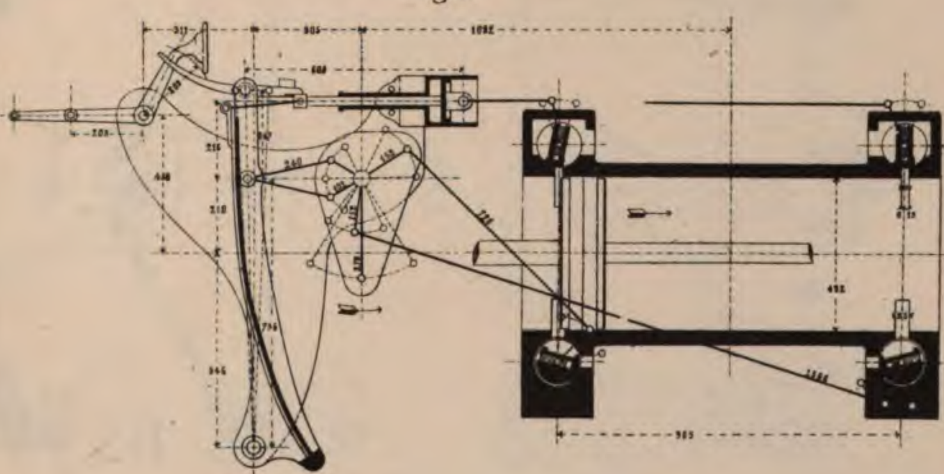


Fig. 3.



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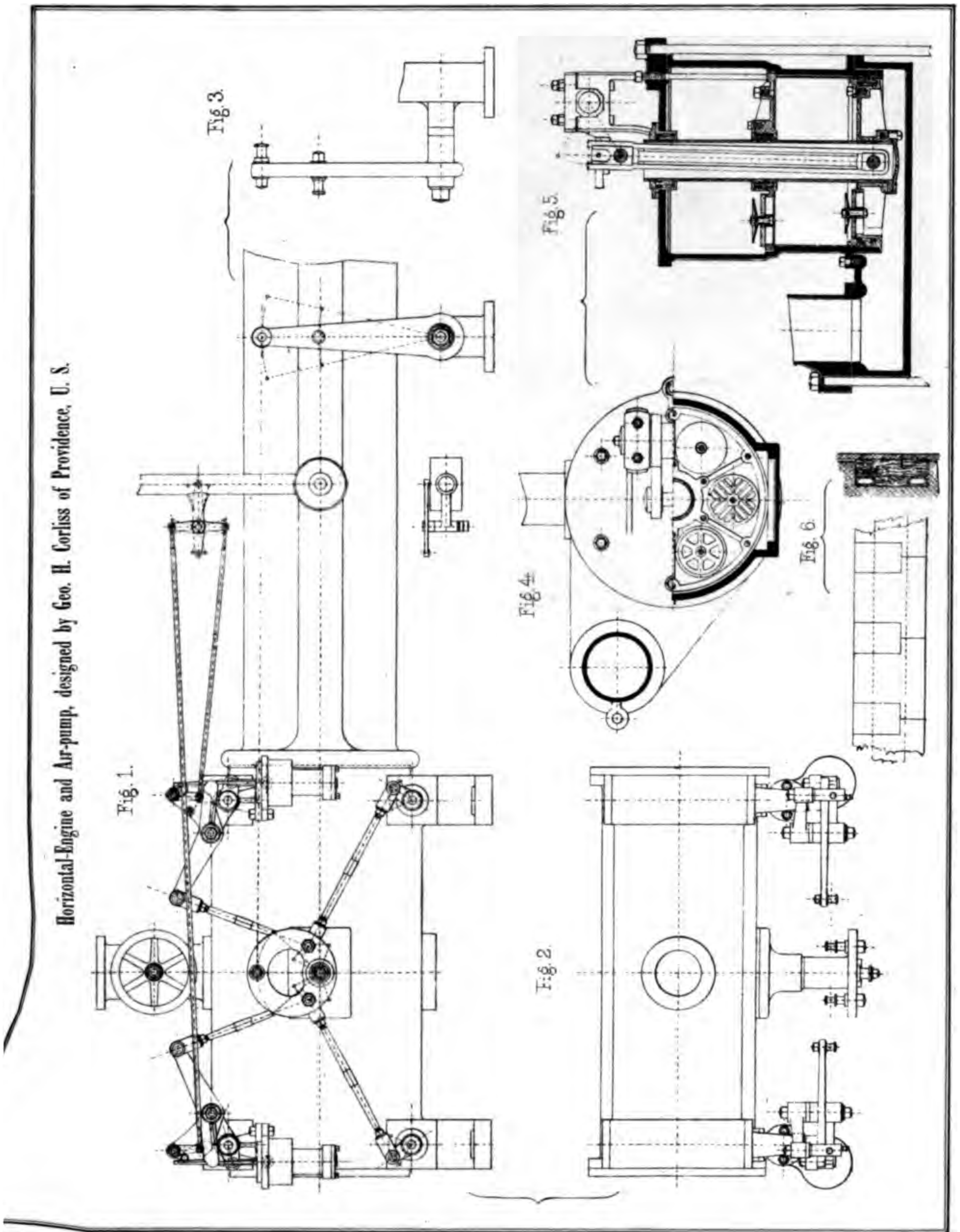
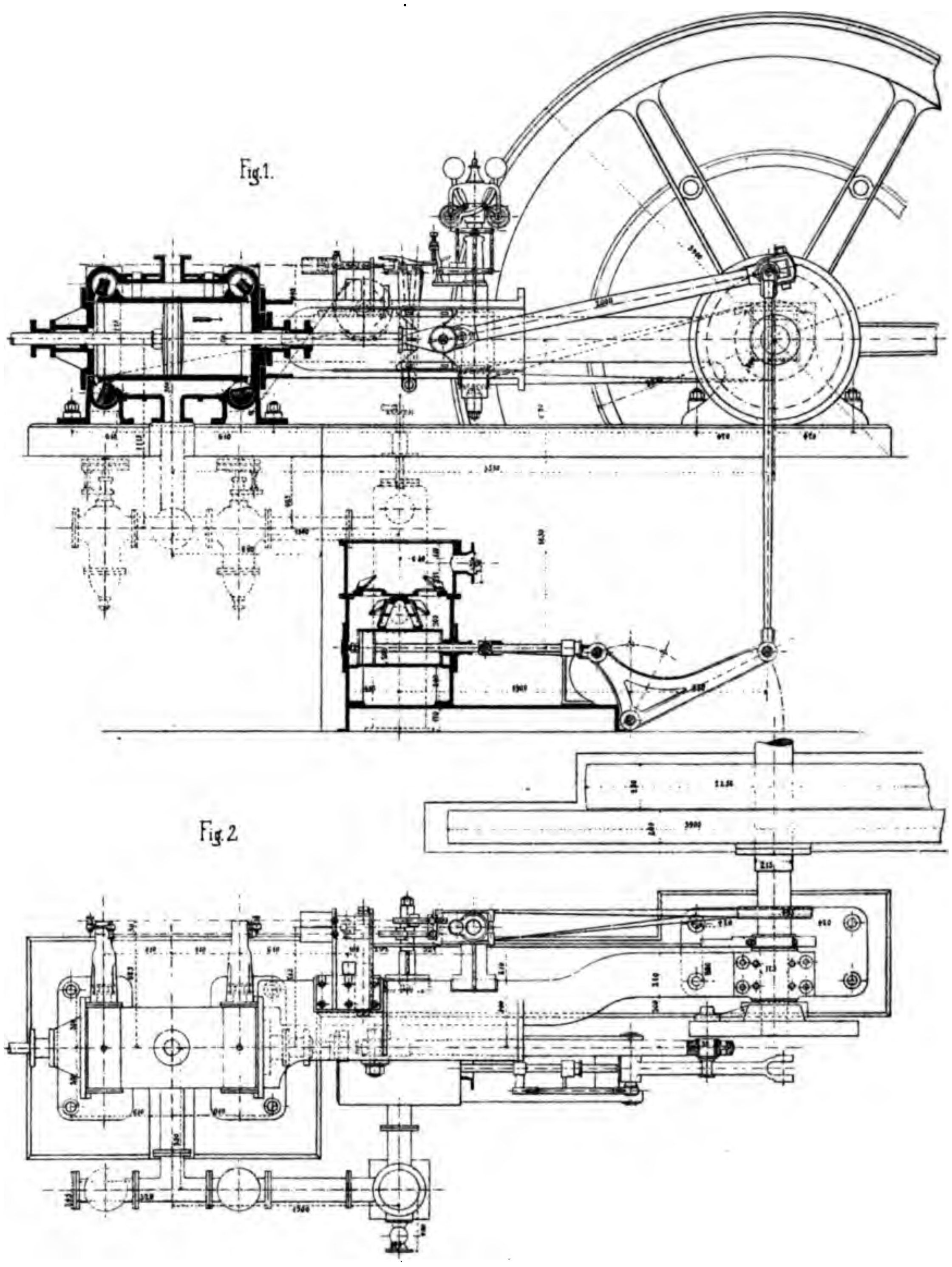


E. & J. N. Spon, London & New-York. H. Springer, Leipsic.

Corliss-Engine of the Stollberg-Machine-works, Ilsenburg.



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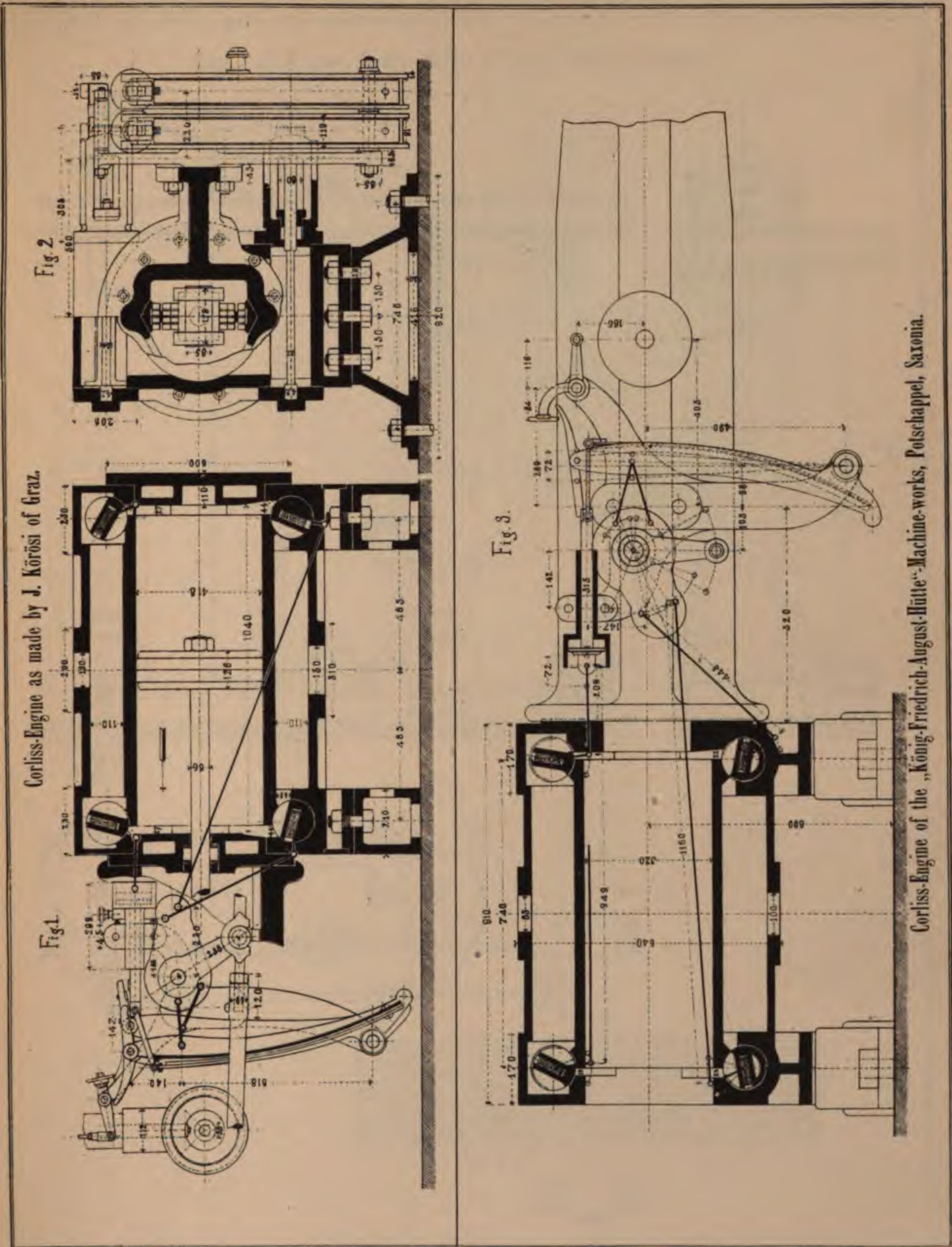
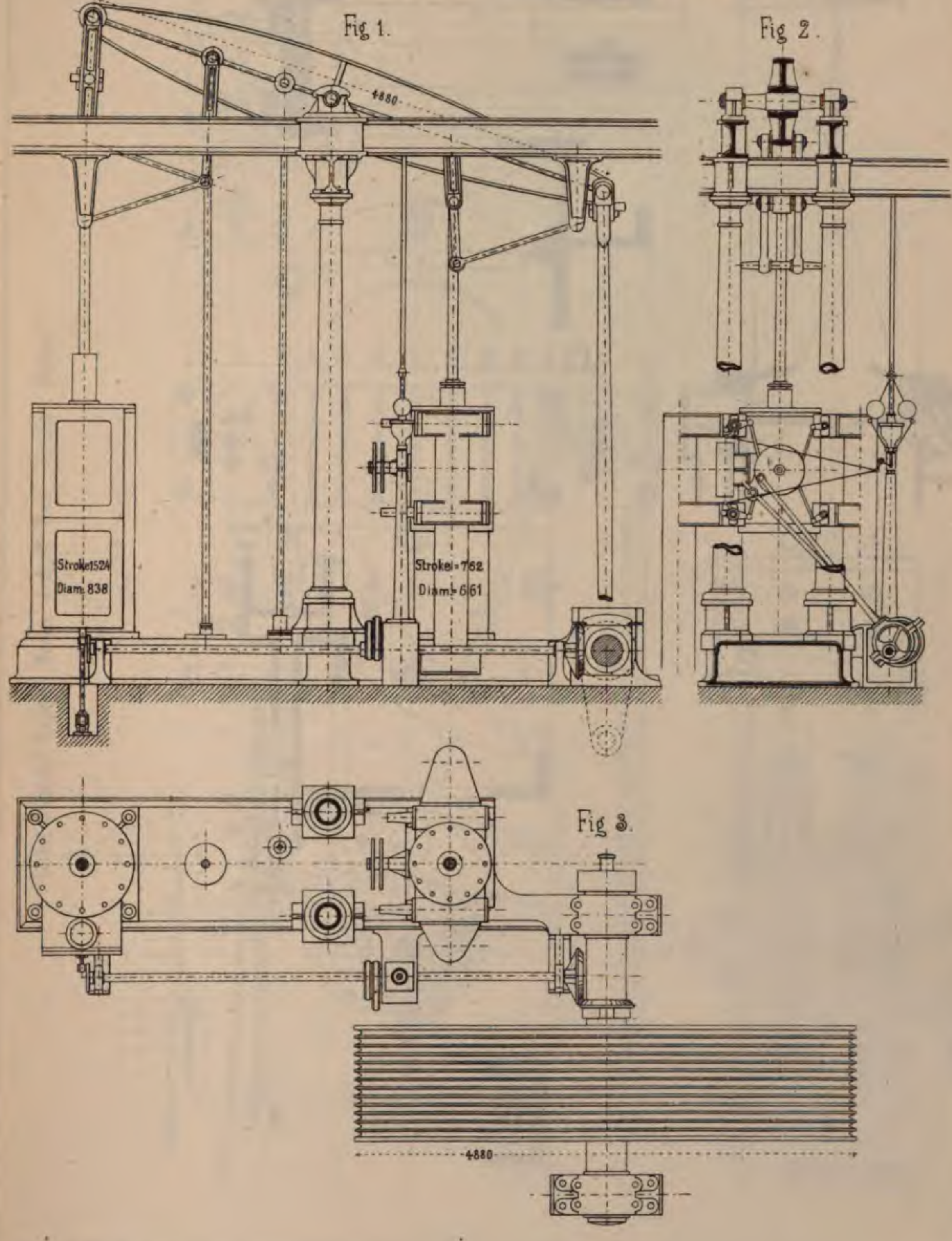


Corliss-Engine as made by J. Kőrösi of Graz.

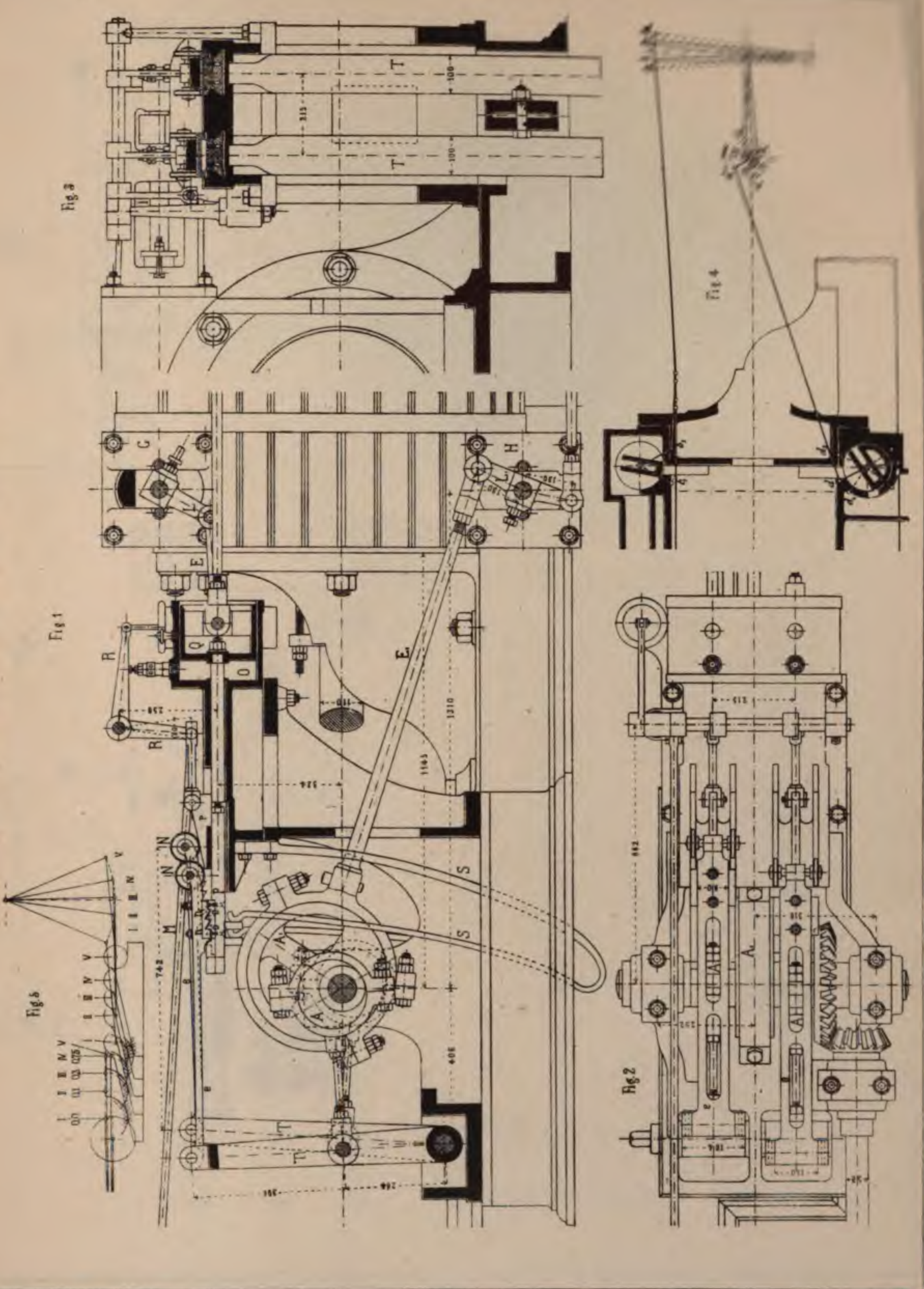
Corliss-Engine of the „König-Friedrich-August-Hütte“-Machine-works, Potschappel, Saxonia.

E. & F. N. Spon, London & New-York. H. Springer, Leipsic.

Beam Corliss-Engines, Messrs. Douglas & Grant, Engineers, Kirkcaldy.

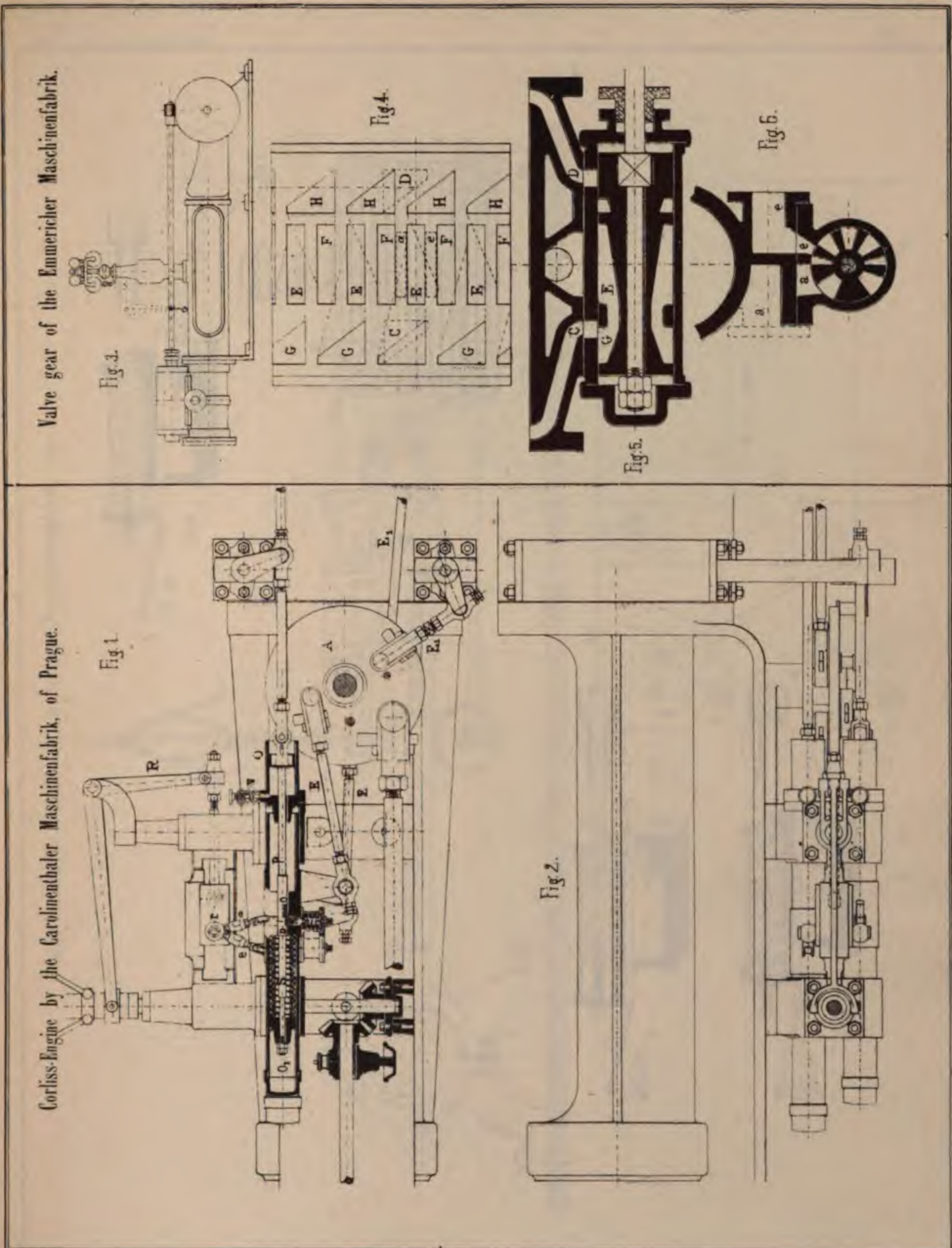


Corliss-Compound Engines, Messrs. J & E. Wood, Engineers, Bolton.

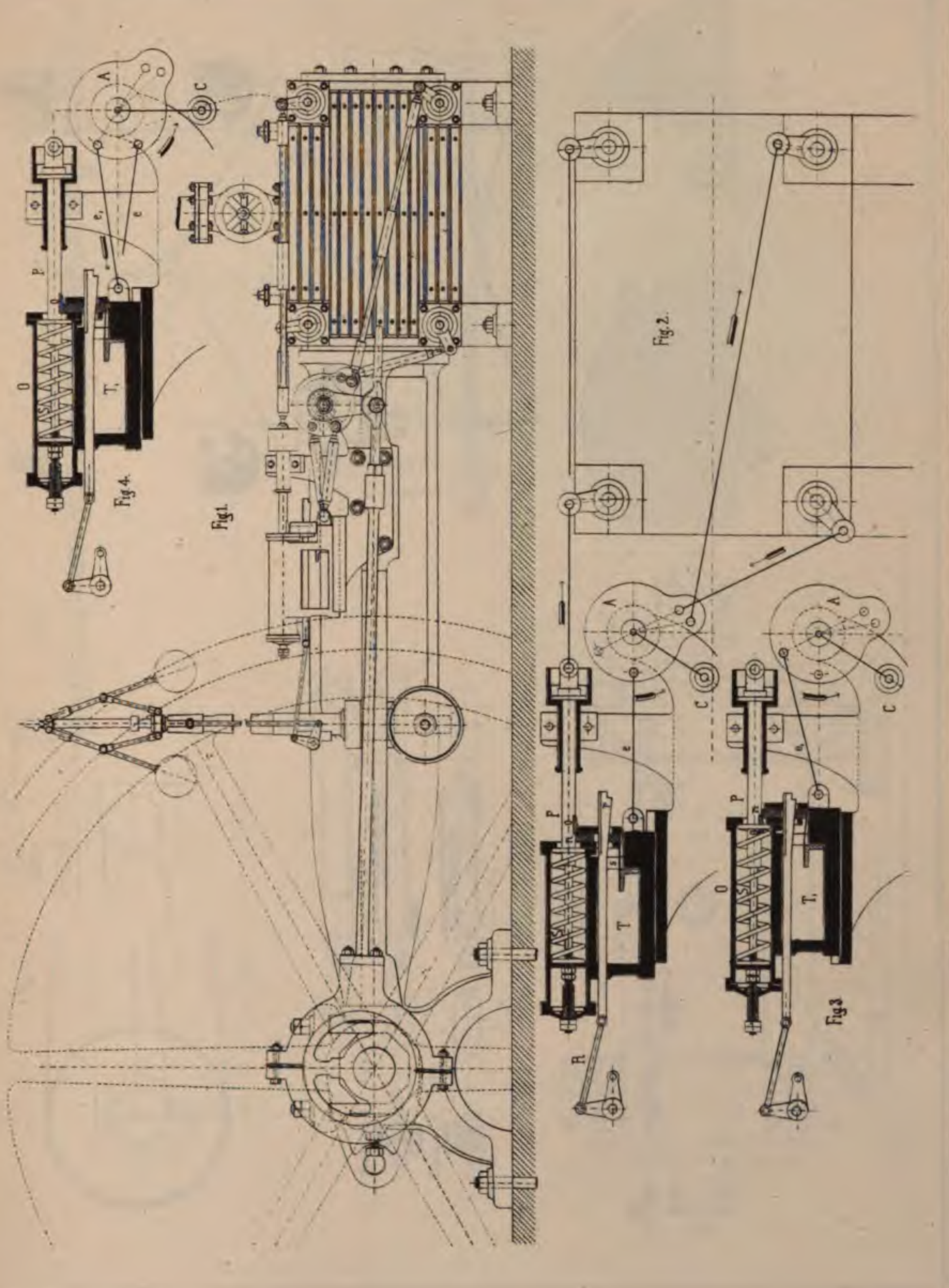


E. & F. N. Spon, London & New-York.

H. Springer, Leipsic.



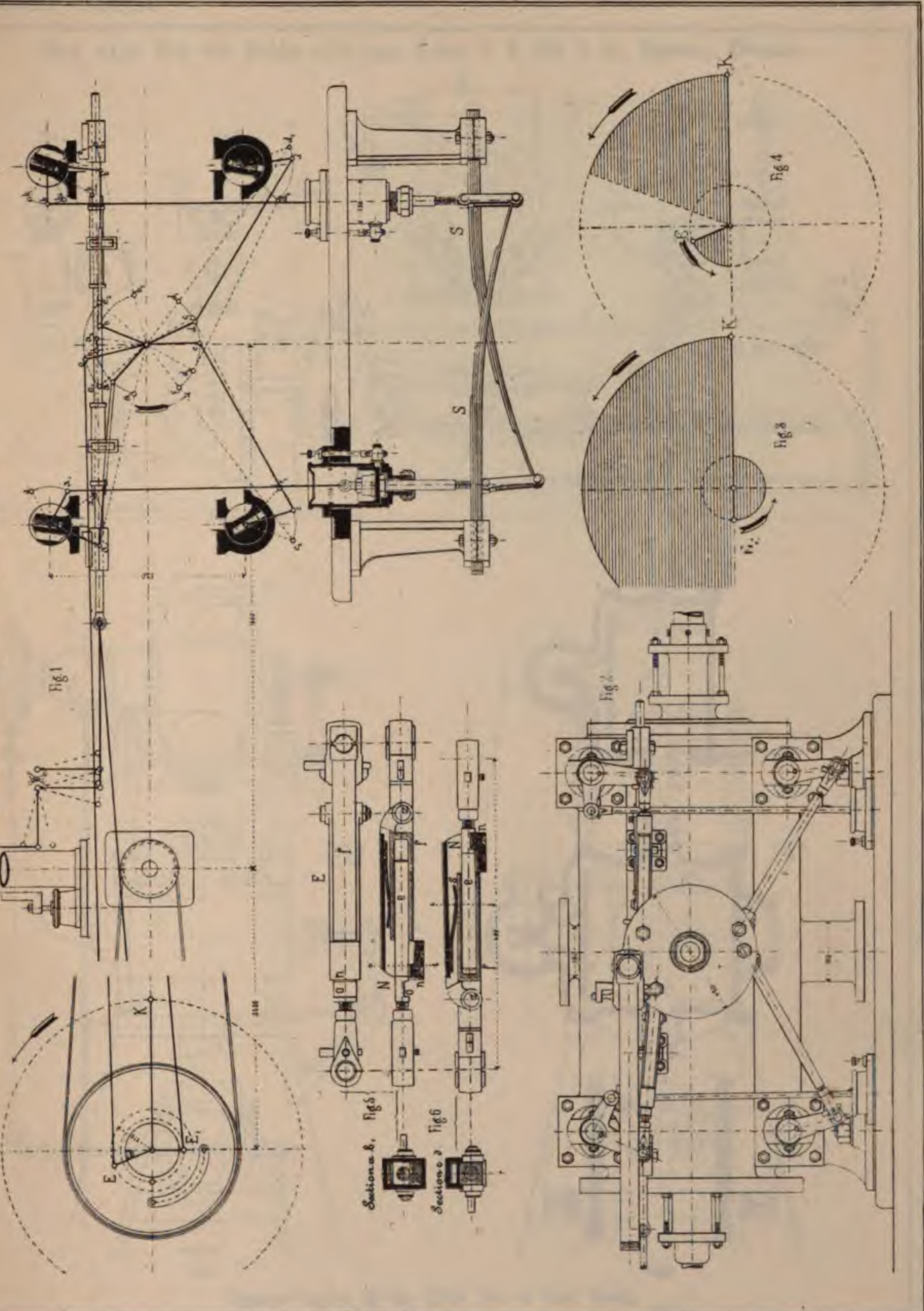
E. & F. N. Spon, London & New-York. M. Springer, Leipsic



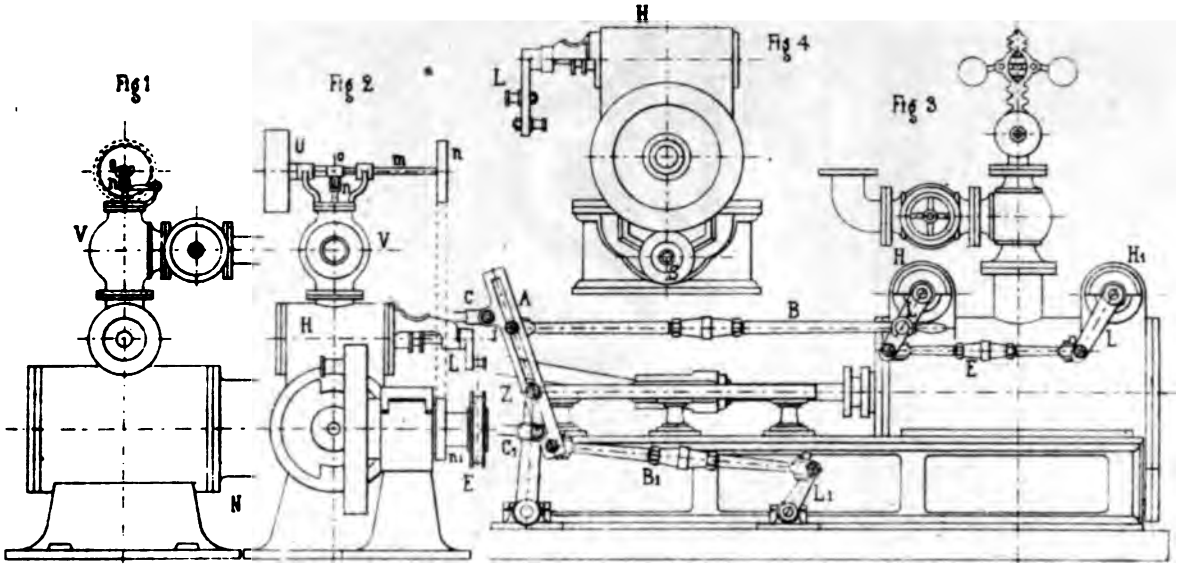
Corliss-Engine (Type Renzsch) the Crimmitzschauer Dampfmaschinenfabrik, Engineers.

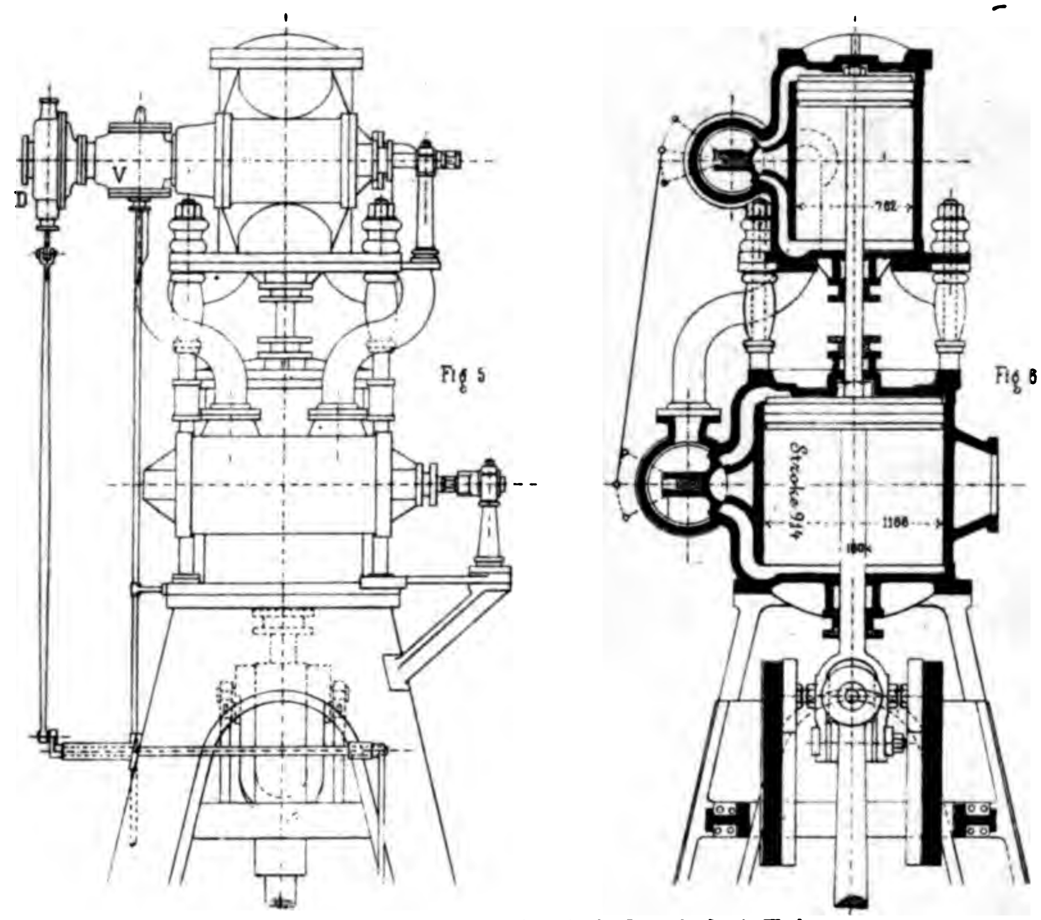
E. & F. N. Spon, London & New-York. H. Springer, Leipzic

Corliss-Engine as made by Fr. Wannieck, of Brünn.



Steam engine fitted with Rocking valve gear, Messrs. E. P. Allis & Co., Engineers, Milwaukee.

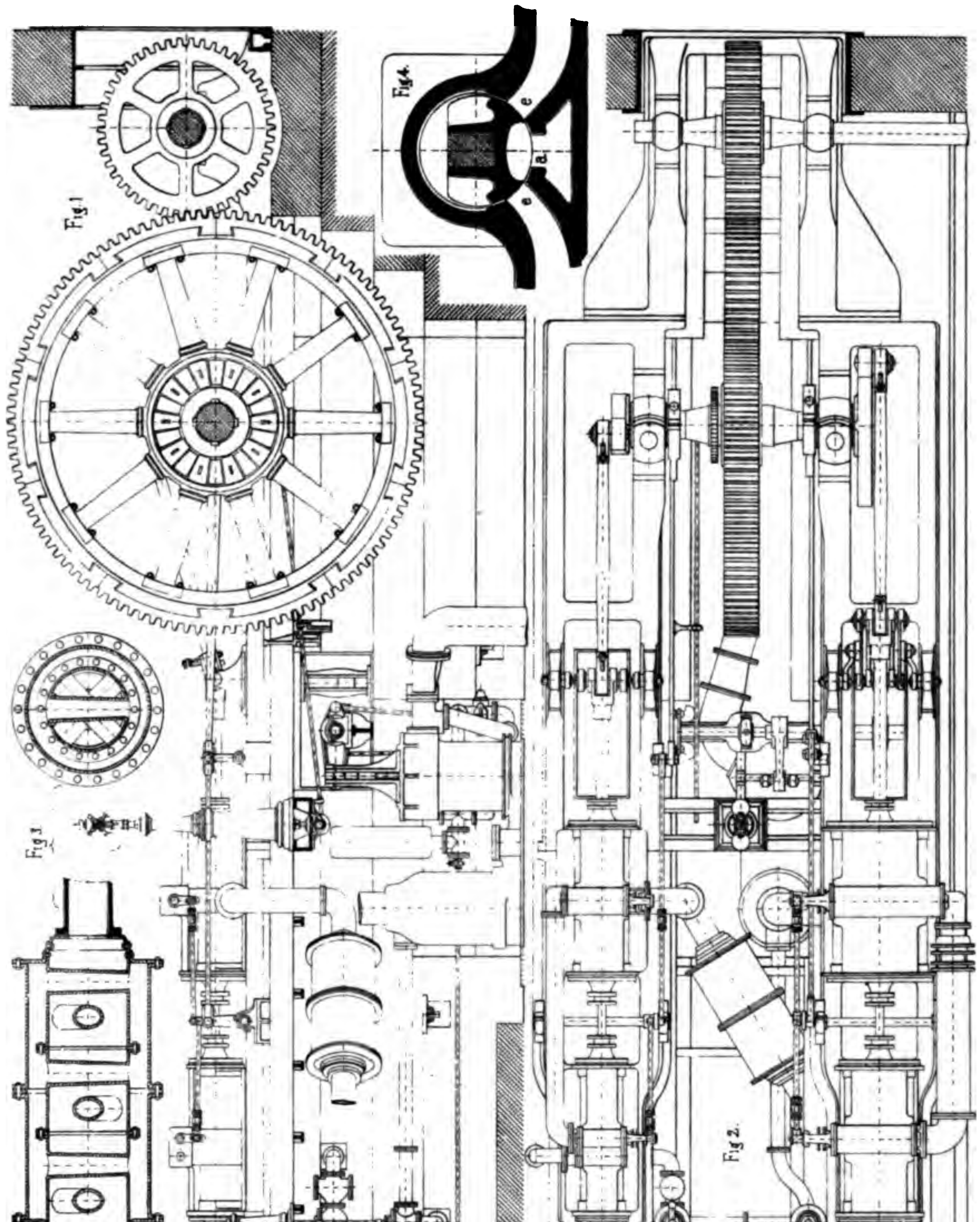




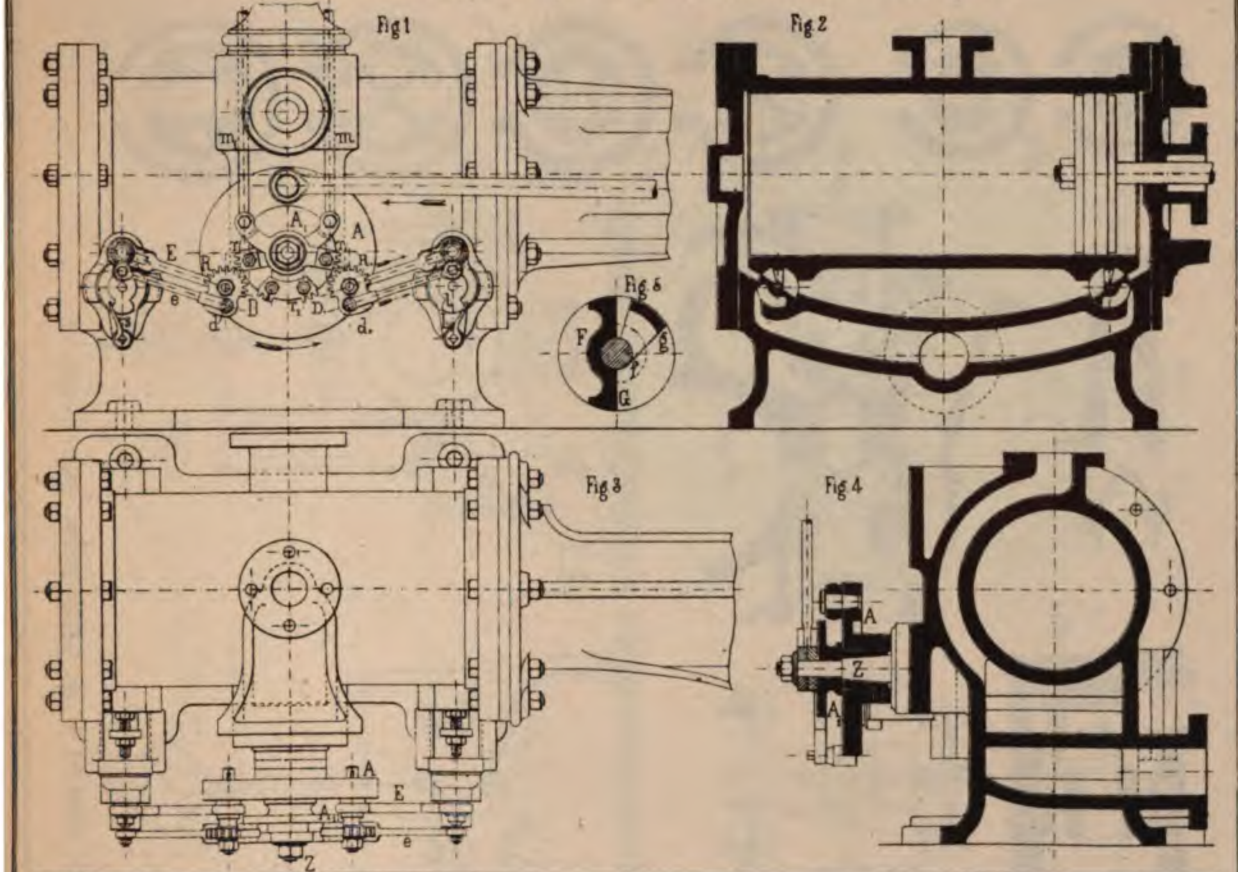
Compound engines of the Phönix Iron & Steel Works.

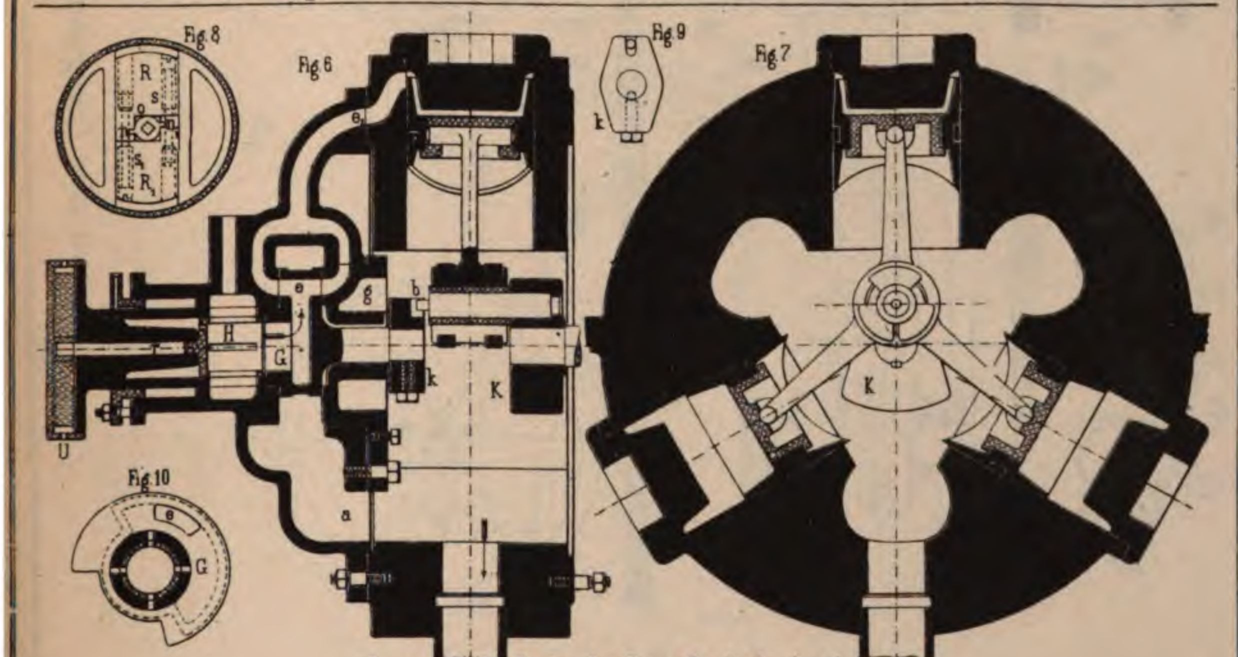
E. & J. N. Spon, London & New-York. H. Springer, Leipzic.

Four-cylinder-steam-engine fitted with Rocking valve gear; Daniel Adamson, Manchester.



Automatic variable expansion gear of Messrs. Loesch and Lüders, Engineers.

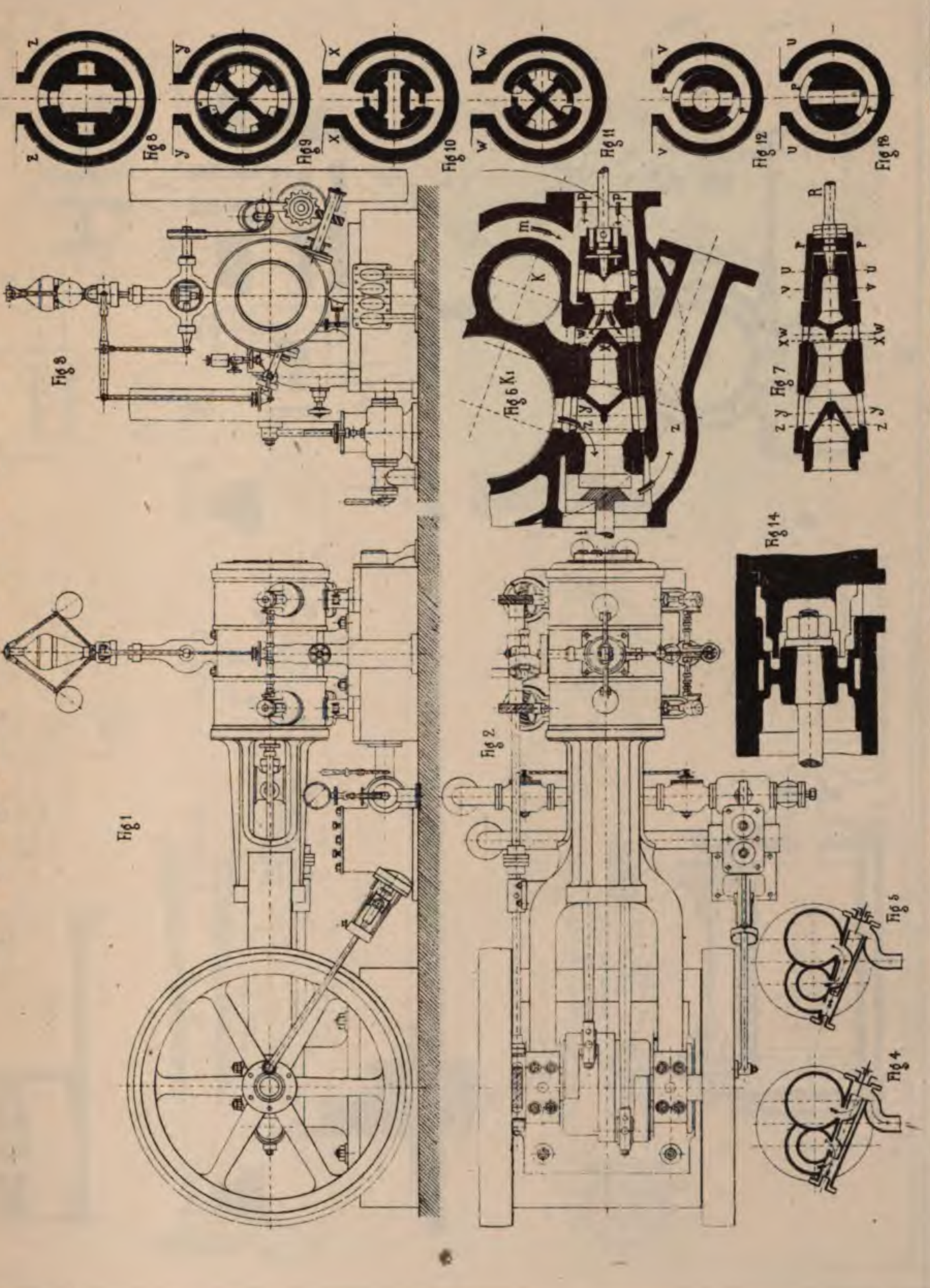




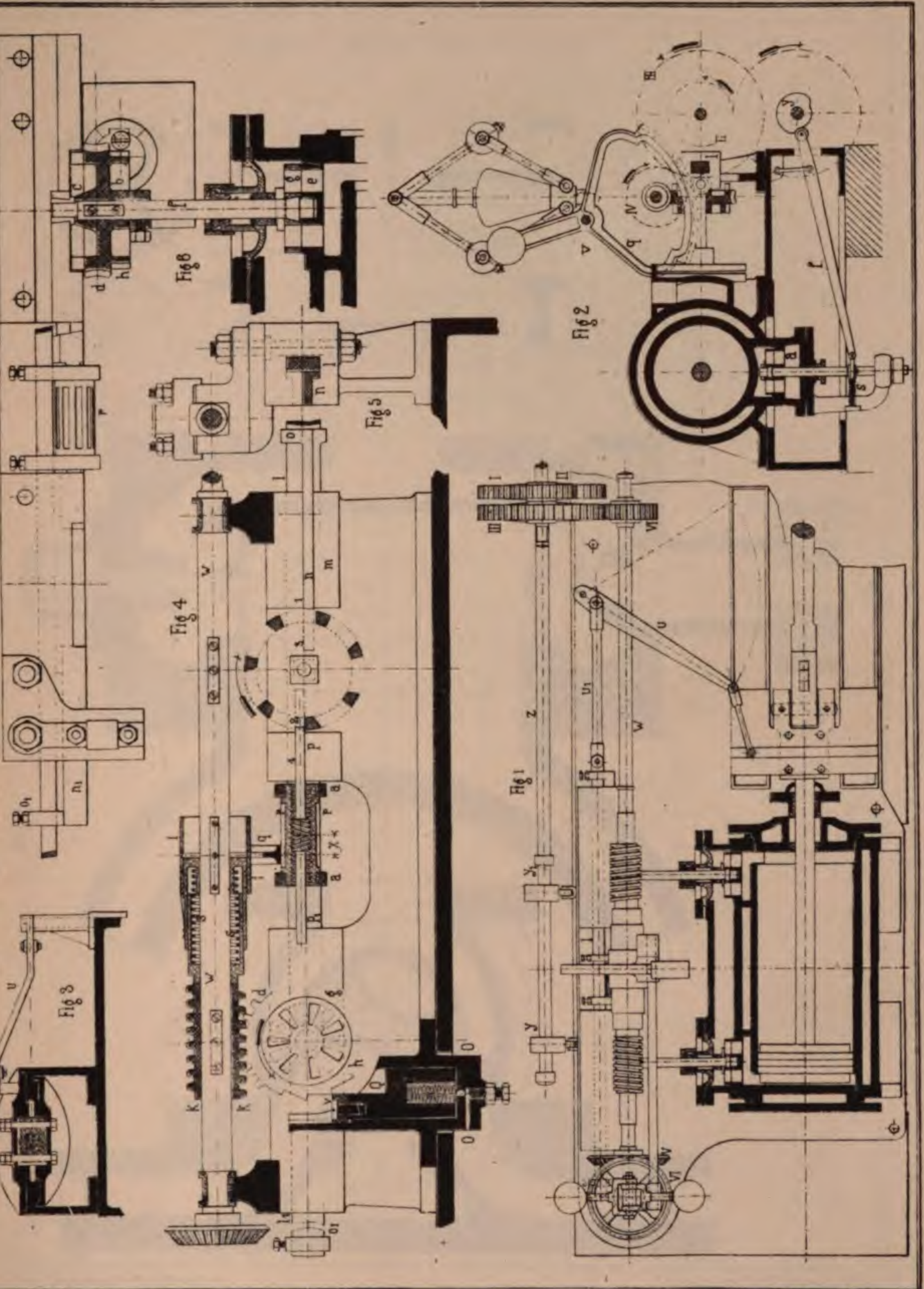
Three cylinder Engine by Peter Brotherhood, of London.

E. & J. N. Spon, London & New-York. H. Springer, Leipsic.

Compound engines (Type Ehrhardt) constructed by the Dingler Machine Works, Zweibrücken.

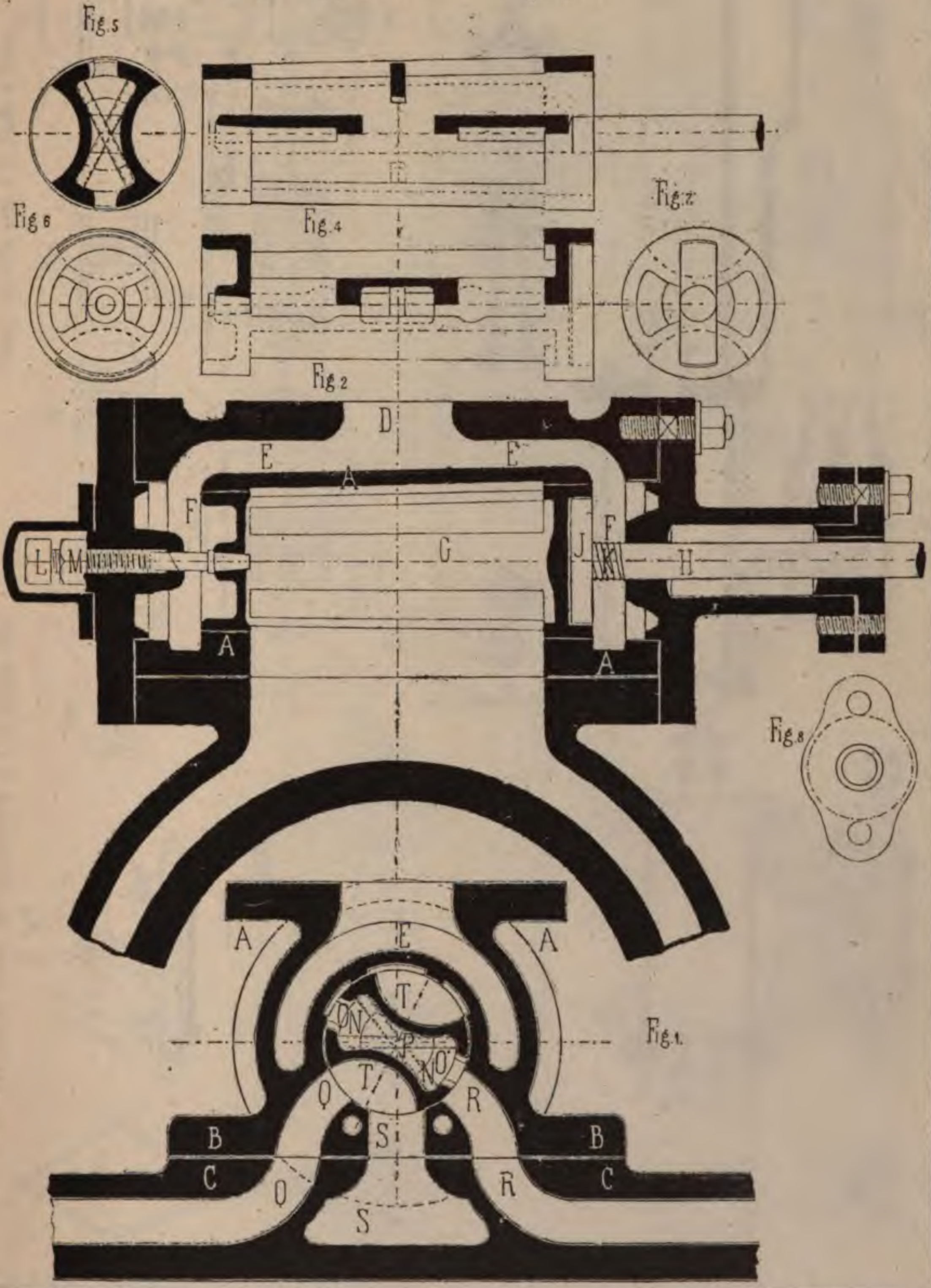


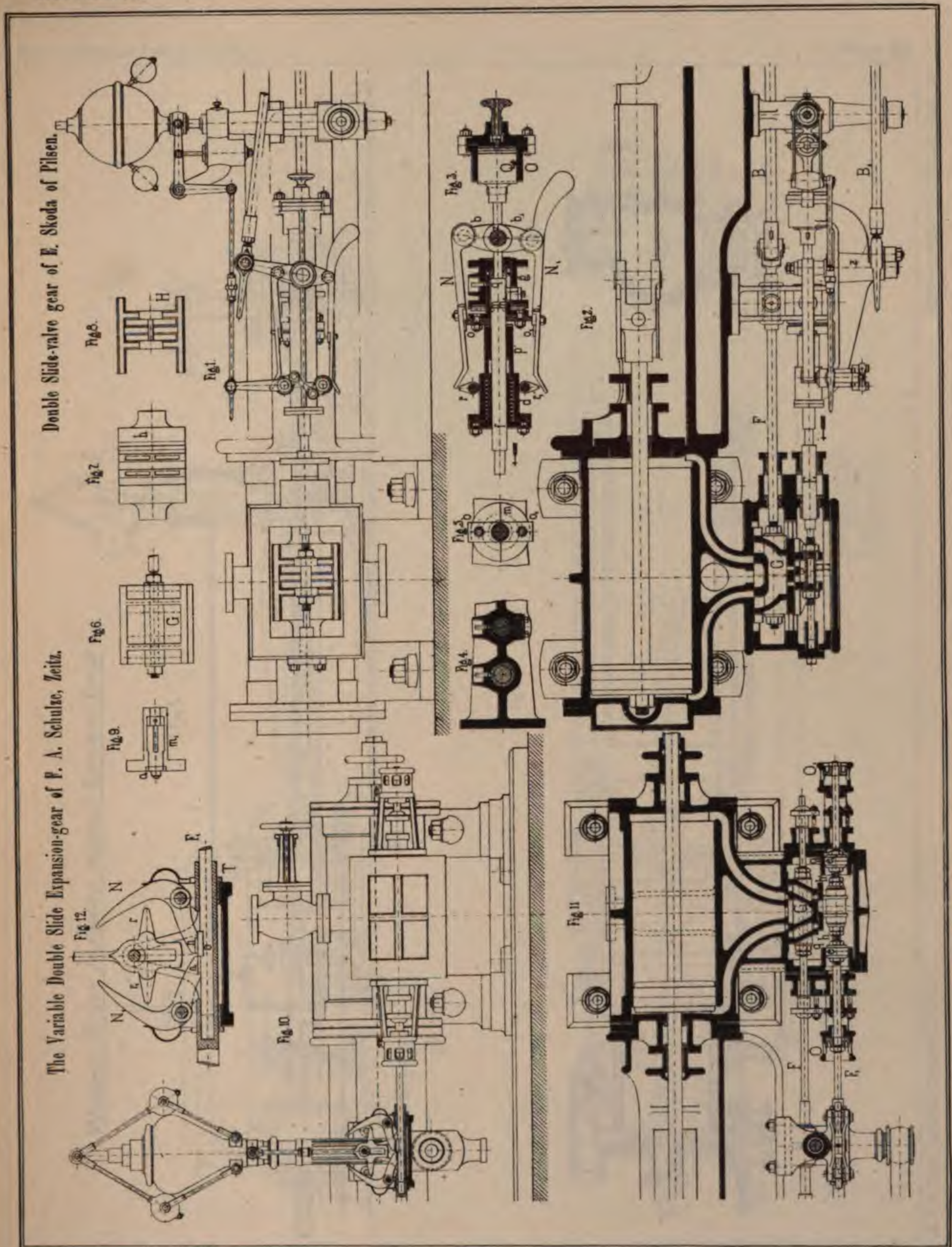
Rocking circular faced Valve gear, designed by Professor H. v. Reiche, of Aix la Chapelle.



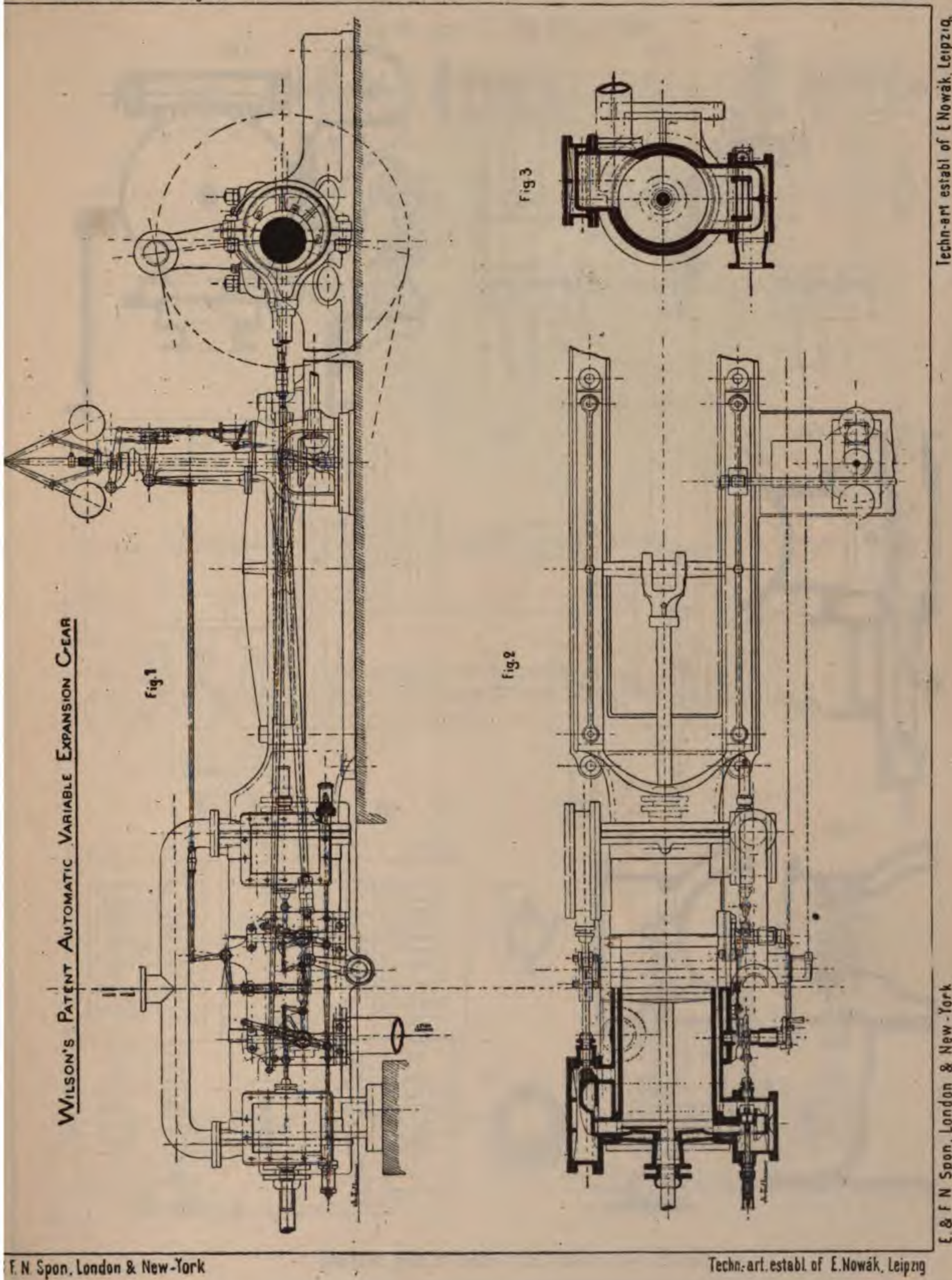
E. & J. N. Spon, London & New-York. H. Springer, Leipsic.

Wilson's Equilibrium Rocking. Valve



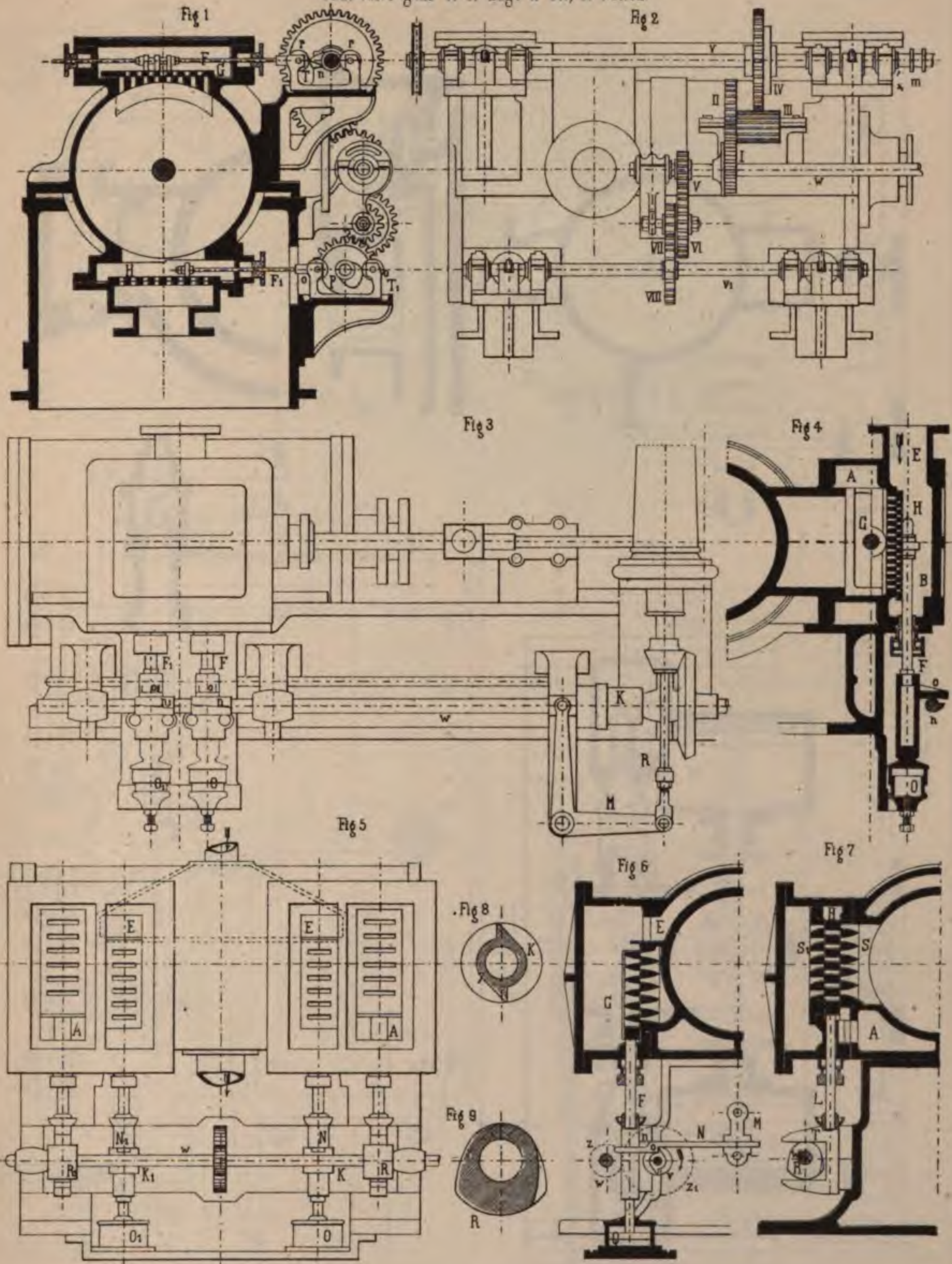


E. & F. N. Spon, London & New-York. H. Springer, Leipzig.

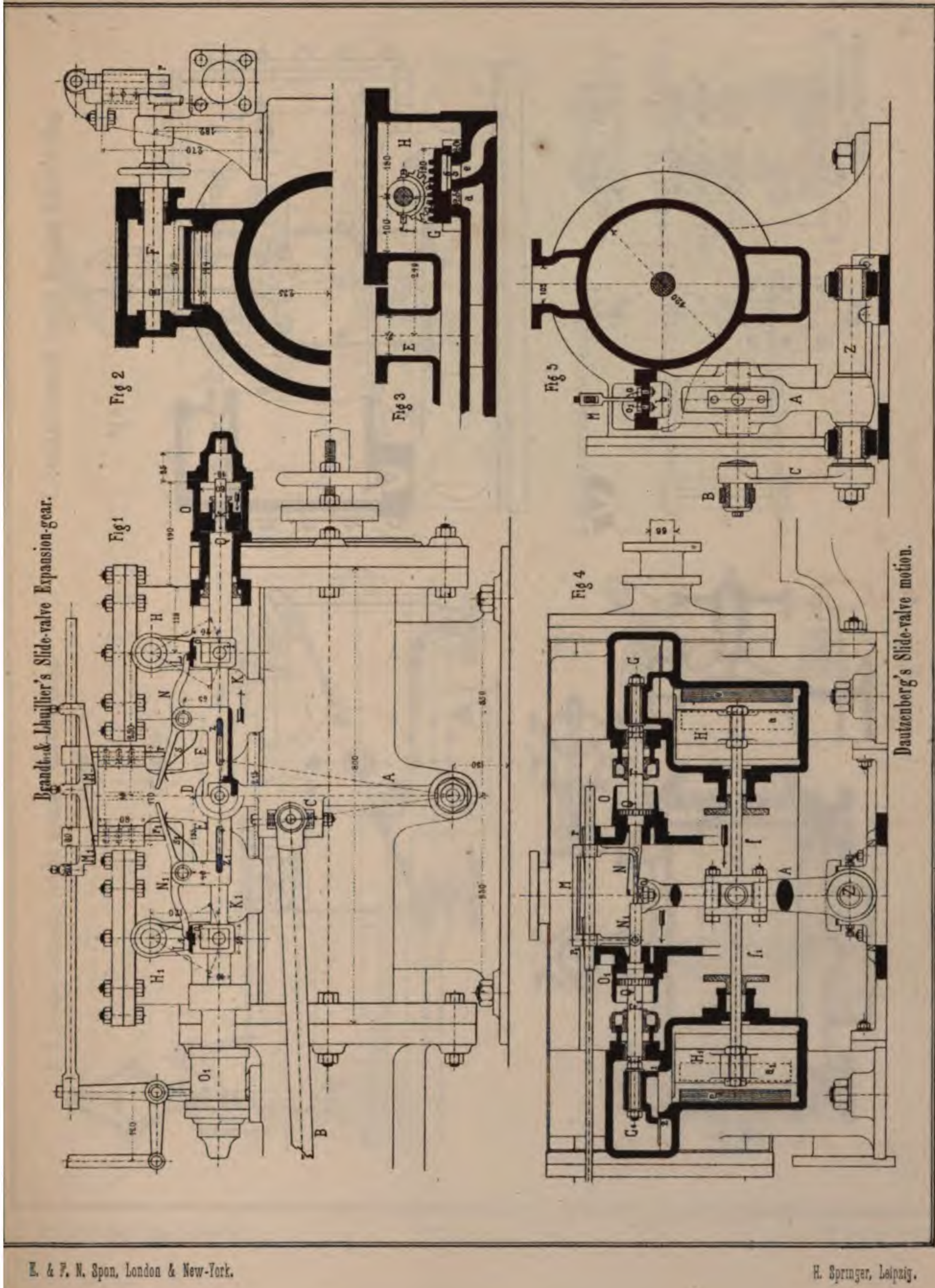


Wilson's Patent Automatic Variable Expansion Gear
Fig.1
Fig.2
Fig.3
Techn-art establ of E Nowák, Leipzig.
E. & F N Spon, London & New-York

Slide-valve gear of J. Edge & Co., of Bolton.



Slide-valve gears of Goldie & Mc. Culloch, Galt (Canada).



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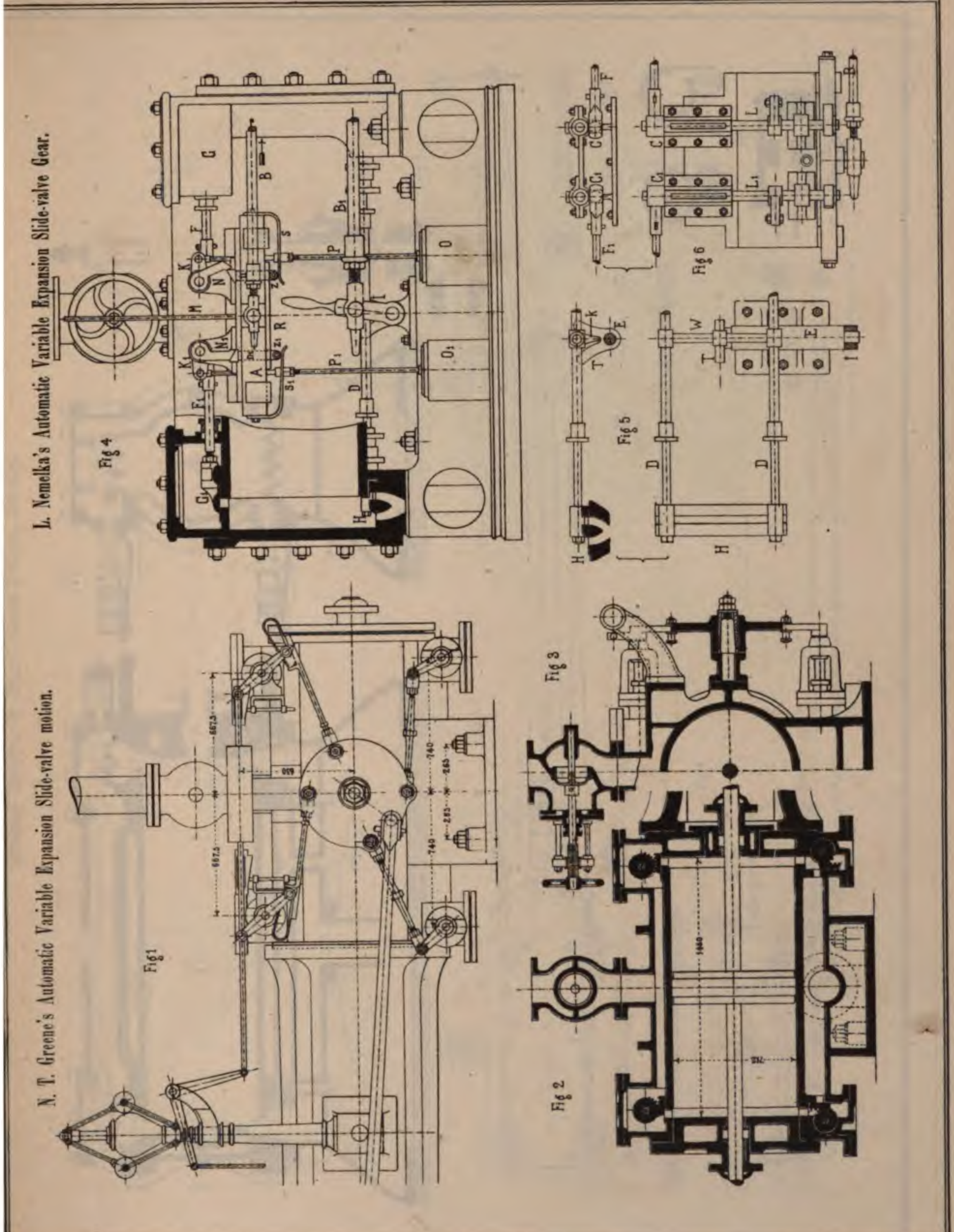

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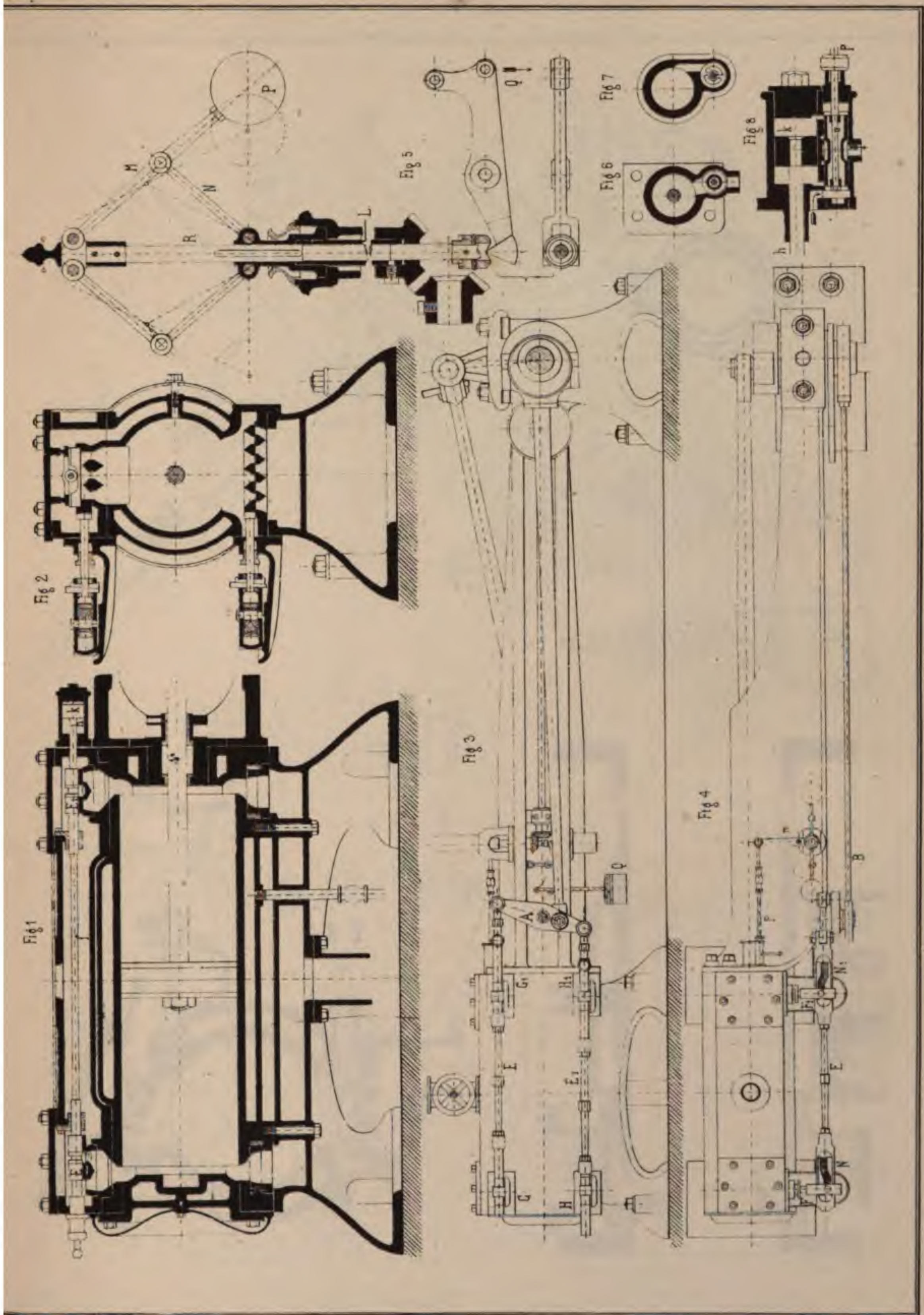

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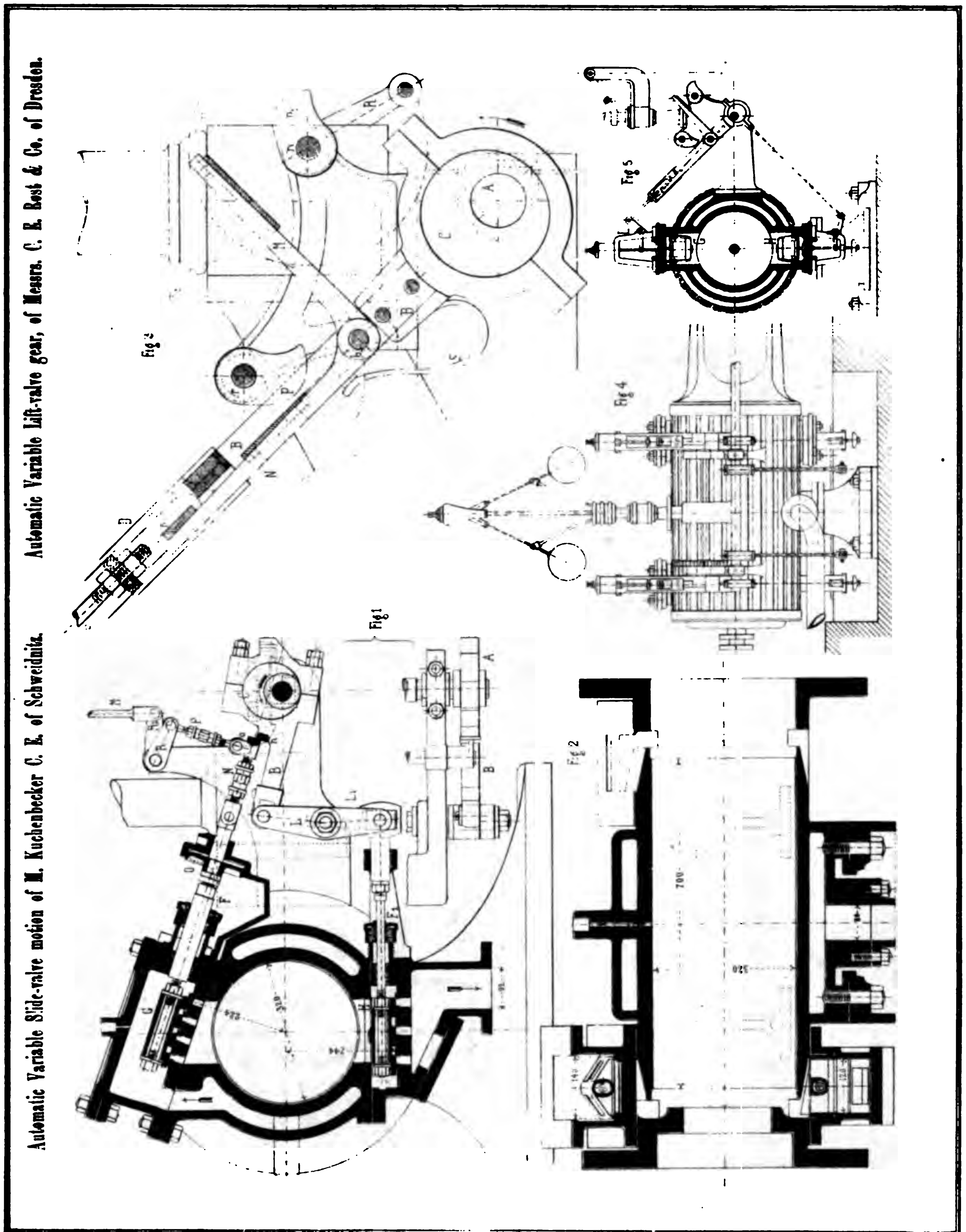
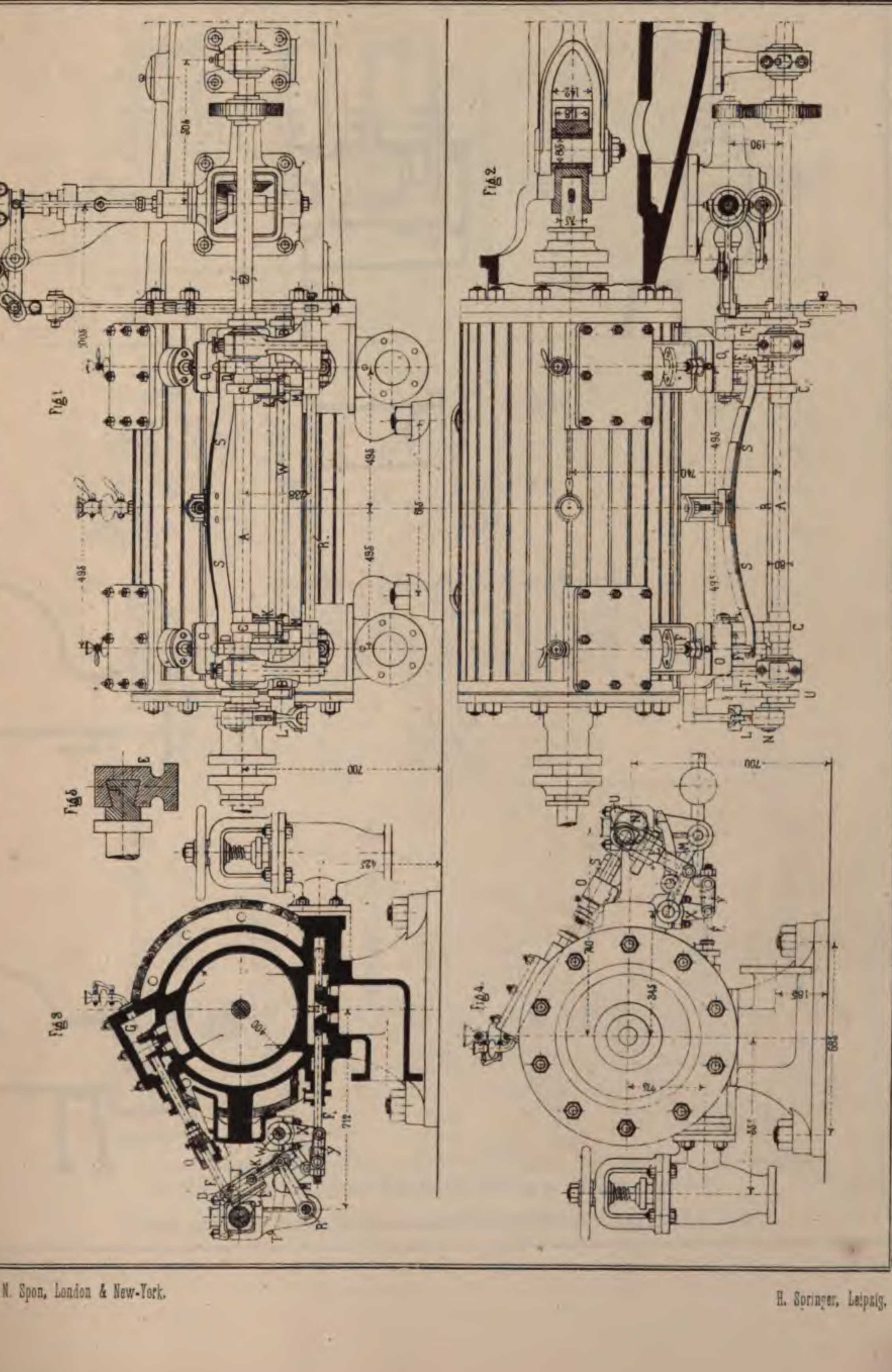


E. & F. N. Spon, London & New-York. H. Springer, Leipzig.

60 H. P. Horizontal Engine Cylinder-arrangement, constructed by Messrs. Cail Halot & Co, Engineers of Brussels.



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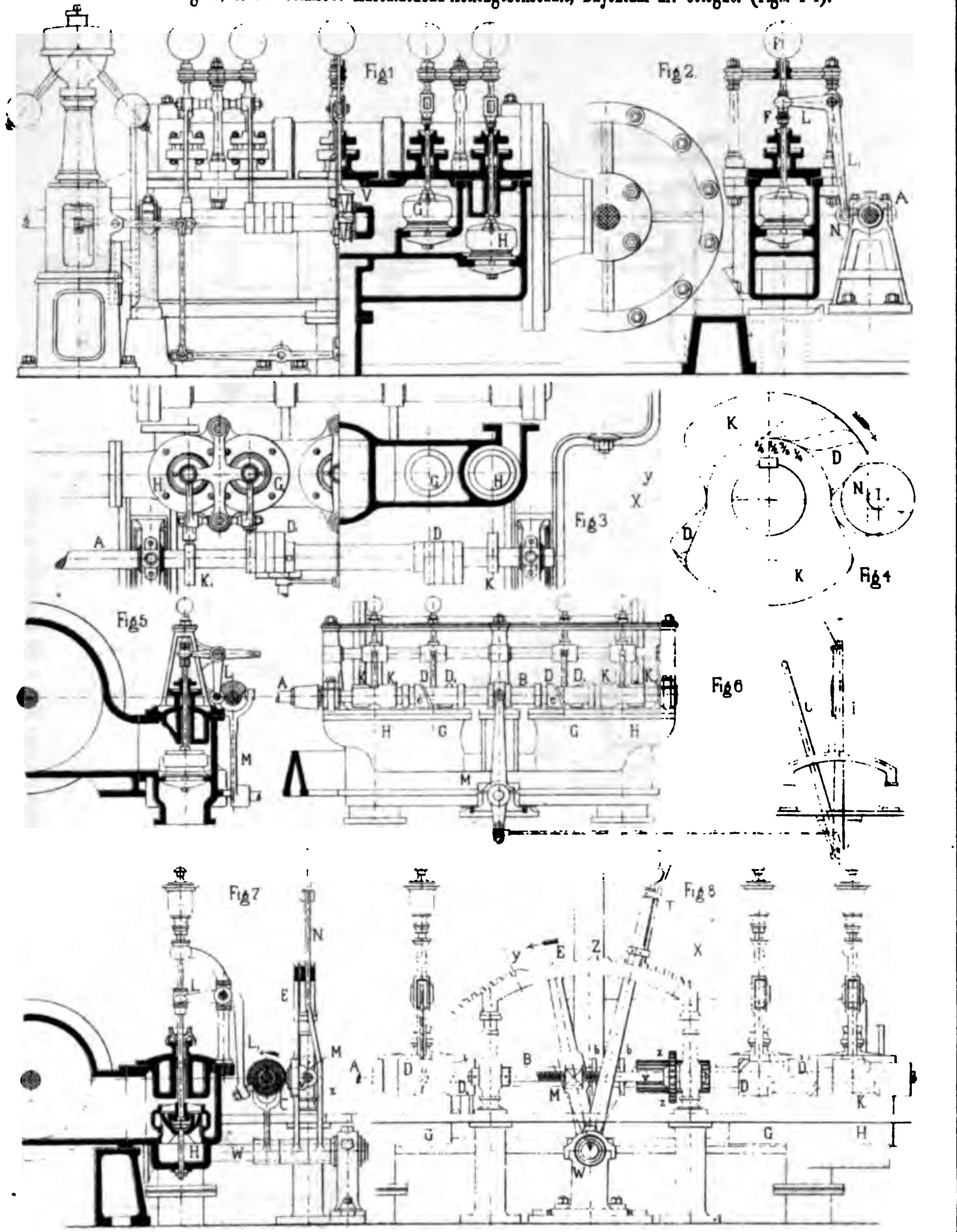
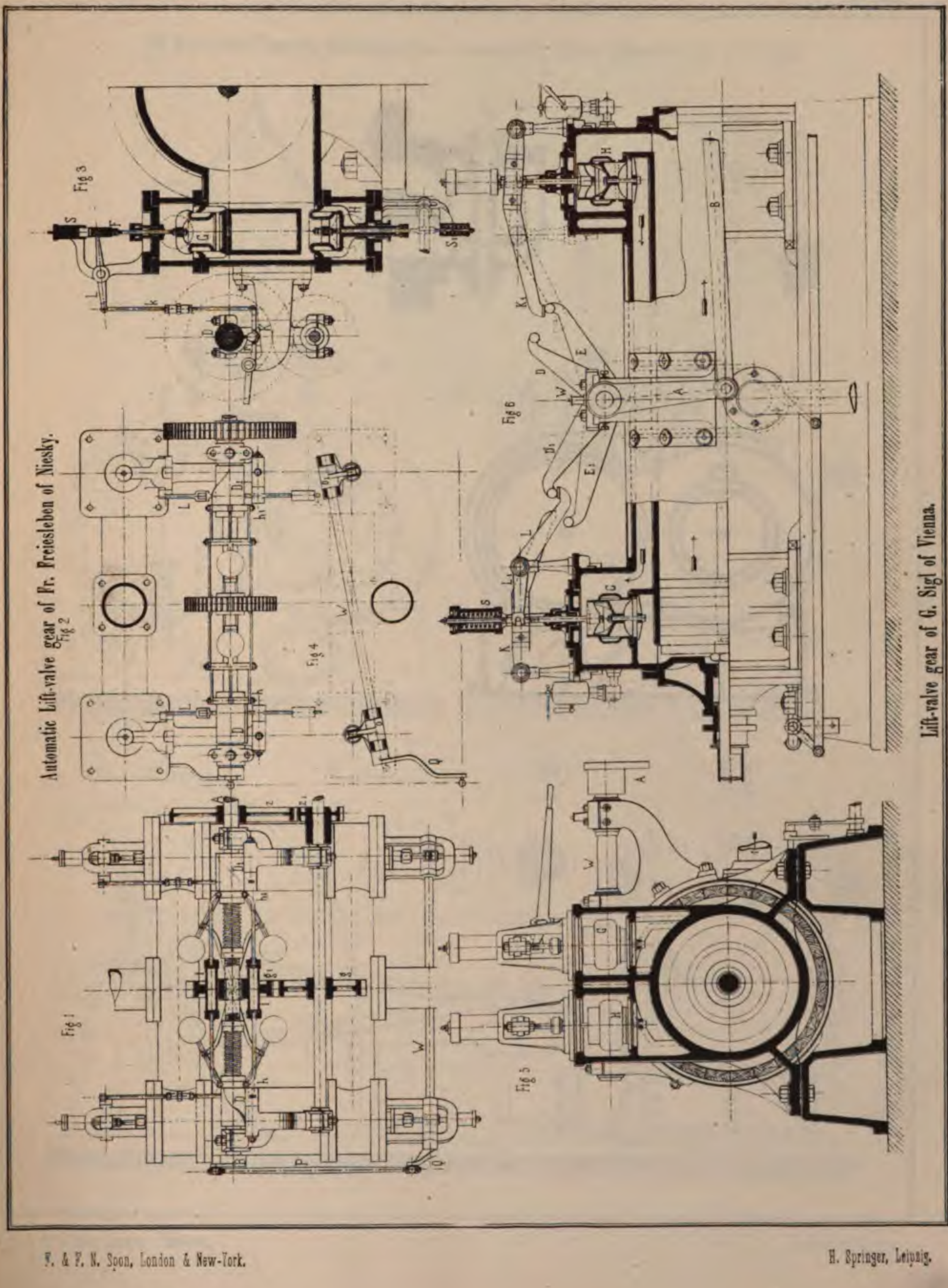
Lift-valve gear, of the Cölnische Maschinenbau-Actiengesellschaft, Bayenthal nr. Cologne. (Figs. 1-4).



Lift-valve motion of the Friedrich-Wilhelmshütte, Mülheim on the Ruhr. (Figs. 5-6).

Lift-valve gear of the Prager Maschinenbauanstalt-Actiengesellschaft of Prague. (Figs. 7-8).

E. & F. N. Spon, London & New-York. H. Springer, Leipzig.

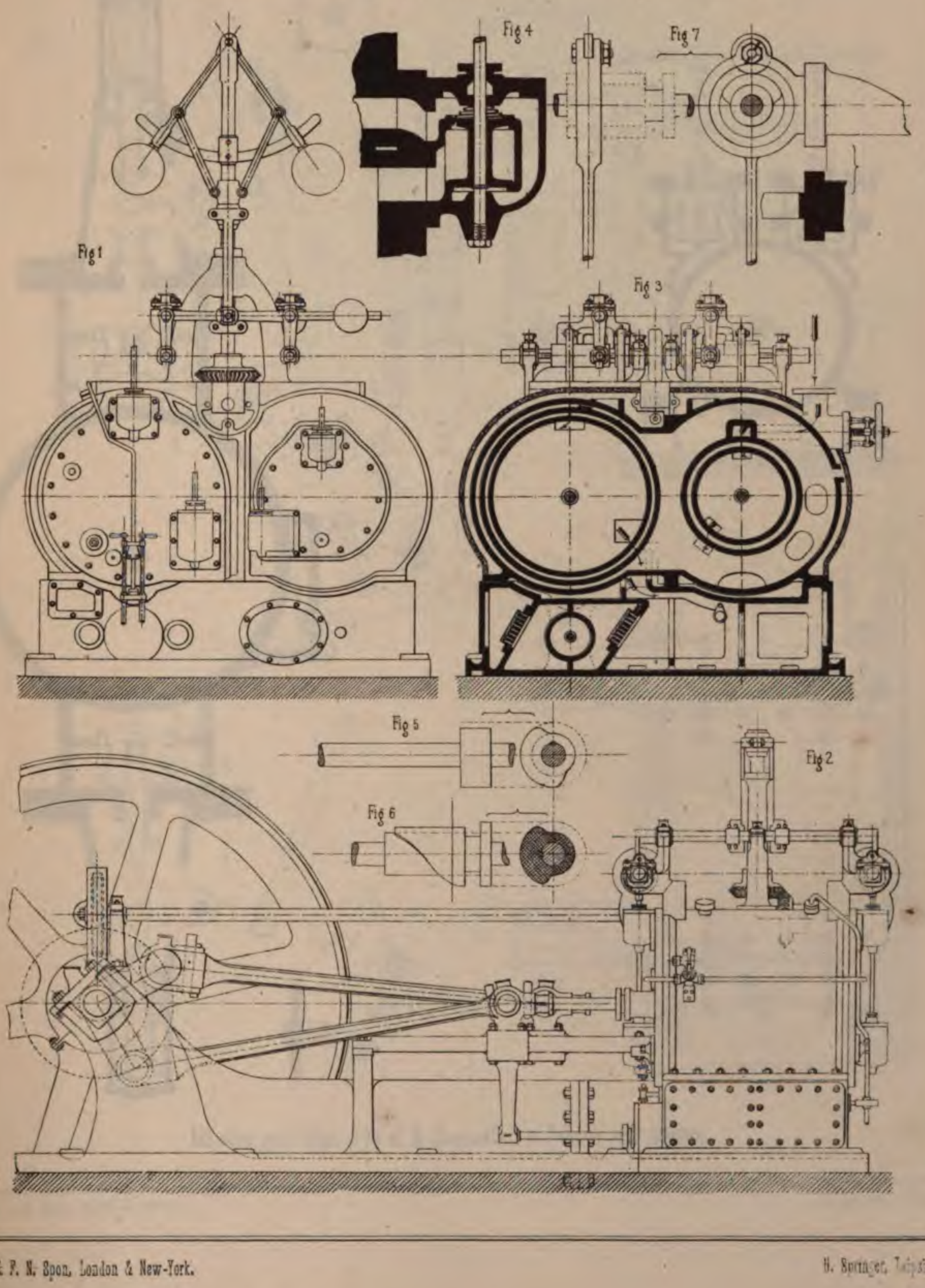


Automatic Lift-valve gear of Fr. Preiesleben of Niesky.

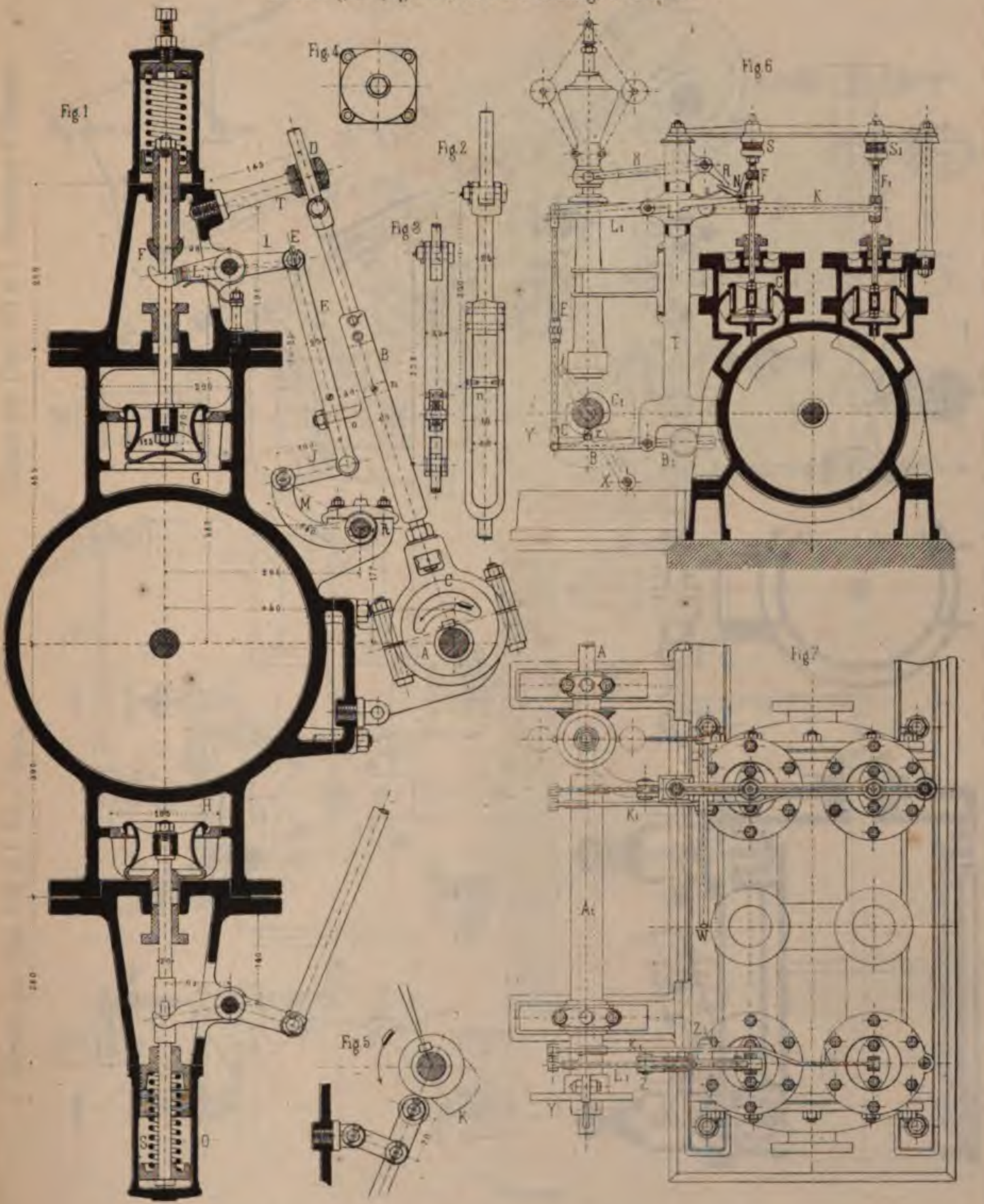
Lift-valve gear of G. Sigl of Vienna.

F. & F. N. Spon, London & New-York. H. Springer, Leipzig.

150 Horse-power Compound Condensing-engines, constructed by Messrs. Claparède & Co. of St. Denis.



Lift-valve gear (Figs. 1-5) of Jos. Pallenberg, of Mannheim.



Lift-valve gear (Figs. 6-7) of H. Borgsmüller, of Hofstede near Bochum.

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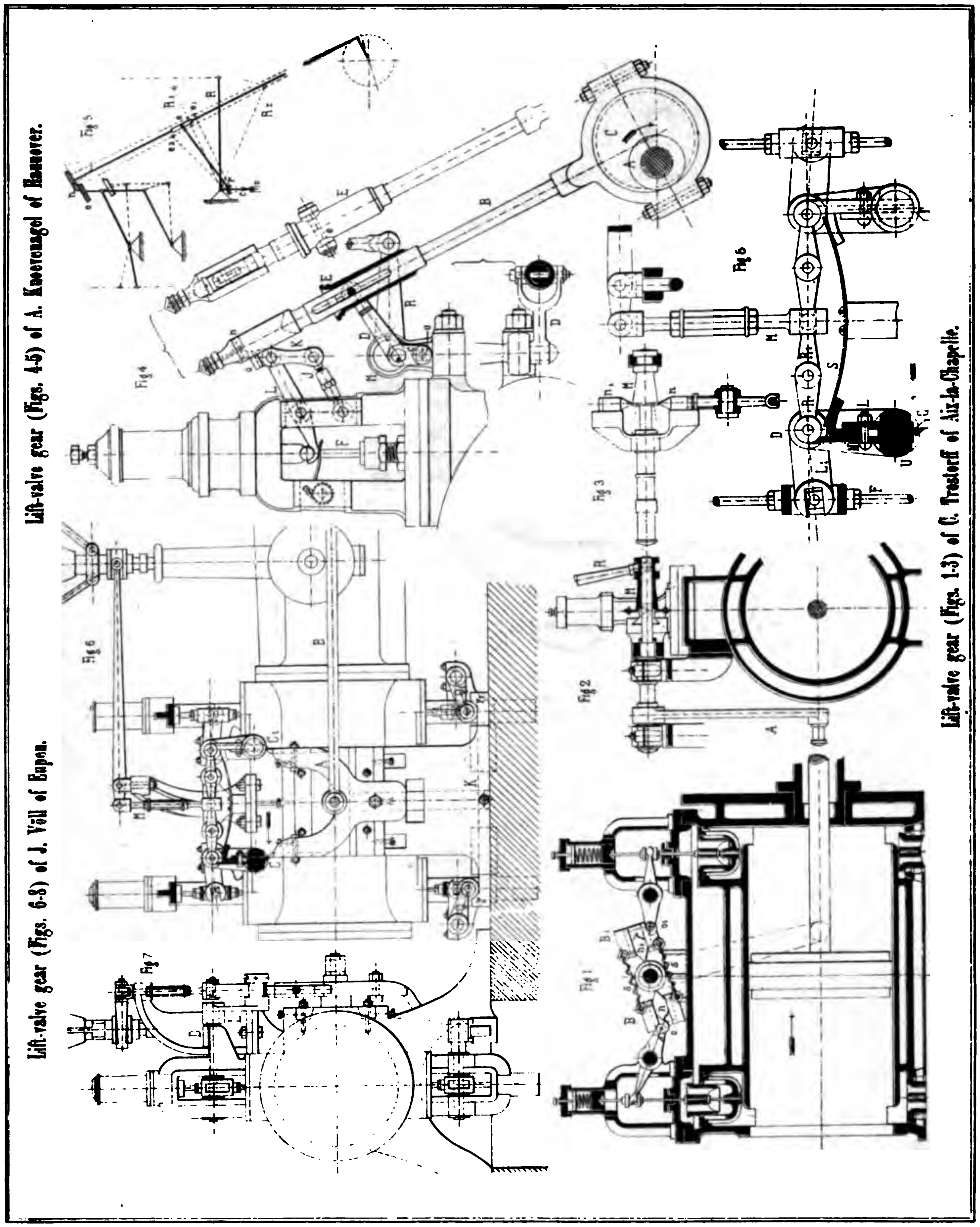
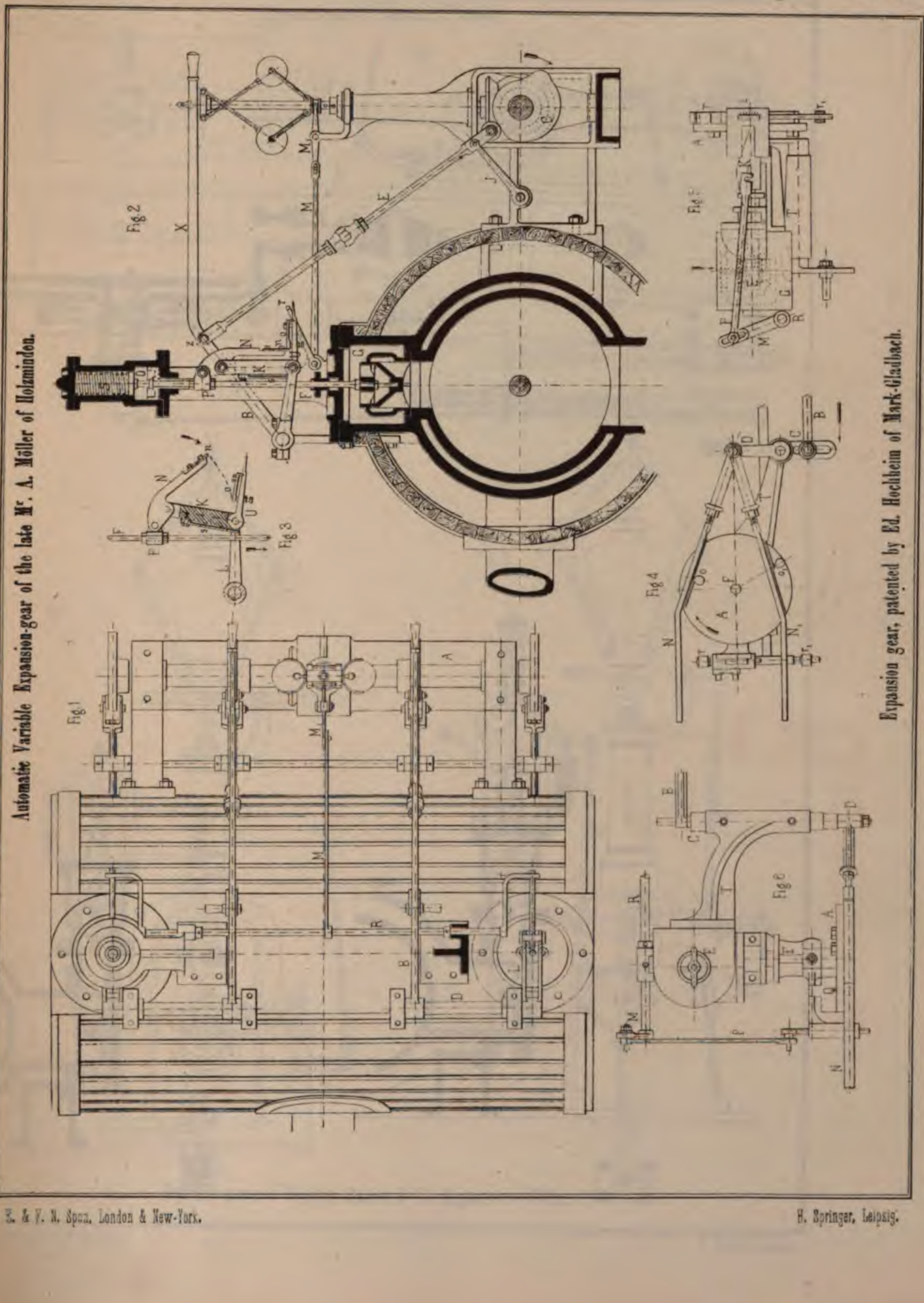
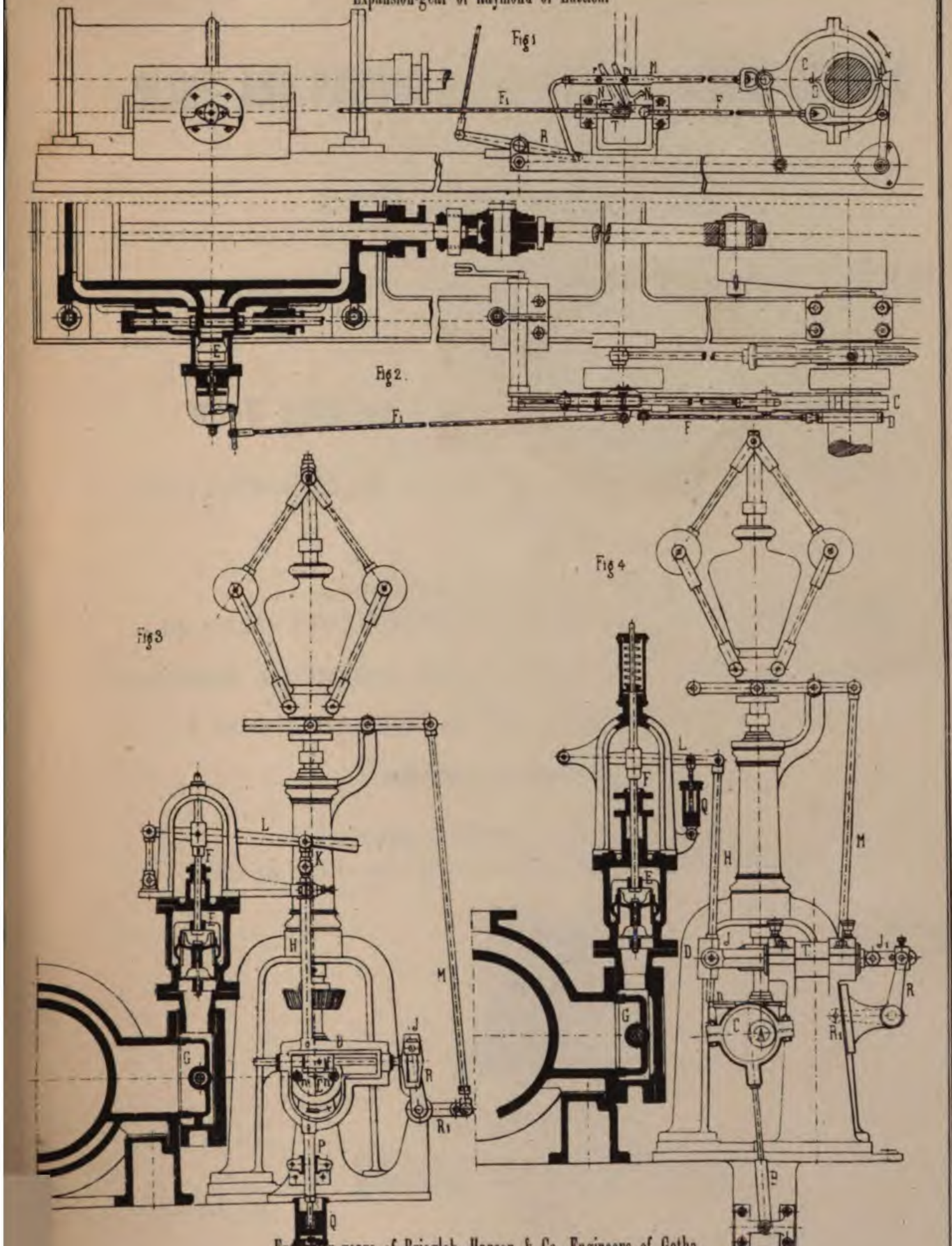

Lift-valve gear (Figs. 4-5) of A. Knoevenagel of Hannover.
Lift-valve gear (Figs. 6-8) of J. Völl of Eupen.
Lift-valve gear (Figs. 1-3) of C. Trostorff of Aix-la-Chapelle.
Fig 1
Fig 2
Fig 3
Fig 4
Fig 5
Fig 6
Fig 7


Automatic Variable Expansion-gear of the late Mr. A. Möller of Holzminden.
Fig 1
Fig 2
Fig 3
Expansion gear, patented by Ed. Hochheim of Mark-Gladbach.
Fig 4
Fig 5
Fig 6

Expansion-gear of Raymond of Lüttich.



Expansion-gears of Briegleb, Hansen & Co. Engineers of Gotha.

F. N. Spon, London & New-York. H. Springer, Leipzig.

SLIDE AND PISTON-VALVE GEARED STEAM-ENGINES

FORMING THE SUPPLEMENTARY VOLUME

TO

CORLISS-ENGINES

AND ALLIED

STEAM-MOTORS WORKING WITH AND WITHOUT AUTOMATIC VARIABLE EXPANSION-GEARS

INCLUDING THE

MOST APPROVED DESIGNS OF ALL COUNTRIES

WITH SPECIAL REFERENCE TO THE

STEAM-ENGINES OF THE PARIS INTERNATIONAL EXHIBITION OF 1878.

A TREATISE ON THE DEVELOPMENT, PROGRESS AND CONSTRUCTIVE PRINCIPLES OF THESE ENGINES

FOR

ENGINEERS, MACHINISTS, STEAM-USERS AND ENGINEERING COLLEGES.

A TRANSLATION OF **W. H. UHLAND'S** WORK WITH ADDITIONS

BY

ANATOLE TOLHAUSEN, C. E.

WITH NUMEROUS ILLUSTRATIONS, AND AN ATLAS OF PHOTO-LITHOGRAPHED WORKING-DRAWINGS.

LONDON

E. & F. N. SPON, 16 CHARING CROSS.
NEW-YORK: 446 BROOME STREET.

1882.

List of Plates and Working-Drawings.*

Vol. II.

*) The Roman Numbers, as applied to the Plates, refer to the small Sketches, whilst ordinary numbers denote the large Working Drawings.

Preface.

The present "Slide and Piston Valve-geared Steam-Engine" Work, forms the Supplementary Volume to "Corliss-Engines" published in 1879—1880. In tone and tendency, it is analogous to the practical course pursued in the last named Work, and accordingly it has been primarily adapted to serve as a Treatise for Steam-Engine Makers, revealing to the Mechanical Engineering Profession, a collection of the most noteworthy Engine-types; these are described with special reference tb their merits and defects, and illustrated with sets of Working-drawings, and Sketches, with all the necessary working dimensions inscribed thereon, for the immediate use of the Pattern-Room or the Drawing-Office.

It was the original intention of my esteemed Colleague Mr. *W. H. Uhland*, to exhaust the subject of "Woolf and Compound Engines" in the present Volume; yet, owing to typographical reasons, this intention had to be abandoned. However, this project will be carried into effect, by treating this subject as a separate Work, which the Undersigned proposes to extend by similarly treating of Portable-, Traction, and Tramway-Engines.

The present Volume, must therefore be accepted as completing "*Corliss Engines*"; thus the three Volumes afford a record of the development and constructive principles of the latest and most approved International Engine-practice, by grouping in

Vol. I.: Corliss-, Rocking- and Rotary Valve-gears.

Vol. II.: Slide- and Beat-valve gears, working with Trip-motions.

Supplementary Volume: Slide- and Piston-Valve gears,

which together form 450 pages of Text, illustrated by 800 wood-cuts, and by 88 Plates of Working-drawings appended in large Atlas-form (16—22 in.) in addition to 53 small lithographed Plates, so collating about 400 Engines belonging to the Mill-driving, Pumping, Blowing, Winding and Marine-types etc.

The Translator avails himself of this opportunity, to correct an erroneous impression which appears to have gained some ground, that the title of "Corliss-Engines" implied the treatment of no other Engine types in the preceding Volumes. On the contrary, the "Corliss-engines" therein enumerated form a conspicuous minority, which classification has been merely adopted, as it offered itself as the most convenient method of comparing various Engines working expansively, with other highly approved constructions; the descriptions given in "Corliss-Engines", of the latest improvements brought to bear on the *details* of these various Engine-types, will be found applicable in many cases, to the Engine-makes of those Engineers who rightly or wrongly discountenance Corliss-gears, and for this reason, too much attention cannot be given to these improvements of detail enumerated in "Corliss-Engines".

In conclusion, the Translator tenders his thanks to those who have assisted him in extending the present Volume, and trusts that his labours in this direction may lead to further improvements in the construction of the Steam-Engine!

PARTINGTON, November 1881.

Anatole Tolhausen.

List of Supplement-Plates and Working-drawings*.

*) The Roman Numbers, as applied to the Plates, refer to the small Sketches, whilst ordinary numbers denote ɛ large Working drawings.

Index to Slide- and Piston-valve geared Steam-engines.

N. B. The English Equivalents of the French Measures mentioned in the Work, will be found appended to the second Volume of "Corliss-Engines".

A. Engines working with ordinary Slide-valve gears.

I. With fixed expansion.

1. The D-slide.

The distribution of the steam used in double acting steam-engines, is accompanied by 'our characteristics, — namely: steam-admission and steam-emission for each of the two piston-ides. These present themselves during every crank revolution, answering to the double stroke f the piston. The mechanical agent producing this steam-distribution, is the "slide-valve", whose 'our working edges, by merely sliding to and fro on the face of the ports, perform the duty of llowing steam to, and cutting steam from, the cylinder. The motion of the slide valve is derived rom the crank-shaft, by means of an excentric-rod connected to the valve-spindle, and as this is he commonly accepted practice, we shall presume this mode of construction to be adopted in all ur subsequent investigations.

In all valve-gears, where no special mechanism is found applied, enabling a variation in he valve-travel to take place, an ever constant expansion of the steam ensues, and we say that uch engines work with *fixed* expansions.

To start from the simplest example, let us take a valve-gear, which admits of no ex-ansion, or which to be more concise, gives steam to the cylinder during the full stroke, such as ve find applied to Pumping-, Winding-, and Blowing-engines. When the crank is on one of ts dead centres, the slide is just midway on its stroke; the ports are opened with the greatest elative speed at the beginning of the stroke, and are similarly closed at the end of the stroke. Consequently we say, that no expansion or compression of the steam takes place. In such cases, he distance between the working edges (taken in pairs) of the slide, equals the width of the ad-mission-port. As a rule however, since it is impossible to work mathematically correct, this listance is made greater, — i. e. lap is given to the slide, and we distinguish *inner* (internal) and *uter* (external) lap.

A slide designed with lap, is illustrated in our Fig. 1 and it is represented in its central or neutral position, e denoting the *external-* and i the *internal-lap;* a is termed the width of the admission (inlet) port, a_0 that of the emission (exhaust) port, and b is called the *bridge.* It will be noticed that in this valve-gear design, the middle, central or neutral position of the slide no longer coincides with the piston stroke end, but on the contrary, the slide as well as the eccentric, have to be moved beyond their central position, so as to admit steam at the beginning of the piston-stroke. On referring to Fig. 2, the moment the piston is on its dead centre, we term the deviation of the eccentric from the perpendiculars $Y\ Y$ to the slide-travel direction, the *advance-angle*, and this angle we shall represent in future simply by δ. Again in Fig. 2, E denotes the eccentric (whose eccentricity is represented as a crank) and K is the crank, which is supposed to be rotating in the direction of the inscribed arrow. According to the size of the advance-angle, (which can however only be varied between certain limits,) a slight expansion —

or rather expansive working — is obtained, which again under special conditions remains constant.

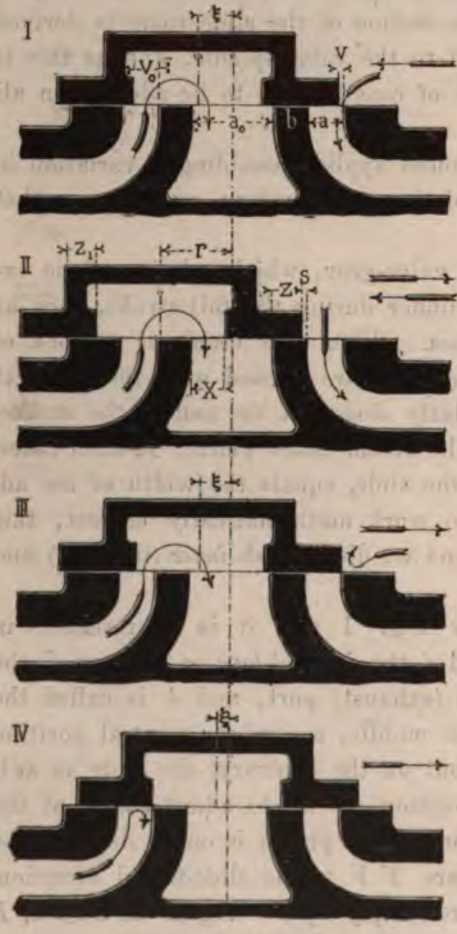
Fig. 1.

Fig. 2.

In addition to these working parts, we pay additional regard to the following features in all ordinary slide-valve gears: We speak of the stroke, the path or the travel of the slide, corresponding with which we have the eccentricity *(r)* of the eccentric, and both these factors may be said to depend on the width given to the steam-port *a*. Then we talk of "lineal lead" as the dependent on the advance-angle and the eccentricity, and this lineal lead *(V)* is measured by the distance through which the slide has already opened out the steam-port at the commencement of the piston stroke. Lastly by the "*ratio of expansion*" we understand, (providing AB represent the full piston-stroke, and AC equal the piston-travel whilst the admission port is still open) the ratio existing between the distance the piston is allowed to travel whilst the admission port is still open and the full piston stroke, thus

$$\frac{AC}{AB} = E = \text{ratio of expansion.}$$

As the crank may rotate in either direction — i. e. in the same or in opposite directions to the ordinary watch fingers — the advance-angle must be drawn accordingly, and to elucidate this fact, we have chosen an opposite rotary movement in Figs. 7—10 to that assumed in Fig. 2, and have consequently carried the advance-angle δ to the other side of the perpendicular YY in these figures.



Figs. 3—6.

Figs. 7—10.

The main positions of the slide during its path from the one extremity to the other of its travel are illustrated in Figs. 3—6, whereas the corresponding positions of the eccentric and of the crank are drawn in Figs. 7—10. On account of the travel of the slide being symmetrical from its middle position, analogous positions are scored on the return stroke of the slide, etc.

In the position marked I: The piston is at the beginning of its stroke on the right. The admission port is open to the extent of the lineal lead (v), and corresponding thereto, the port permitting exhaust is opened to the extent of the inner lineal-lead $= v_0$. The deviation or travel of the slide from its central position is determined by $\xi = e + v$.

In the position marked II: the slide has attained its maximal external position on the left, and its travel $\xi = r = e + a + s$. Both ports are quite open. The distances z and z_1 are equal to each other.

In the position marked III: the commencement of expansion takes place. Exhaust is continuing. The slide-travel up to its central position, expresses itself as $\xi = e$.

In the position marked IV: compression begins. The slide travel is written as $\xi = i$. Owing to expansion taking place behind the piston, whilst compression shews itself in front of the piston, this period is sometimes termed the "false expansion" period.

In short, the action of the slide may be summarised as follows: Whilst the slide is in the positions indicated by I, II, III, we have a uniform constant steam-effect. Between positions III and IV, expansion of the steam takes place. In position IV, compression begins and continues till the right hand port is opened for emission. The function of the valve may therefore be pronounced good from position I—IV, but from position IV up to the stroke-end, it is defective. If the outer lap be made small, and the lead be also diminished, the range of the expansion-period becomes very limited, but on the other hand the forementioned defective working is almost quite obliterated.

We have now to enquire, into the positions assumed by the crank, corresponding to the opening and closing of the ports, as well as to the extent of such openings. These questions are best answered by graphic delineations, as these not only readily shew the various phases proceeding in the steam-distribution, but they also enable us to find out the best and most advantageous proportions for the valve-gear working parts. In short, we thereby obtain, the most profitable and efficacious distribution of the steam.

2. Zeuner's Valve-gear Diagram.

Zeuner's valve-gear diagram affords us the readiest means of ascertaining the relative positions taken up at different periods by the piston- and by the steam-distributing organs. It is true, this diagram merely affords approximate results, yet these results are sufficiently accurate for practical purposes, and are ample for preliminary designs.

Taking an ordinary slide-valve gear, let the eccentricity $= r$, and the advance-angle $= \delta$; assuming these magnitudes, we desire to know the distance of the valve from its central position when the crank is removed from its dead centre over an angle of say ω; this problem we shall now solve, by means of the Zeuner diagram. We draw the line XX to coincide with the slide-travel, and erect the perpendicular YY (Fig. 11). The advance-angle δ is transposed to one side of OY, so that $YOJ = \delta$, and taking $OJ = OJ_1 = r$, circles are described over these diameters, and the circles are called valve-circles.

The various dimensions are inscribed full size in this diagram. If a circle be now described round O, as the reduced crank-circle, and a radius OR_1 be drawn to represent a position of the crank, then the length OP falling between the valve-circle, corresponds to the deviation $= \xi$ of the slide from its neutral position, when the crank is thus placed. The upper circle denotes the path of the slide to the right, whilst in the lower circle, we have represented, the travel of the slide in opposite direction — return stroke; — as both are symmetrical to each other, it suffices in most cases, to draw merely one of these circles.

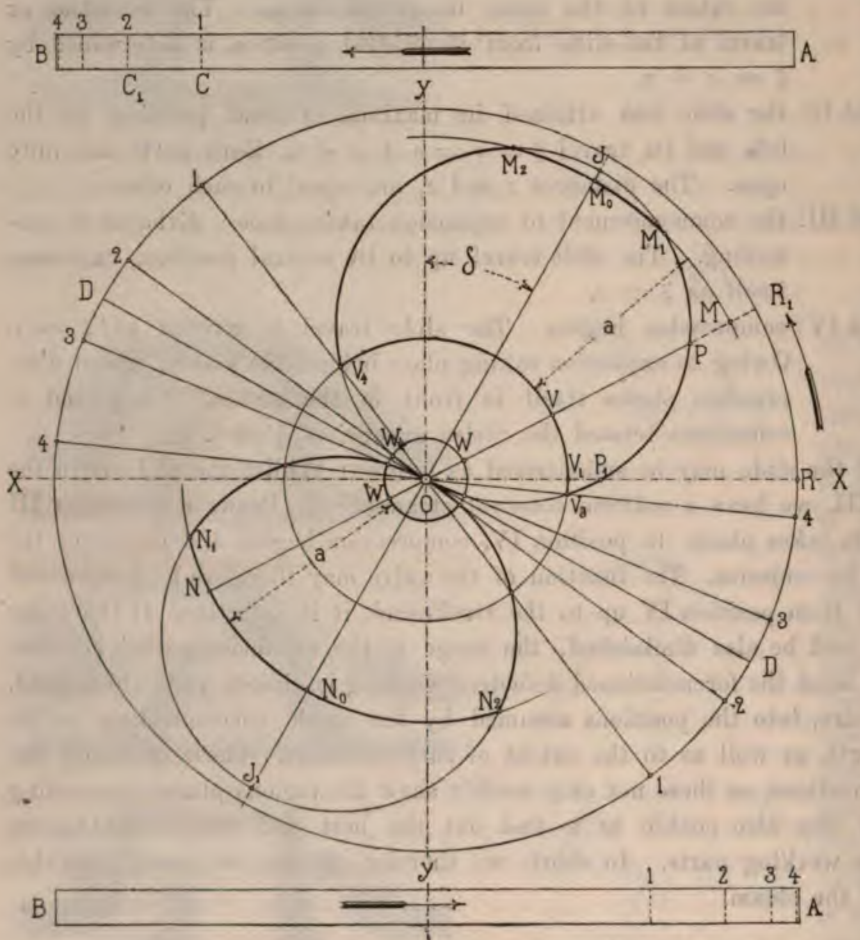


Fig. 11.

The representation of the chief positions of the slide is obtained in the following manner: With the crank on its dead centre, coinciding say with OR, the slide has travelled a path $= OP_1$ from its central position; in this respect, the greatest deviation of the slide from its middle position, corresponds to the crank position OJ. In the crank-position OD — i. e. perpendicular to OJ — the slide is just on its central position. If the rotation of the crank be pursued in the direction of the inscribed arrow, we perceive that at the commencement, the slide-travel increases rapidly, whereas this path varies little, when the crank is approaching position OJ. In the middle of its travel, the slide presents the greatest velocity, whereas at its greatest deviation, (corresponding with the change of motion) its motion becomes very slow. The diagram therefore enables us also to form an idea, as to the moving velocity of the Slide.

In addition, the diagram sets itself the task of also disclosing the extent of the port-openings, for any desired position of the crank. Let us suppose, the slide had moved to the extent of ξ (vide Fig. 12) from its neutral position B, thereby opening the port to the extent of a_1, then evidently $a_1 = \xi - e$, and for the emission $a_2 = \xi - i$. Consequently in Fig. 11, we should obtain the width of the openings of the ports, were we to subtract the outer and the inner lap from the radius-vector; as this holds good for all positions of the slide, it is only necessary to sweep circles from O to the radii of $OV = e$ and $OW = i$; the intersected portions VP and WP on OP, now give the openings of the ports for the steam admission and emission.

If we now mark off the port-width a from V and W on one of the radii, (we have merely done so in one of the valve-circles, to prevent complications) we will next sweep circles round O to the radii OM and ON, so that $VM = a$ and $WN = a$, when the clear openings of the ports are indicated by the lengths of the chords between the circles V and M, as well as between the circles W and N.

The intersection of the circle M with the slide-circle takes place with the crank-position OM_1, whereby the admission port is quite open; the corresponding slide-deviation $\xi = e + a$. Moreover, the crank-position OM_2 answers to another intersection of the circle M with the slide-circle. Whilst the crank is travelling over the arc $M_1\ M_2$ the admission-port remains quite open. In $M_0 J$ we have the actual maximal deviation of the outer slide-edge over the inner port-edge. Similarly on the other side of the figure, corresponding to the emission, $N_0\ J_1$ indicates how far the inner slide-edge has travelled beyond the outer port-edge.

Fig. 12.

The action of the steam in the cylinder, may now be definitely defined; for, expansion begins at crank-position 1; compression at 2; commencement of steam-emission at 3, and beginning of steam-admission at 4.

Thus, the exhaust takes place sooner than the admission, and finishes also later. Following the general practice, the piston-diagram of Fig. 11 is drawn under the supposition of an endless crank-rod. The positions of the crank are merely projected, and consequently the ratio existing between AC and AB is the "*ratio of expansion*" and $AC_1 : AB$ = ratio of compression.

We can now perceive, what modifications require to be made in order to attain a different distribution of the steam. If for instance, the eccentricity r^1 be made larger, then expansion takes place later on, and the lead is augmented, which is however never advisable. If on the contrary, the advance-angle δ be augmented, the closing of the admission-valve takes place sooner, and accordingly we receive a stronger expansion and a greater lead. By augmenting the outer lap, we also obtain earlier cut-off, — resp. expansion — but later steam-admission.

These remarks prove that the ordinary slide-valve is little adapted to working very expansively, and its application is therefore best restricted to small engines, where simplicity of construction is of the greatest moment.

3. The Slide-valve ellipse.

The relations, existing between the crank-length and the slide-travel, as expressed in terms of the piston-stroke, may be graphically represented by the slide-valve ellipse. It is true, this method demands more time, than the one we have just described, but it leads us to a representation of the slide-travel, which in an elucidatory sense, leaves nothing to be desired.

In order to explain this method, we shall do well to examine more minutely, the relations existing between the crank and the piston motion, for as is well known, the piston paths corresponding to equal crank-angles, are not equal to each other in the first and second half of the piston stroke. As may be read off our Fig. 13, we may draw to a reduced scale, the crank-path circle R, along with its connecting-rod L (generally made five times as long as half the piston stroke), so that A and B may represent the dead centres of the piston. We will now describe tangential arcs $a\,a$ and $b\,b$ from A and B with radii = length of connecting-rod L; assuming any position of the crank answering to the inscribed angle ω, we will draw a parallel, $c\ d$ (from the point of intersection on the crank circle to the tangential arc) to the cylinder-axis, then it is not difficult to prove that $c\ d$ is the actual distance of the piston from its dead-centre, at that time.

The correctness of this assertion may be proved, by disconnecting the connecting-rod from the crank, and allowing the same to fall on to the cylinder axial line, without disturbing the crank; for then the distance $c_1\ d_1 = c\ d$.

The same crank-angle ω is also drawn in the second quadrant of the crank path. If we proceed as just explained, we shall arrive at the distance $e\ f$, which is smaller than $c\ d$.

Fig. 13.

The representation of the combined diagram may be effected as follows: After drawing in the Zeuner slide-valve diagram (Fig. 14) in the manner already described, we draw the tangential arcs $a\,a$ and $b\,b$ (referred to in Fig. 13), and if by way of an example, we place the crank-angle at 60^{0} we receive the true piston-travel $= X$ as depicted in Fig. 14. Simultaneously, the deviation ξ of the slide corresponding to this piston-travel is ascertained, and consequently the actual piston travel and the corresponding slide-valve deviation from its neutral position may be similarly determined for any other crank-angle.

In order to obtain a clear understanding in this respect, this method is repeated at regular intervals of from 20^{0} to 30^{0} along the crank-path, as our Fig. 14 explains. The piston-travels are next marked off on a line $A\,B$, (= piston stroke) whereas the corresponding deviations ξ of the slide from its neutral position are erected in vertical distances thereon, as shewn in Fig. 15. In this manner, a certain curve is plotted out, which is the slide-valve ellipse, and which refers the slide-valve deviations (travels) to the positions of the piston. So as to render our illustration still more explanatory, the two piston-strokes — forward and return — are drawn behind each other, so that we do not get a closed ellipse. Our illustration is completed, by representing the outer and inner lap perpendicularly to the axis $A\,B\,A$, though to simplify our illustration, the former is shewn in the upper-, whilst the latter is drawn in the lower part of the wood-cut.

Lastly, if we insert the width of the port *a* on both sides, then the shaded portion of our diagram indicates the corresponding openings of the ports. The line *A B A* answers to the neutral (central) position of the slide, and in addition the main positions of the slide are again denoted by 1, 2, 3, 4.

The Slide-valve ellipse, moreover instructs us of the velocity with which the ports are opened or closed by the slide; it stands to reason, that the valve-gear is all the more perfect, the more rapidly this occurs, — i. e. the more the angle, formed by the curve and its bordering straight lines, approaches to being a right angle.

Fig. 14.

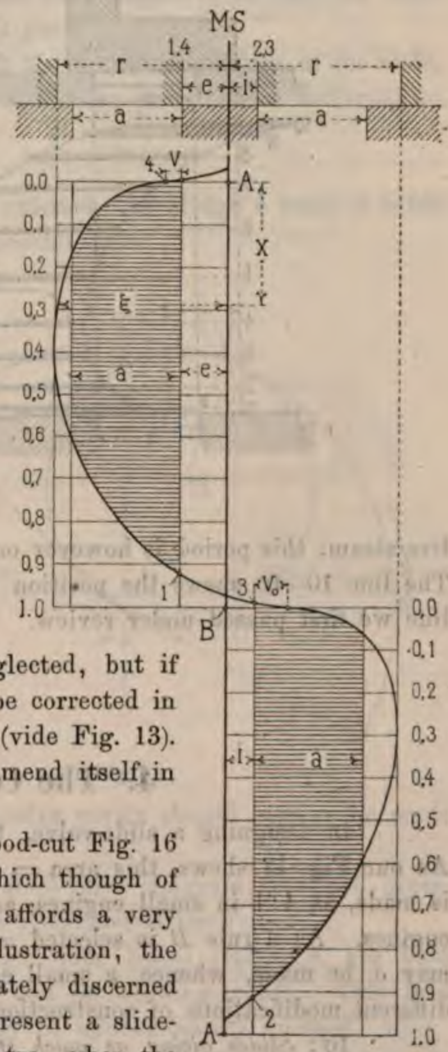


Fig. 15.

Reliable as this method is, for giving one a clear idea of the working of a slide-valve, it suffers from the defect, that the finite (limited) length of the eccentric has not been taken into account. As a rule, when long eccentrics are used, the deviation is so small, that it may be altogether neglected, but if strict accuracy is desired, then the travels of the slide may be corrected in a similar manner to the one described for the piston-travels (vide Fig. 13). Still, such a far reaching method would probably only recommend itself in complicated valve-gears, by using a model.

Utilising the slide-valve elliptic diagram, in our wood-cut Fig. 16 we have drawn another representation of the valve travel, which though of little importance for the construction of the valve-gear, still affords a very easy way of observing its functions. With the aid of this illustration, the piston travel in relation to the slide-valve path may be accurately discerned without trouble. The upper portion of this engraving, represent a slide-valve in its neutral position. The piston is on its dead centre, when the slide being on the line 0—10′, takes up thereon the position indicated by the small vertical sectional lines. The lineal lead may be recognised on both sides by V and V_0. The piston whose stroke may be taken to be represented vertically, advances, from the line 0—10′ to 1 — 9′, which distance corresponds with $^1/_{20}$ of the crank circle.

The slide in the meantime, has moved horizontally to the right, and as shewn by the sectional lining, (representing the position of the slide on the line 1—9′,) it has then opened out the port to about half its width. When the piston has reached the line 4—6′, and has so completed about $^3/_{10}$ths of its stroke — corresponding to about $^4/_{20}$ths of the crank-circle — the slide has quite opened out the admission port, which port remains thus, from about 2·5—5. If the return stroke of the valve is next examined, it is apparent, that both ports for admission and egress remain closed between the piston positions 8—2′ and 9—1′ so shutting off the cylinder from all

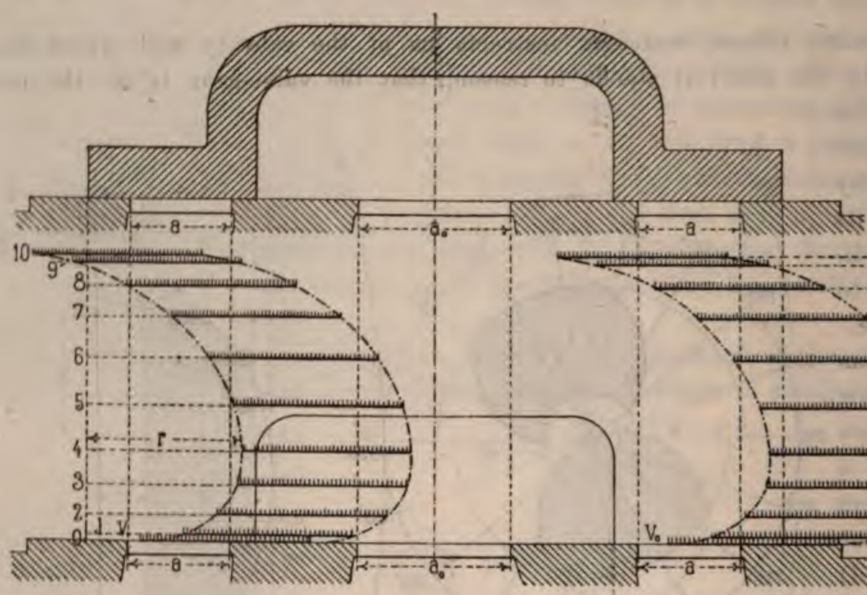


Fig. 16.

live steam; this period is however only of short duration, scarcely lasting over $^1/_{10}$th of the stroke. The line 10—0′ shews the position of the slide at the end of the stroke, and is similar to the line we first passed under review.

4. The Construction of the Slide-valve.

In designing a slide-valve, the most important factor, is the magnitude of the port-areas. As our Fig. 17 shews, this area $= a \times B$. The proportion between the width *(a)* and depth *(B)* is made, as 4 : 1 in small engines, as 5 : 1 in middle-sized engines, and as great as 10 : 1 in large engines. As a rule B is selected $= {}^2/_3$rds cylinder-diameter; the larger B is chosen, the smaller may a be made, whence a small eccentricity ensues. Respecting the eccentricity given, three different modifications of constructions are applied, according as it is desired to adopt:

1ly: *Slides giving as much steam expansion as possible, and to which a small stroke is applied.* In this constructive-method, the necessary exhaust area is given to the two ports, but during the steam-admission periods, these ports are merely partially allowed to open, so as to allow the necessary steam-volume to pass through at a normal speed. The maximum travel of the slide does not therefore quite open out the port. In these cases the eccentricity is advantageously made $= a + i$.

2ly: *Slides which in their maximum travel, have their outer working edge, exactly covering the edge of the steam port.* The eccentricity thus calculates itself at $r = a + e$. (Recommended by Messrs. Armengaud).

3)γ: *Slides, which in their maximum travel have their outer working edges protruding over the port-bridge.* In these cases, according to Fig. 4, the eccentricity $r = a + e + s$, and the portion marked z and z_1 is made from 0·39 in. — 0·59 in.

The outer lap e varies between wide limits; in ordinary constructions e ranges between $0·25a$ and $0·66a$. A normal value is $e = 0·3a$. The inner lap displays less variation, and it is often not chosen in proportion to the port-width, but it is frequently taken $i = 0·04 — 0·12$ in.; at other times $i = 0$ where small advance angles are used, and even negative, so that the slide in its neutral position allows steam to escape through both its ports.

In arranging the exhaust, care must be taken, that with the greatest deviation of the slide, the middle port may still remain open to the extent of the admission port; hence referring to Fig. 4, in Position II, x is made $= a$, and consequently

$$a_0 = a + r + i - b.$$

So as to prevent, the slide giving live steam into the exhaust, the bridge b must be made larger than $M_0 J$ in the diagram (Fig. 11) hence Dr. Zeuner recommends

$$b = 10 + 0·5a \text{ millimetres}$$

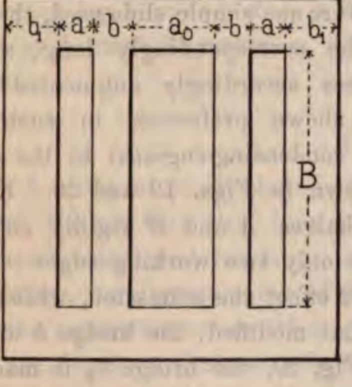


Fig. 17.

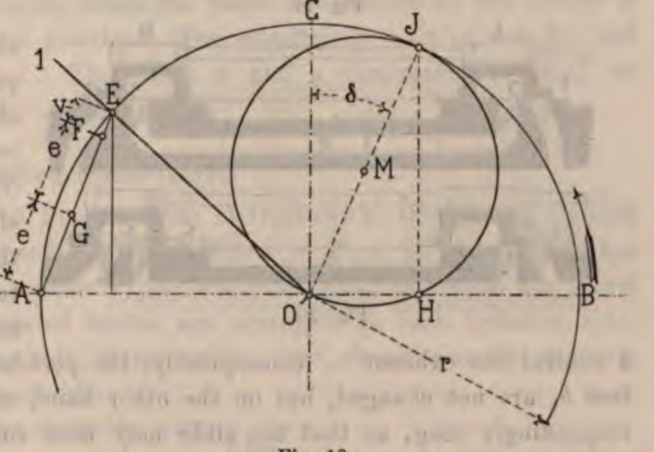


Fig. 18.

by taking the value of a in millimetres. The height of the valve cavity should always be made larger than a.

When all the dimensions demanded by the Zeuner slide-valve diagram, are not given, and the advance-angle is unknown, the following construction recommends itself:

We may assume, that the ratio of expansion and the outer lineal lead $= v$, are both known (as these are already determined by the engine type and its working-speed). This lead varies between 0·04 in and 0·24 in. The eccentricity $= r$ may be approximately guessed.

Referring to Fig. 18, a circle ACB is described to a radius $= r$. Drawing the crank-position OE corresponding to the beginning of expansion (No. 1), E is connected with A by a straight line. Marking $EF = v$, the half of $FA = GF = GA$ will be equal to the outer lap e. If we now make $OH = EG = e + v$, and erect in H, a perpendicular on AB, then by connecting the point of intersection (J) with the centre O of circle ACB, $\measuredangle\, OJC$ will $=$ the advance-angle δ. Consequently the position of the slide-valve circle is now found, and the diagram may be completed, as before explained.

In the majority of slide-valve gears, the slide is arranged, that in both dead-centres of the piston, the corresponding admission- and emission-ports are open equally wide. But we obtain thereby unequal cut-offs, which fact becomes all the more apparent, the smaller the crank and the eccentric, are made. In order to obtain equal cut-offs, we must apply unequal laps, which in their turn, cause an unequal lineal lead. Therefore, in order to determine the above named dimensions, the mere drawing of the slide valve circles will not suffice in many cases, as it appears moreover advisable to mark out the slide valve ellipses with the greatest possible accuracy.

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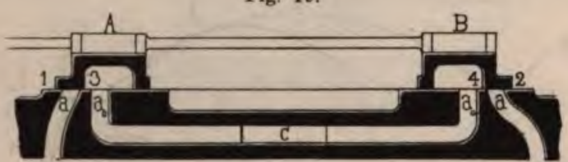
5. Various Forms of Slide-valves.

Various designs have been given to slide-valves, according to the different conditions they were expected to fulfil. Some of the special conditions here alluded to, refer to High-speed engines, where a rapid distribution of the steam has to be effected, or again where it is required to reduce the stroke or the width of the ports. The various slide-valves now mostly used, are described in the following examples.

a. Divided Slide-valves.

Fig. 19.



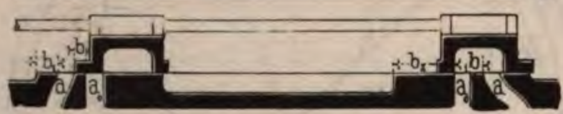


Fig. 20.

In Engines having long strokes, it becomes evident, that were one simple slide used, the steam-ports would be correspondingly long, and the clearance spaces accordingly augmented; hence practice has shewn preference in such cases, (especially in condensing-engines) to the divided slide-valve shewn in Figs. 19 and 20. Each of the two slide-halves A and B rigidly connected together, have only two working edges — those marked 1 and 2 effect the admission, whilst 3 and 4 control the exhaust — consequently, the port-face is somewhat modified; the bridge b and surface b_1 are not changed, but on the other hand, as shewn in Fig. 20, the bridge b_2 is made correspondingly long, so that the slide may have sufficient support in its maximal deviation. The width a_0 of the exhaust port may be made $= a$. In our Fig. 19, the valve is in its neutral (central) position, whereas in Fig. 20, it is drawn in its maximal deviation. The two exhaust passages a_0 unite in the exhaust-pipe c.

b. Channelled Slide-valve.

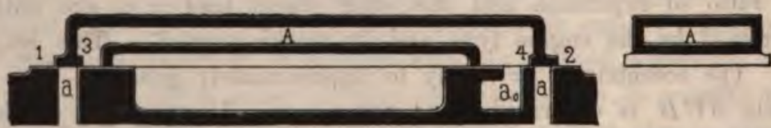


Fig. 21.

The channelled Slide-valve, as shewn in Fig. 21, is also applicable to heavy engines. Instead of the two exhaust passages used in the divided slide-valve pattern, one exhaust-passage a_0 is only here employed, by taking the steam thereto through a channel, made in the slide-valve itself. The central portion of this slide-valve is balanced, and the working edges are the same, as in the preceding example.

c. Trick's Channelled Slide-valve.

As a double steam-admission can be obtained with this slide-valve, it is chiefly used in locomotives and engines running at high speeds. It is traversed by a passage A, which answers the purpose of doubling the admission-area at the beginning of the stroke. For example, as soon as the valve has moved to the right to the extent of its outer lap e, the edge 1 begins to open the left steam-port; simultaneously the edge 1^1 comes to lie exactly over the working-edge I, so that steam passing up the right extremity of the valve-passage A also enters into the left steam-port.

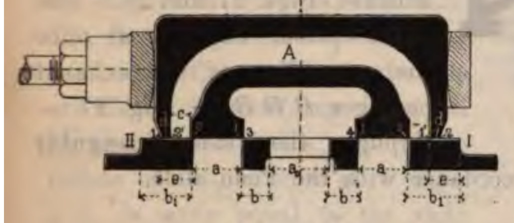


Fig. 22.

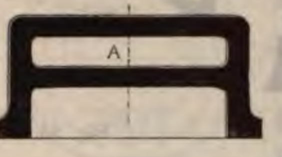


Fig. 23.

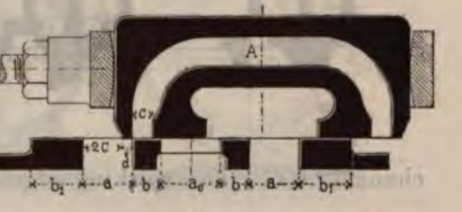


Fig. 24.

An increase in the steam-admitting area continues, until $d = 1 - 2^1$, has reached the middle of the passage a_1, so that on each side of d the distance c remains, because $a = 2\,c + d$. This area remains constant up to the valve position shewn in Fig. 24. The port-widths are also here $= a = 2\,c + d$. The steam-admission begins, when the valve has moved to the extent of its external lap $e = o + d + c$, from its neutral position. The eccentricity $= r = e + 2\,c$, and the bridge b must be made $= b_1 = e + c + o$. The parts d and o are made as small as possible.

d. Double ported Slide-valve.

A slide-valve, attributed to Messrs. John Penn & Sons of Greenwich, though not claimed by them, further than that they have largely used it, is illustrated in Figs. 25 and 26. It has been mostly employed for large engines of the marine type, where in order to reduce the travel of the slide, two steam-ports of half the calculated width, are arranged on each cylinder side; hence the eccentricity $r = 0{\cdot}5\,a + e$. To each half of the valve, two simultaneously working edges are fitted, so that on referring to our wood-cuts,

1 and 1^1 resp. 2 and 2^1 form the outer } lap.
3 and 3^1 resp. 4 and 4^1 form the inner } lap.

The steam-passages $A\,A$ pass through the valve, and allow steam to enter from each side, whilst the exhaust takes place through B. It is advisable to make the width of the central surfaces

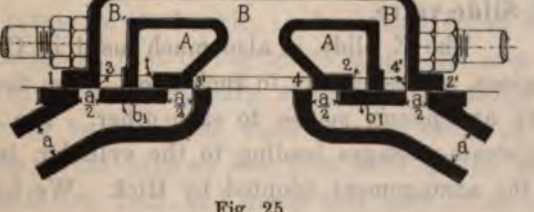


Fig. 25.

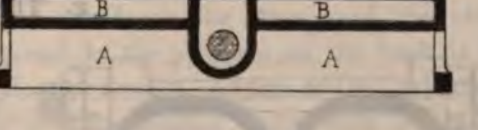


Fig. 26.

b_1 b_1 in the steam ports correspondingly large, so that the greatest travel of the valve, may not open out the narrow steam port 2 into the external steam passage.

The lap and the lineal lead in this slide-valve, require to be only made half as large as usual. Similarly to the ordinary D-slide, this valve may be used in two, where the cylinder is exceptionally long, but it is best suited to the low-pressure cylinder in Compound Engines working under constant expansion.

e. Borsig's Grid-iron Slide-valve.

Borsig's Grid-iron valve enjoys the advantages of the preceding slide, and permits moreover the arrangement of expansion plates being added to its back. We do not shew this in the annexed Figs. 27 and 28. The valve-section, explains at once the connection of the exhaust passages $B\,B\,B$ — Fig. 27 — through the side triangular channels $C\,C$. The working edges have been lettered in accordance with the Penn slide.

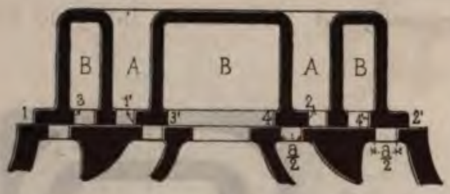


Fig. 27.

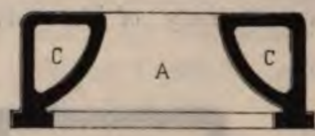


Fig. 28.

f. Hick's Slide-valve.

In Compound-engines, with pistons running in equal directions, the Hick Slide-valve, represented in section in Fig. 29, has often been applied. The cylinder face is furnished with five steam-passages, the two external ports a and a_1 leading to the high-pressure, whereas the inner passages $b\,b_1$ communicate with the low-pressure cylinder; the central port c is the exhaust outlet passing on to the condenser.

Fig. 29.

Hick's valve may be looked upon as consisting of two ordinary slides, the one pushed into the other, and it has therefore eight working edges. The distribution of the steam to the high- and low-pressure cylinders, is effected by the valve edges 1, 2, 3, 4 and 5, 6, 7, 8 respectively. The steam after performing its work in the high-pressure cylinder, passes out through the steam-passage A into the opposite side of the low-pressure cylinder. As a rule, the steam-ports of the low-pressure cylinder are made wider, than those of the high-pressure cylinder, still in both cases, the outer lap is made equal. A modification of this valve suited for cylinders with ports at each end, was for many years, largely used by Messrs. Hick, Hargreaves & Co. of Bolton in their Compound Engines, but of late the separate admission valves controlled automatically from the governor, have nearly altogether displaced the more simple slide valve.

g. The E Slide-valve.

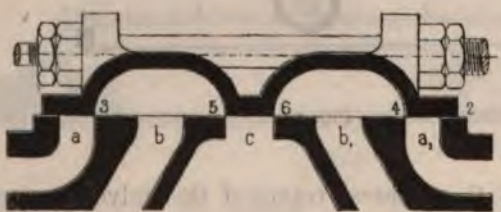


Fig. 30.

The E Slide is also much used in Compound Engines, and especially in such cases, when the pistons have an *opposite motion* to each other. The order of the steam-passages leading to the cylinder, is similar to the arrangement adopted by Hick. We have here however, only six working edges, because the edge of the exhaust in the high-pressure cylinder, does duty simultaneously for the admission in the large cylinder.

h. Webb's Circular Slide-valve.

The advantage of this Slide consists in its being able to move freely in its circular frame, whereby the surface of the slide is not only retained true, but wear and tear is also compensated thereby. This slide is not merely carried on a single cheek of the valve-box, but it is wholly supported by the frame, whilst the latter is provided with a slipper *a*. The cylinder-surface has a top and bottom recess $b\ b_1$, so as to allow the pressure of the exhaust steam to be always playing on a portion of the slide-face. The bottom recess b_1 is fitted with an outlet *c*. The port-edges are all of circular-form, described by two different radii: namely, the radius of the external port edges $d\ d_1$ is made equal to the slide external curve-radius, whereas the internal port edges $(e\ e_1)$ are drawn to a curve, corresponding to the radius of the slide-cavity. (The diameter of the slide is 9 in. = 228 mm.). Constructed in this style, Webb's circular slide works in the same manner, as the ordinary D-slide. In addition to the excellent results obtained with this valve on the London and North-Western Railway, Messrs. Aveling & Porter of Rochester, have introduced it on their Traction-engines.*)

Fig. 31.

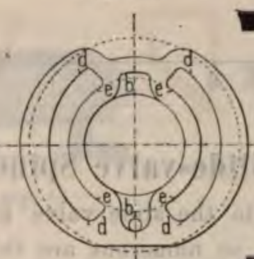


Fig. 32.

Fig. 33.

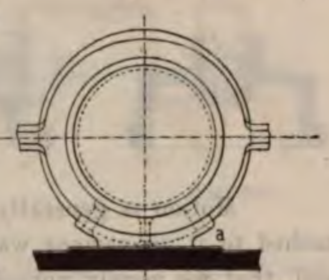


Fig. 34.

i. Everitt's Circular-Valve.

This circular-valve patented by Mr. Everitt of 35 Queen Victoria St., London, has two faces, one bearing on the port face proper and the other on what may be termed the outside of the steam chest cover. According to the proper proportions of these two faces to each other, the valve can have any proportion balanced, that is deemed fit. However, it has been found by practice, that about 70 per cent of this valve, is all that it is desirable to balance.

The exhaust steam is carried straight away through the centre of the valve, thus saving an exhaust port and also giving a freer exhaust than with other types of valve. This arrangement of exhaust renders the valve especially applicable to Compound steam and Hydraulic Engines. The advantage of an ordinary round valve is, that if any part of its face grinds, the valve being free to rotate in its buckle, a fresh surface is brought round; on the other hand, the attendant disadvantage is, that owing to its shape, the area exposed to the pressure on the back is larger, than even with an ordinary square shaped valve. Messrs. Everitt, Adams & Co., calculate that an ordinary valve of the same size as their 10 *HP* Traction Engine valve with 2" travel and $^1/_2$ in lap would have no less than 4680 lbs. on the back of it, assuming the steam pressure to be 60 lbs. to the sq. inch. and would only have 28 sq. inches of wearing surface, this being tantamount to 167 lbs. pressure per sq. inch. of wearing surface. Now with Everitt's valve there is only 2220 lbs. on the back of valve the steam being at the same pressure; but as there is 55 inches of wearing surface to this slide, we get only 40 lbs. pressure per sq. inch. of wearing surface. The advantage of this it is hardly necessary for us to point out, as it ensures a far longer life to the

*) See Engineering d. 12 Decembre 1879, p. 443.

valve, and also reduces very greatly, the power required to drive the same. The total area of Everitt's valve here alluded to is 7854 sq. in.; its balanced area = 41.28 sq. in., and the total wearing surface of valve = 55.52 sq. in. as before mentioned.

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6. Slide-valve Spindles.

Motion is generally imparted to the slide valve by a spindle or stem, connected or attached to it, in various ways. In fact, so numerous are the constructive methods applied to this end, that we merely purpose considering in these pages, the latest approved designs.

Formerly the practice of furnishing the valve-spindle end with a thread was largely resorted to, and it was then merely screwed into the valve, so that a rigid connection was thereby obtained.

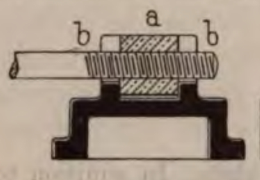


Fig 35a.

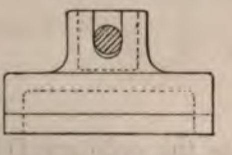


Fig. 35b.

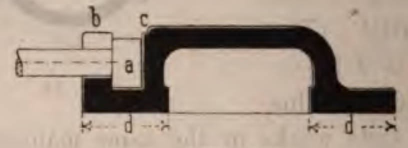


Fig. 36.

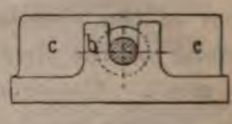


Fig. 37.

Alone this method should be altogether rejected, since the distance from the centre of the rod to the valve-face can never be kept with the accuracy required for any length of time. The valve-spindle connection should therefore be of such a nature, as to ensure the greatest solidity in moving, simultaneously allowing an easy disconnection, and permitting the slide to move freely in its frame, so as to allow the action of the steam on its surface, to press it tight on to its seating. Where small slides are used, the connection represented in Figs. 35*a* and *b* may be

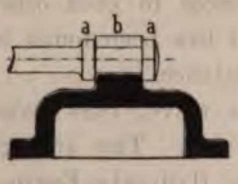


Fig. 38.

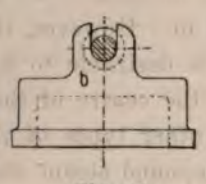


Fig. 39.

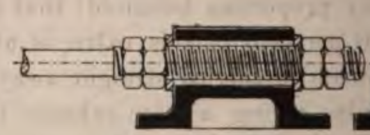


Fig. 40.

Fig. 41.

applied. The end of the valve-stem has a thread which screws into a nut *b* fitted exactly between the ribs *b b* of the slide. The disconnection between spindle and valve is facilitated by cutting out the ribs over the rod, so that nut and rod may be easily lifted off together.

Another construction suited to small slides, is the one shewn in Figs. 36 and 37. In this example, the end of the valve-spindle has a round head *a* which fits in behind the rib *b* and in front of the valve-metal *c*. It will at once be apparent, that this method can only be used where the valve lap *d* is made sufficiently large. Should the lap not be correspondingly suited, the construction shewn in Figs. 38 and 39 may be resorted to. In this case, the end of the valve-spindle is furnished with two collars *a a* which fit into the claw *b* of the valve.

A valve and spindle connection, largely used is shewn in Figs. 40 and 41. The valve is closed at the top, and its back is formed as illustrated, with an oval passage into which the round and threaded end of the valve-spindle passes, the two being screwed up by lock-nuts. The play left to the valve by its oval passage, allows it to adjust itself to the steam-pressure. If on the one side, this construction shares the defect of the thread being likely to wear in time, the counter claim may be set up in its favor, that it can be easily re-adjusted. Similar constructions to the one just described are shewn in Figs. 42—44 with this main difference that the valve rod passes over, instead of under, the valve-back.

Fig. 42.

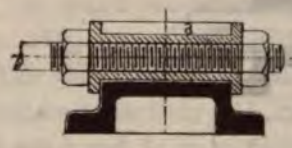
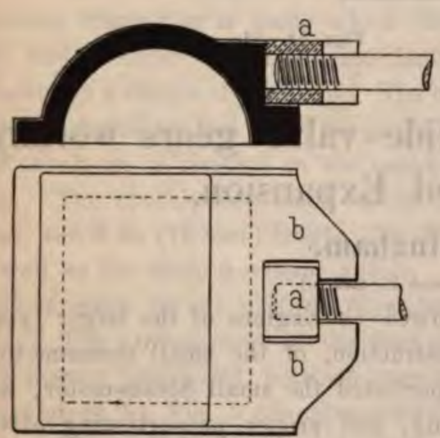


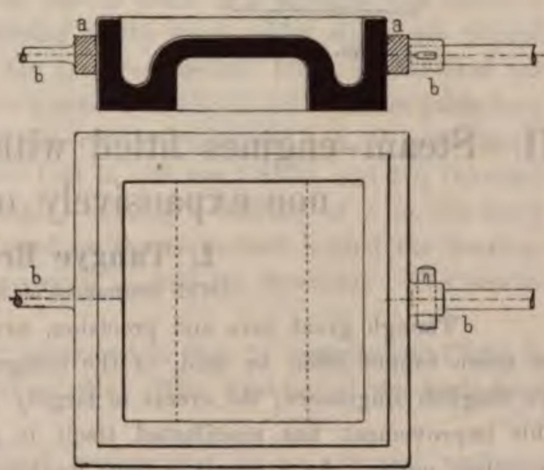
Fig. 43.

Fig. 44.

A plan both simple and cheap, and in fact also often resorted to, is shewn in Figs. 45—46. The brass-nut *a* which is made to receive the end of the valve-stem, is bedded in the flanges *b b*



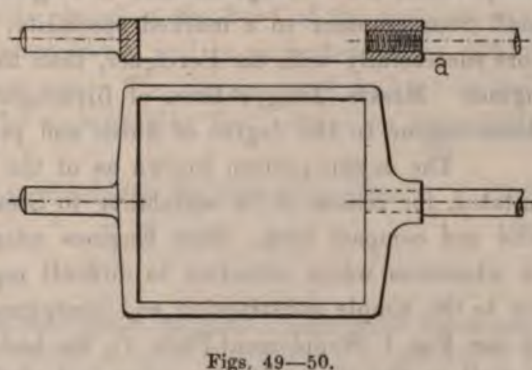
Figs. 45—46.



Figs. 47—48.

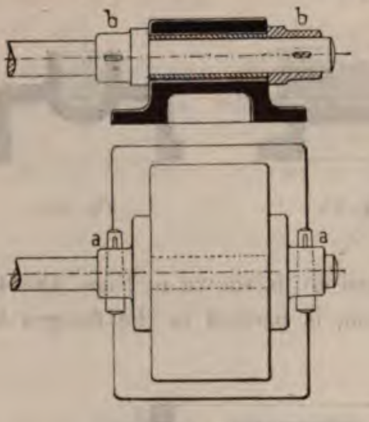
of the slide. The nut allows a certain amount of play to the valve, and for this reason its edges are rounded off. In these various slide and spindle connections, it is customary, — to ensure a sure travel of the slide, — to make the valve slide on planed ledges in the valve chest.

Our illustrations (Figs. 49 and 50) shew a plan, where the slide is motioned by a square frame, which is somewhat rounded off, on its inner contact-surfaces, so that the slide may be thereby prevented from sticking fast, against the steam-tendency. The connection between frame and stem is effected by boss and wedge *b*. It frequently occurs, that spindle and frame are screwed into each other, as shewn in Figs. 49—50.

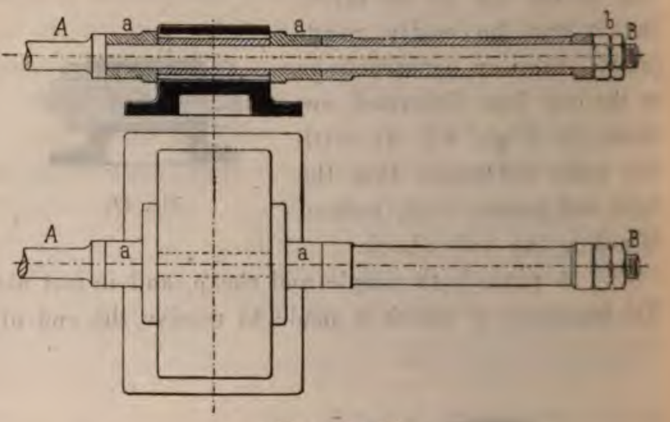


Figs. 49—50.

In the construction shewn in Figs. 51 and 52, threads and nuts have been superseded by sleeves *b b* and wedges *a a*, but this plan has been further improved upon by a Mr. Krämer, who has devised the method shewn in Figs. 53 and 54, which illustrations are sufficiently explanatory in themselves to require further comment.



Figs. 51—52.



Figs. 53—54.

II. Steam-engines fitted with simple Slide-valve gears working non-expansively or with fixed Expansion.

1. Tangye Brothers, Birmingham.

(With illustrations on Supplement-Plates 1 and 2, and I.)

Though great care and precision, are generally bestowed on Engines of the larger types, as much cannot often be said, of the design and actual construction, of the small steam-motors. To English Engineers, the credit is largely due, of having perfected the small Steam-motor, and this improvement has manifested itself in good workmanship, and proper proportioning of the working parts. As a result higher working speeds and greater power-developments have been attained, than inferior machines previously allowed. In the second volume of this Work, pg. 249 the writer of these lines, took occasion to point out, the important rôle small engines might enjoy in the Future, and on page 213 of the same volume he referred to the different progressive ideals set up by English and Continental Engineers. Whilst referring the reader to these remarks, it is indisputable, that a large number of English Engineering Firms, have raised the construction of small Steam-motors to a marked speciality, which still enables them to compete in this branch, more successfully with the Foreigner, than they are now able to do in the heavier builds of Steam-engines. Messrs. Tangye Bros. of Birmingham, have undoubtedly done much, to raise the small Steam engine to the degree of finish and perfection, which it now enjoys.

The engine-pattern known as of the Tangye-type, has been largely introduced and much imitated, for reason of its suitability to Steam-motors of the smallest sizes. On account of their solid and compact form, these Engines adapt themselves admirably for driving small Works, or for situations where attention to difficult repairs, cannot be relied upon. This solidity is largely due to the simple construction and conspicuous reduction of component engine-parts, for, as seen by our Fig. 1 (Supplement-Plate 1), the bed-plate, with the crank-shaft bearings, the motion-bars, as well as the front cylinder cover and stuffing box, all form together one single casting.

Characteristic in this Engine-type is the handsomely designed bed-plate, which combines the advantages of the Corliss-frame, with that of the horizontal engine foundation-plate. The cylinder is bolted to the bed-plate and overhangs the latter, and the engine-bed — supported on a wide basis — is securely held down, by five strong foundation-bolts.

This 2 *HP* Engine has a cylinder diam. of 4 in. (101 mm.) and a stroke of 8 in. (203 mm.). The piston-runs at 4 ft. speed per sec. answering to 180 crank revolutions per min. For the generation of the necessary steam of $3^1/_2$ atm. pressure, $16^1/_2$ lbs. of coal and 120 lbs. of water are respectively consumed and evaporated per hour. The weight of the engine is $5^1/_4$ cwt., and the fly-wheel (2 ft. 6 in. diam. and 3 in. on the face) weighs separately $1^3/_4$ cwt.

The eccentric is set to an eccentricity 0·87 in. (22 mm.) and to an advance angle of 53°, and as the outer lap = 0·51 in. (13 mm.), expansion begins at half stroke. (?) The steam supply-pipe, is $^3/_4$ in. in inner diameter, or $^1/_{28}$th of the cylinder-area, hence the live steam-velocity assumes the speed of 108 ft. (33 m.)*) per sec. The exhaust pipe is internally $1^1/_4$ in. (28 mm.) in diam. The steam-ports are 0.43 in. (11 mm.) wide and $2^1/_2$ in. (64 mm.) in depth, corresponding to $^1/_{11}$th cylinder cross-area.

The connecting-rod is made to five crank-lengths, and in place of a wrought iron crank, a cast-iron crank-disc is used, which facilitates the balancing of the same. The slides are planed flat, and in order to compensate for wear and tear, the cast-iron motion block is rendered adjustable by a couple of set-screws. The crosshead-pin is not placed centrally to between the guide-bars and is fastened by two nuts; its length and diameter are respectively $1^1/_2$ in. and 1 in. (38 and 23 mm.). The crank-pin is rivetted in the crank-disc, and is made 1·38 in. (35 mm.) diam. and $1^3/_4$ (45 mm.) long. The crank-pillow-block is on the angular principle, offering a bearing of 2 in. (50 mm.) diam. and 3 in. (72 mm.) length. (?) The eccentric is keyed on the main-shaft behind the bearing, as well as the strap governor pulley — fixed with set-screws — and the fly-wheel. The crank-shaft is made of one uniform diameter throughout.

The arrangement of the feed-pump is original; as shewn in Fig. 2, (Supplement-Plate 1) it is merely interposed between eccentric rod and valve-spindle. The working of the feed-pump is explained by Fig. 5 (Supplement-Plate 1).

The engine-governor is represented in longitudinal section and to an enlarged scale in Figs. 6 and 7 (Supplement-Plate 1). It reacts on a throttle-valve which is placed in the casing of the shut-off valve. The governor is shewn with the balls in their highest position, whereby the throttle-valve is shewn closed. The governor-spindle is driven by bevel-gearing, and in order to be able to adjust the governor for different speeds, a spiral-spring is arranged on the steel pressure-rod, which reacts on the governor-balls. For this purpose, the spiral-spring may be more or less compressed, which is done by a nut and threaded spindle placed at the head of the governor-support. This threaded spindle passes through the steel pressure rod and is connected to the end of the spiral-spring. The governor is run at 500 revs. per min. The engine speed is kept so uniformly by this governor, that even the flying off of the main driving belt, shews no perceptible change of speed to the eye.

Messrs. Tangye Brothers, construct these engines chiefly in the following sizes:

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*) Compare page 287, Vol. II. After many experiments, Radinger found that where no appreciable loss of pressure manifested itself, the average Steam-velocity, = 30 m. per sec. Hence if f = cylinder-bore area, v = piston-speed in metres per sec. and if C be taken to represent the reciprocal value of the steam-velocity (i. e. $C = ^1/_{30}$), whilst f_1 = steam-supply-area, then we may write $\frac{f_1}{f} = Cv$.

Nominal Horse Power	2	3	4	6	8	10	12	14	20	25
Diameter of Steam Cylinder	4 in.	5 in.	6 in.	8 in.	9 in.	10 in.	11 in.	12 in.	$14\frac{1}{4}$ in.	16 in.
Length of Stroke	8 in.	10 in.	12 in.	16 in.	18 in.	20 in.	20 in.	24 in.	28 in.	28 in.
Revolutions per Minute	180	144	120	100	90	85	85	75	65	65
Approximate Weight of Engine, all compl.	$5\frac{1}{4}$ cwt.	$9\frac{1}{2}$ cwt.	$14\frac{1}{2}$ cwt.	24 cwt.	33 cwt.	47 cwt.	52 cwt.	60 cwt.	100cwt.	120 cwt.
" " " Fly-wheel	$1\frac{3}{4}$ cwt.	$3\frac{3}{4}$ cwt.	$6\frac{1}{4}$ cwt.	$9\frac{1}{2}$ cwt.	$13\frac{1}{2}$ cwt.	19 cwt.	19 cwt.	22 cwt.	33 cwt.	40 cwt.
Diam. of Fly-wheel	30 in.	39 in.	48 in.	54 in.	60 in.	66 in.	66 in.	72 in.	90 in.	108 in.
Width of Face, turned	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	8 in.	9 in.	10 in.	12 in.
Diameter of Fly-wheel shaft	2 in.	$2\frac{3}{8}$ in.	$2\frac{3}{4}$ in.	$3\frac{1}{4}$ in.	$3\frac{5}{8}$ in.	4 in.	$4\frac{1}{4}$ in.	$4\frac{1}{2}$ in.	$4\frac{7}{8}$ in.	$5\frac{3}{8}$ in.
Length of " "	28 in.	36 in.	39 in.	45 in.	48 in.	51 in.	54 in.	54 in.	63 in.	72 in.
Diameter of Steam Pipe	$\frac{3}{4}$ in.	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	$1\frac{3}{4}$ in.	2 in.	$2\frac{1}{4}$ in.	$2\frac{1}{2}$ in.	$3\frac{1}{2}$ in.	4 in.
" " Exhaust Pipe	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	$1\frac{3}{4}$ in.	$2\frac{1}{4}$ in.	$2\frac{1}{2}$ in.	3 in.	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.	$4\frac{1}{2}$ in.	5 in.

Of late years, Messrs. Tangye Brothers have introduced another typical construction known as the Soho-engines, and we represent, one of these horizontal Engines of 10 horse-power on (Supplement-Plate 2 (Figs. 8—11); it has a cylinder diam. of 10 in. (254 mm.) and a stroke of 1 ft. (304 mm.).

Owing to the peculiar form given to the bed-plate, the general appearance of the Engine is rendered abnormal. As a cranked-shaft is used in place of the crank-disc, the bed-plate has two pillow blocks. The fly-wheel is keyed on the open end of the shaft. Again, the slide-bar arrangement is also peculiar, as it is formed by one portion of the bed-plate, and is arranged above the piston-rod.

Crank-rod and eccentric-rod are of cast-steel, made to an **I** section. The butt-end of the connecting rod is made closed, with wedge-adjustment. By placing the eccentric within the bed-plate, very short steam-ways are obtained; on the other hand, the bed-plate has to be scooped out to allow the eccentric rod to pass through, and owing to the same reason, the feed-pump has to be worked off a prolongation of the valve-rod; this arrangement allows the feed-pump to be dispensed with when so desired.

All the sliding surfaces are made proportionately large. The crank-pin is $3^1/_4$ in. (83 mm.) in diam. and 5 in. (127 mm.) long. The crank-bearings are $3^1/_2$ in. (89 mm.) in bore, and $6^3/_4$ in. (172 mm.) in length. The motion-block pin is $1^3/_4$ in. (44 mm.) in. diam. and $4^1/_2$ in. (113 mm.) long, and the cross-head slides = 48.7 sq. in. (314 qcm.)

An oil-catcher is placed under the crank, between the bed-plate and the foundation. The dimensions of the Soho Engine types are given in the following table.

Nominal horsepower	3	4	6	10	14
Cylinder diameter in. in.	5	$6^1/_2$	8	10	12
Revolutions per min.	240	210	180	150	130
Diam. of fly-wheel in ft. and in.	$2^1/_2$ ft.	2 ft. 11 in.	3 ft. 4 in.	5 ft.	6 ft.
Face of fly-wheel in in.	4	5	6	8	10
Length of crank-shaft outside bearing in in.	5	$6^1/_2$	8	10	12
Diam. of Steam-supply pipe in in.	$1^1/_4$	$1^1/_2$	2	$2^1/_2$	3
Diam. of Steam-exhaust pipe in in	$1^1/_2$	2	$2^1/_2$	3	$3^1/_2$
Diam. of Feed-water pipe	$^3/_4$	$^3/_4$	1	1	$1^1/_4$
Length and width of Engine in ft. and in.	5' × 3' 10"	5' 8" × 4' 7"	6' 10" × 5' 6"	7' 8" × 6' 10"	10' × 8' 7"

Vertical Engine: Messrs. Tangye Brothers were also represented at the Paris International Exhibition of 1878 by a Vertical Engine, a sketch of which we represent on Supplement-Plate I (Figs. 11—13). It may be here observed, that this type distinguishes itself by its compact and solid construction; for in this arrangement, the bed-plate, the vertical engine frame and the lower cylinder-cover are again cast in one piece, same as we noticed in the Horizontal Engine-type. The cylinder is bolted to the vertical frame, which is cast hollow; it is jacketed and steel-cased. The cylinder bore = 8 in. (203 mm.) and its stroke = 9 in. (228 mm.); running at 180 revolutions per minute, it is classed as a six horse-power engine. The slide-bars form part of the frame, and the crosshead is of the usual construction; the motion block-slides are made adjustable, by double set-screws and have a slide surface of 18.6 sq. in. (120 qcm.). The connecting rod is made as we described with the horizontal engine type. The slide-valve is arranged at the side of the cylinder, and is moved by an eccentric, whilst a second eccentric works the feed-pump, which is bolted to the bed-plate.

In the two pillow-blocks of the bed-plate, a solid cranked shaft is placed on bearings of $2^3/_4$ in. (70 mm.) bore and $5^1/_2$ in. (140 mm.) in width. In order to utilise the flywheel (3 ft. 4 in. = 1016 mm. diam. and 6 in. = 15·2 mm. on the face) as strap-pulley, its face is planed bright, and it allows itself to be mounted on either end of the crank-shaft. The governor works on to an equilibrium valve, and it is driven by strap.

2. E. S. Hindley, of Bourton, England.

The horizontal and vertical engines made by this Firm are chiefly intended for export, and accordingly all complications are advoided in their construction, and they are further designed to afford great durability.

An illustration of the horizontal type is given in Fig. 55, which shews that the cylinder overhangs and is bolted to the foundation plate; the latter has two crank-pedestals, and rests on

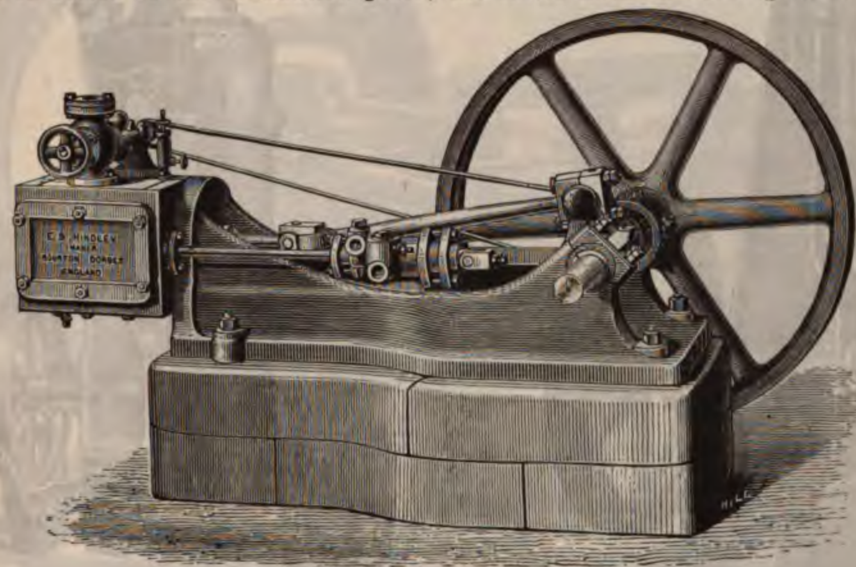


Fig. 55.

the foundation over its entire length. The motion-block runs in a slipper guide. The eccentric, working the feed-pump and the slide-valve, is fitted on one side of the crank behind the first pedestal; on the other side of the crank, a belt-pulley is mounted for driving the governor. The fly-wheel may be keyed on either side of the engine.

The sizes and dimensions to which these engines are constructed, are given in the following table:

Nominal horse-power .	2	3	4	5	6	8	10	12	15
Diameter of Cylinder .	4	5	6	7	8	9	10	11	$12\frac{1}{4}$
Stroke of Piston . .	6	$7\frac{1}{2}$	9	$10\frac{1}{2}$	12	13	14	15	17
Diameter of Fly-wheel	28	32	36	42	48	54	60	72	78
Revolutions per Minute	240	210	180	160	140	130	120	110	90
Space occupied ins.	23	26	30	35	36	42	46	50	56
	×	×	×	×	×	×	×	×	×
ins.	46	55	64	74	84	92	100	120	127

*) A Horizontal Hauling Engine of Messrs. Tangye Brothers make was illustrated in "The Engineer" d. 6 Aug. 1880, page 103.

Hindley's Vertical Engine Type is illustrated in Fig. 57, connected with a steam-boiler, and they are both mounted on a water tank and four travelling wheels. The engine frame is of I section, and its lower end is made to support the crank-shaft. The crank-plate is provided with two holes, and the crank-pin can be placed in either one or the other, according to the direction in which it is most convenient to run the engine. The top portion of the engine-frame is planed, to receive the cylinder. The top side of the cylinder is closed, — i. e. it has no cover in the ordinary sense of the word — and its valve-chest is cast with it in one piece; in this manner the engine-frame simultaneously forms the valve-chest cover.


Fig. 56.


Fig. 57.

The eccentric is placed between the first pedestal and the crank disc, and a space is cut out of the engine frame to take up the governor-driving pulley.

The engine type represented by our Fig. 56 is constructed in 11 different sizes, varying from 1 to 15 nominal horse-powers. On the other hand, the combined boiler- and engine-type is only built in 9 sizes answering from 1 to 8 horse-powers. Engine and boiler are arranged independently of each other, on a cast iron tank serving the double purpose of water-heater and ash-pan. This tank is bolted firmly to the hind axle, but sits on the first axle on a swivel-bolt. When required, the engine allows itself to be turned bodily round, so as to permit the driving to be done from either side.

3. The Halle Engineering-Works and Iron-Foundry, of Halle a. S.

Simplicity and originality are the main characteristics of the engine-type constructed by this Engineering Firm, — formerly Messrs. R. Riedel & Kemnitz. — The engines we now propose discussing, are built in two arrangements, according to their size. The smallest are of the pattern shewn in Fig. 58 in which the main-shaft is cranked, and is carried on two pillow-blocks cast with the bed-plate. In the larger constructions, the cranked main-shaft is replaced by a crank-disc, and correspondingly, the second bearing is fixed independently of the engine-frame, so that the fly-wheel is placed as usual, between the two bearings.

The form of the bed-plate is characteristic, and it forms one casting with the cylinder-cover and the slide-bars. Easy accessibility to all the working parts is thus secured, without sacrificing solidity, or stability.

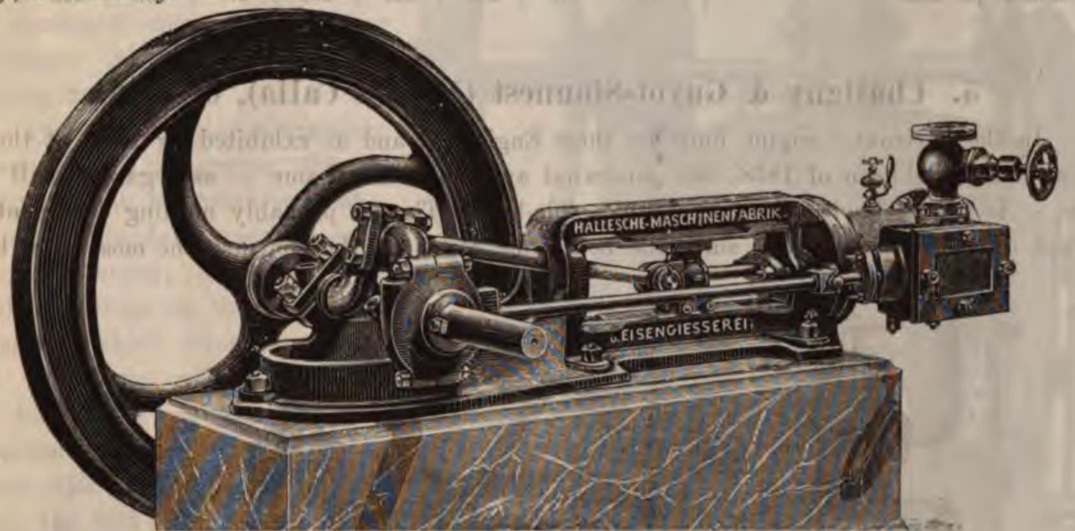


Fig. 58.

To give a handsome appearance to the engine, the various flanges, cylinder-covers, governor balls and counter-weight on the governor are polished bright, and the flywheel (adapted as strap-pulley) is turned both on its face and sides. The crank shaft is sufficiently prolonged on the one engine-side to take up additional driving pulleys if required. The slides of the motion-block are rendered adjustable by wedges. These engines can be easily converted for wall-purposes, or require only a light foundation, when used as horizontal engines. If employed for portable purposes they are mounted on a strong metal bed-plate, which in its turn, is bolted to the boiler-shell.

These engines are constructed in the following ten sizes:

Nominal *HP.* (The indicated *HP.* calculates itself at double the nominal when working at $3^1/_2$ atm. cylinder steam-pressure)	2	3	4	5	6	8	10	12	15	18
Steam-cylinder diam. in in.	4	5	6	7	8	9	10	11	12	$12^3/_4$
Stroke in in.	7.87	7.87	11.81	11.81	11.81	$15^3/_4$	$15^3/_4$	$15^3/_4$	21.66	21.66
Average revolutions per min.	180	180	120	120	120	90	90	90	65	65
Steam-supply pipe (bore) in in.	0.79	0.98	1.38	1.38	1.58	1.97	1.97	2.36	2.56	2.56
Steam-exhaust pipe (bore) in in.	1.38	1.58	1.97	1.97	2.56	2.56	3.15	3.15	3.54	3.94
Approximate Engine-weight in cwts.	$6^1/_2$	8	14	17	28	31	34	50	56	62

4. John Bourne & Co., of London.

(With illustrations on Supplement-Plate 1, Figs. 8—13.)

The engine designed by John Bourne, has now been so long before the English public, and has been so frequently reviewed in the Engineering Press, that we content ourselves here in merely illustrating this construction on Supplement-Plate 1, Figs. 8—13, as a High-pressure High-speed Engine, and in giving the following Table of Dimensions of the various sizes, to which it has hitherto been built.

Horse-power (effective)	4	8	12	20	30	40	50	70	90
Cylinder diam. in inches	$2^1/_2$	$3^1/_4$	$3^3/_4$	$4^3/_4$	$5^1/_2$	$6^1/_2$	$7^1/_2$	$8^1/_8$	$9^1/_8$
Stroke in inches	5	$6^1/_2$	$7^3/_4$	$9^1/_2$	$11^1/_4$	13	14	$16^1/_4$	$18^1/_8$
Diameter of Fly-wheel	1 ft. 3 in.	1 ft. 8"	2 ft.	$2^1/_2$'	3'	3' 6"	3' 9"	4' 2"	4' 8"
Revolutions per min.	516	436	388	337	302	277	265	233	210

5. Chaligny & Guyot-Sionnest (Maison Calla), of Paris.

In the horizontal engine built by these Engineers, and as exhibited by them at the Paris International Exhibition of 1878, the somewhat antiquated box-frame — as regards small steam-motors — is retained with the four double slide-bars. Though probably nothing detrimental can be urged against this adoption, since the box-frame forms on the contrary the most solid bed for

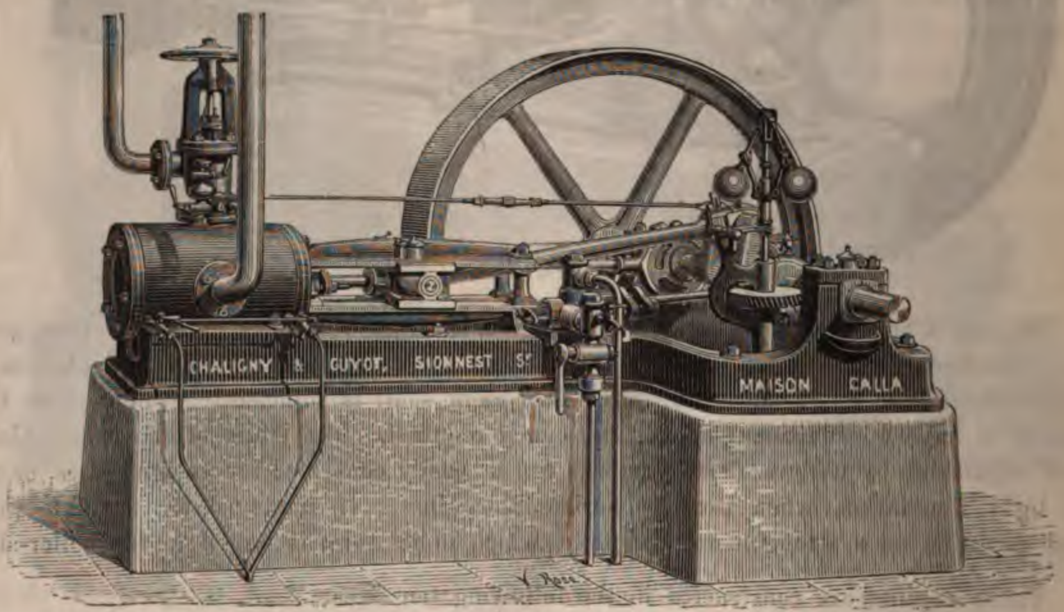


Fig. 59.

large engines, still its retention with small engines is scarcely advisable, inasmuch as such capital designs, embodying a later practice have been offered us in other engine bed-plates.

In the engine in question (Fig. 59) the bed consists of a closed narrow casting, which rests on a stone or brick foundation. The two crank-shaft pedestals are cast in one with the bed. Between the crank and the front bearing, an eccentric is mounted on the main shaft for driving the feed-pump, whilst a second eccentric fitted on the other side, works the slide. A Watt's governor is erected behind the front pedestal, and it is driven by worm-gear, which method necessitated the bellying out of the bed, to the detriment of the general appearance. The governor is made to act on a throttle-valve.

The slide-bars rest with their front ends on the engine bed, and are bolted to the cylinder at their other extremity. The cylinder, is steam-jacketed, and is bored to 7·47 in. (190 mm.) whilst its stroke = 11·81 in. (300 mm.). The crank is run at 115 revolutions per minute, so throwing off a piston speed of 3 ft. 9 in. (1·15 m.) per sec. Working at 6 atm. boiler-pressure, these engines develop 16 *HP* and their approximate weight = 25½ cwt. (1300 kilogr.).

The Vertical engine type, constructed by this Firm (as illustrated in Fig. 60) is of more pleasing design. As a combined engine and boiler arrangement, it is built in sizes developing 2—8 *HP.*

The vertical Field-boiler stands independently of the engine, though it is mounted on the same bed-plate. Two curved standards rise at each side of the boiler, and these two form the bearings for the horizontal crank-shaft, which runs over the boiler. The steam cylinder is bolted to the foot of the one standard, and the motion block is made to grip only one slide-bar. For symmetrical reasons, the feed-pump was fixed to the other standard, where it is worked off a second eccentric.

In this vertical engine type, the cylinder diameter is made to vary between 4·3″—6″ (110—150 mm.) with corresponding strokes from 8·66″—11·81 in. (220—300 mm.); the crank-revolutions number 125 per minute.

The horizontal engine, illustrated in Fig. 59 is built in the following sizes:

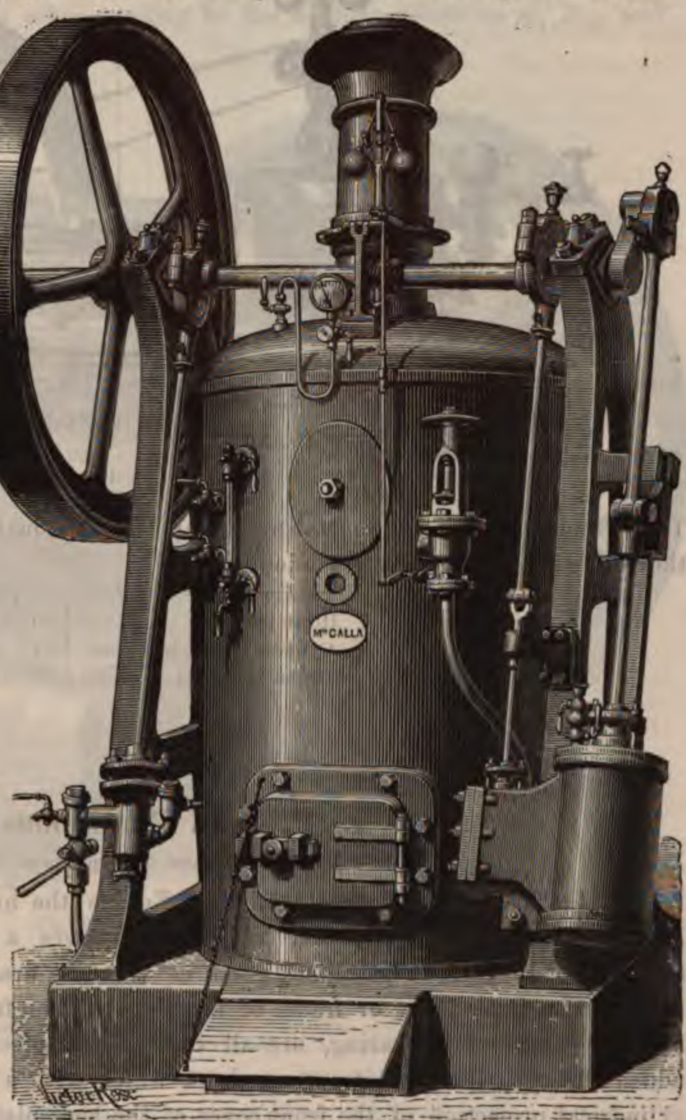


Fig. 60.

Horsepower	3—4½	4—6	6—9	8—12	10—15	12—18
Cylinder diam. in inches. .	4.72	5.19	5.90	7.47	8.26	9.05
Stroke in inches	9.84	9.84	11.81	11.81	12.60	12.60
Diameter of crank-shaft . .	2.36	2.36	2.76	2.95	3.15	3.74
Diameter of fly-wheel . . .	4ft. 1in	4ft. 1in	4ft.11in	4ft.11in	4ft.11in	5ft. 9in
Revolutions per min. . . .	125	125	115	115	110	105
Engine-weight in cwts. . .	14	15	20	26	39	47

6. Erie City Iron-works, Erie (Penn. U. S. A.).

This Firm uses the flat bed-plate in all its engines. As shewn by Fig. 61, the cranked main-shaft is carried on two pedestals, whilst the cross-head, slides between a pair of slide-bars.

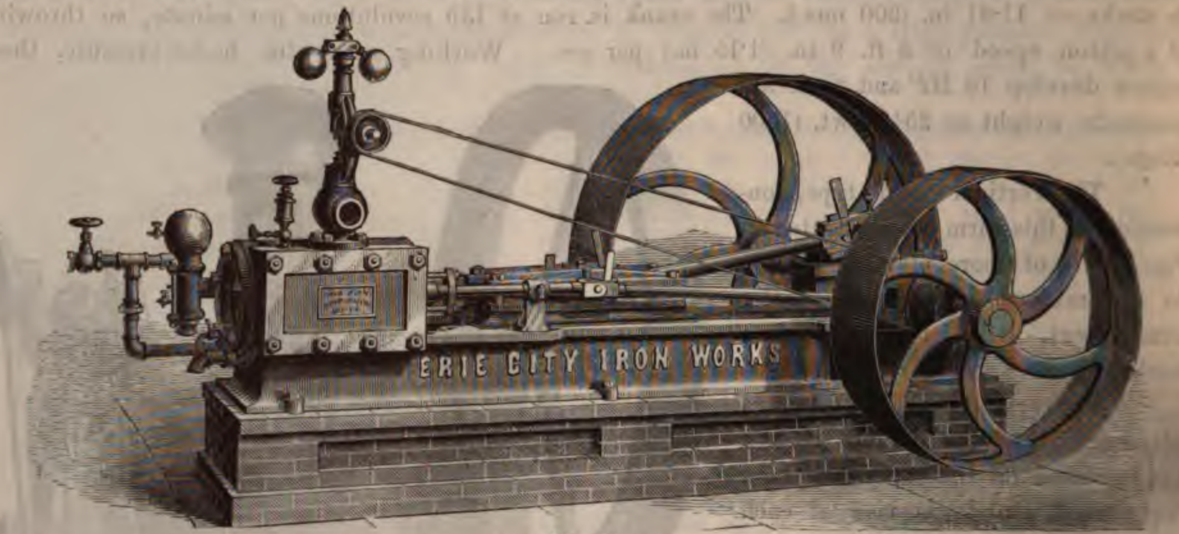


Fig. 61.

The cylinder has a double metal-lining, and for the smaller sizes, (working without expansion-gear,) the following dimensions are adopted:

Horse-power	10	12	15	18	20
Cylinder diam. in inches	7	8	8	9	10
Stroke in inches . . .	10	10	12	12	12

7. P. & H. P. Gibbons, of Wantage.

(With illustrations on Supplement-Plate 2, Figs. 1—5).

In this improved construction of Engine the number of working parts, joints and bolts, has been considerably reduced, and Fig. 62 gives a perspective view of this Engine, whereas Supplement-Plate 2, (Figs. 1—5) gives us Working-drawings of this type.

The Base-plate or frame of the Engine, the front Cylinder cover, the cross-head guides, and the crank-shaft bearing, are all cast in one piece, to which, practically speaking, may be added the cylinder with its steam-chest, which with a carefully wrought recess, fitting upon the cylindrical projection of the front cover of the base-plate, makes an almost undivided arrangement. The cross-head motion blocks, and the connecting-rod ends, are made adjustable to provide against wear and tear, which, however little, may be eliminated at any time. All parts are made interchangeable, those admitting of gauging, to Whitworth's Gauge. The cylinder covers and flanges, the connecting rod and ends, the crank-plate, shaft, and the rim of the fly-wheel, are turned and polished.

The Governor, of the pseudo-parabolic class, involves a principle which is highly suited for sensitiveness and energy, characteristics which embody the best requirements of a Governor.

The Governor is so constructed, as to keep the plane of revolution of the pendulum balls, below the free bearing point of the governor spindle, an item of great advantage in regard to the steady working of high-speed governors. "Engineering" gives the following theory respecting this governor:

Let l = length of pendulum lever.

a = distance of point of suspension from axial line of governor.

a_1 a_{11} the angles of the arms corresponding to the angular velocities $\tilde{\omega}_1$ $\tilde{\omega}_{11}$, and h_1 h_{11} the corresponding pendulum heights,

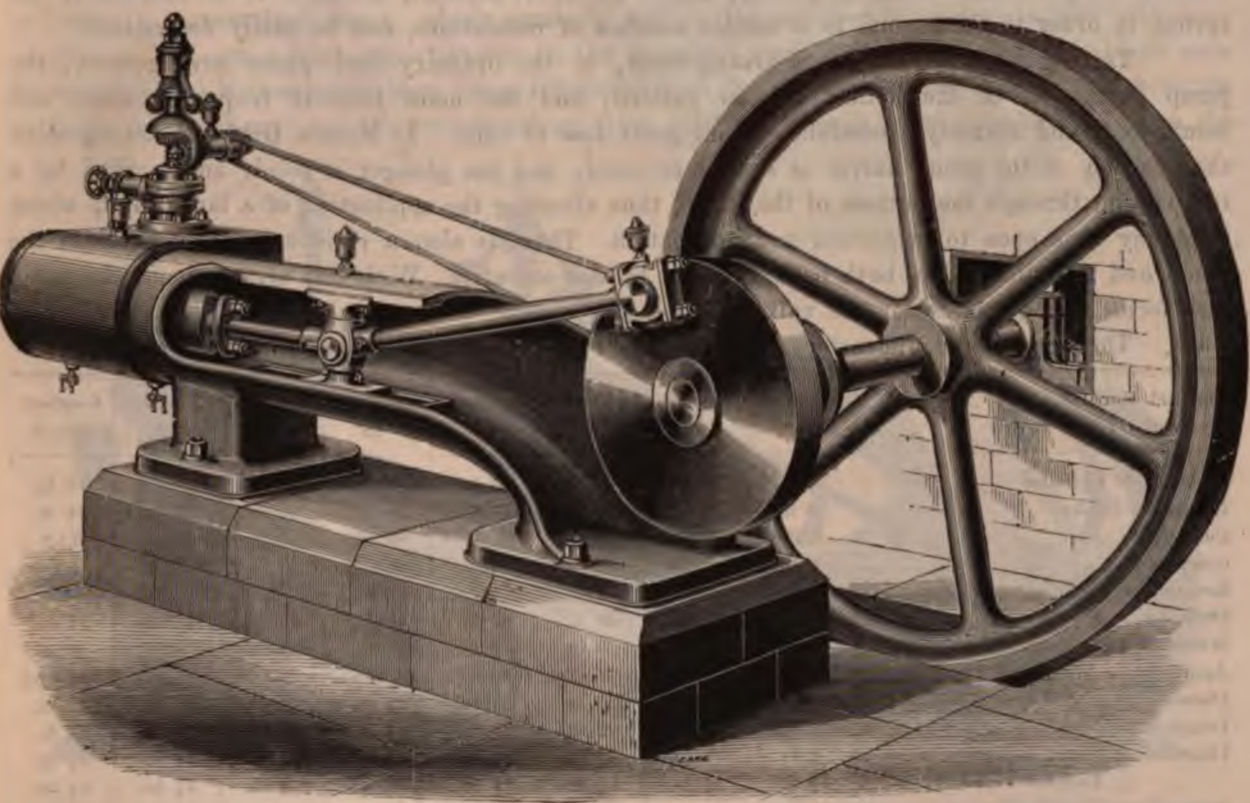


Fig. 62.

then,

$$\frac{h_{11}}{h_1} = \frac{\tilde{\omega}_1^2}{\tilde{\omega}_{11}^2} = \frac{l \cos. \alpha_{11} - a \operatorname{cotg.} \alpha_{11}}{l \cos. \alpha_1 - a \operatorname{cotg.} \alpha_1}$$

where

$$\alpha_{\text{min.}} \text{ is given by } \sin. \alpha_{\text{min.}} = \sqrt[3]{\frac{a}{l}}$$

In Fig. 5, (Supplement-Plate 2) which illustrates by way of diagram, the principle of the governor, we have B a rod with crosshead A, to which are pointed the levers D E and D_1 E_1. C_1 D_1 and C D are two links joining the ends D and D_1 to C and G respectively. The end of D when the ball E has a tendency to rise, moves in a circle, whose centre is C; and in the same time, the point F of lever E D being obliged to move parallel to the axis of the governor, the ball E is forced to move in an elliptic curve.

On the top of the central spindle crosshead A, there is a spring which, when more or less compressed, regulates the speed of the engine correspondingly. Thus let G = the weight of the ball; G_1 = the force exerted by the spring plus the weight of the rod and throttle valve and coupling, then

$$\frac{G}{G} = \frac{l}{l_1} \left\{ \frac{\bar{\omega}^2}{g} (l \cos. \alpha - a \text{ cotg. } \alpha) - 1 \right\} - 2$$

where $\frac{\bar{\omega}^2}{g} = \frac{n^2}{35{,}215}$ in. approximately, and n = number of revolutions per minute, and g = acceleration of gravity. From the above formula, the force to be exerted by the spring, in order to correspond to a certain number of revolutions, can be easily determined.

Turning next to the pump arrangement, in the ordinary feed pump arrangement, the pump plunger is of the hollow tubular pattern, and the main joint is frequently small and insufficient, and scarcely accessible without great loss of time. In Messrs. Gibbons' arrangement the position of the pump barrel is simply reversed, and the plunger is solid, and worked by a rod passing through the bottom of the pump, thus allowing the application of a large joint, which is at any time open to inspection and lubrication. There is also a rigid connection between the pump and the slide valve, both being worked by one eccentric. With this arrangement, the pump also forms a good guide for the valve spindle.

The powers and dimensions to which these Engines are built, are tabulated as follows:

Nominal Horse Power	Two	Three	Four	Six	Eight	Ten	Twelve	Fourteen
*Indicated Horse Power	4	6	9	15	19	24	29	34—5
Diameter of Cylinder	4 in.	5 in.	6 in.	8 in.	9 in.	10 in.	11 in.	12 in.
Length of Stroke	8 in.	10 in.	12 in.	16 in.	18 in.	20 in.	20 in.	24 in.
Cut off at	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
Compression	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Revolutions per Minute	188	144	120	100	90	85	85	75
Diameter of Fly Wheel	30 in.	39 in.	48 in.	54 in.	60 in.	66 in.	66 in.	72 in.
Width of Face	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	8 in.	9 in.
Approximate Weight of Fly Wheel ..	1¾ cwt.	3¾ cwt.	6¼ cwt.	9½ cwt.	13½ cwt.	19 cwt.	20½ cwt.	22 cwt.
Diameter of Fly Wheel Shaft	2 in.	2⅜ in.	2¾ in.	3¼ in.	3⅜ in.	4 in.	4¼ in.	4½ in.
Length of ,, ,, ...	28 in.	36 in.	39 in.	45 in.	48 in.	51 in.	54 in.	54 in.
Diameter of Steam Pipe	¾ in.	1 in.	1¼ in.	1½ in.	1¾ in.	2 in.	2½ in.	2½ in.
,, ,, Exhaust Pipe	1¼ in.	1½ in.	1¾ in.	2¼ in.	2½ in.	3 in.	3½ in.	3½ in.
Approximate Weight of Engine complete	5 cwt.	9 cwt.	14 cwt.	24 cwt.	33 cwt.	43 cwt.	52 cwt.	59 cwt.
Length of holding-down Bolts	2 ft.	2 ft. 6 in.	3 ft. 6 in.	4 ft.	4 ft. 6 in.	5 ft	5 ft. 6 in.	5 ft. 6 in.
Diameter of ,, ...	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.	1⅜ in.	1½ in.
Approximate extreme Length of Engine	5 ft.	6 ft. 4 in.	7 ft. 6 in.	9 ft. 4 in.	10 ft. 4 in.	11 ft. 5 in.	12 ft. 4 in.	13 ft. 2 in.

* When cutting off at Half Stroke, Speed of 240 Feet per minute, and 50 Pounds pressure in the boilers.

8. E. R. & F. Turner, of Ipswich.

(With illustrations on Supplement-Plate 2, Figs. 6—7.)

In the second volume of this Treatise*), the vertical Engine and Boiler arrangement of the so-called Gippeswyk type was described and illustrated, though it was there not only wrongly classed, but by a printer's error, the horizontal engine-design was also omitted. The reader will

*) Page 251.

therefore find this omission made good in Supplement-Plate 2 (Figs. 6—7), but as the two engine-types were fully described in the said Vol. II, we will not here revert to them.

9. Ames Iron-works, of Oswego (N. Y.)

This is one of the oldest established American Engineering Firms, and they make their horizontal engine shewn in Fig. 63, on an independent bed plate, which may either be bolted on the top of a boiler — portable or otherwise — or fixed to a stationary-foundation. The cylinder*) is bolted to a cast iron frame, which similarly carries the crank-shaft pedestals and slide-bars or guides. The crank-shaft pedestals are on the improved angle system, and the slide-block runs between top and bottom guide-bars, being lubricated from the top. The steam chest is cast with the cylinder in one piece, and the corresponding slide valve is worked in the usual way, from the

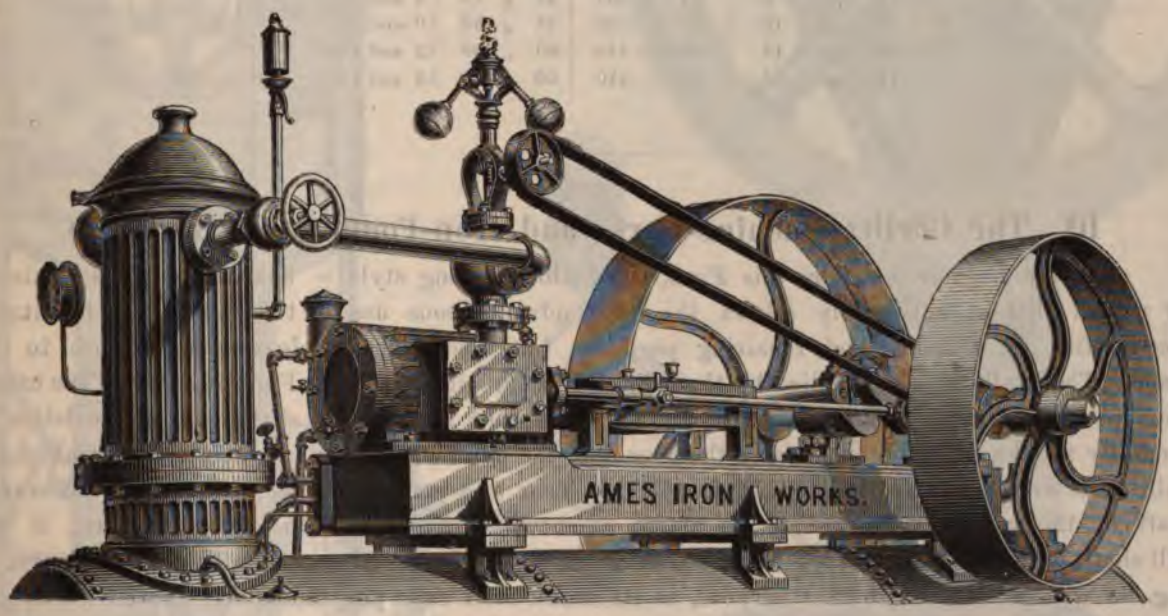


Fig. 63.

crank-shaft, by an eccentric. The throttle valvè is regulated by a Watt's governor, driven by belt from the crank-shaft; the slide valve spindle is steadied in the manner shewn by the forementioned guide-bars. The steam ports are worked with one slide. The piston is constructed in the customary manner with metallic packing rings, and the ordinary connecting rod construction is likewise retained. The two driving pulleys are mounted on the crank shaft as shewn. The cylinder is carefully clothed in felt, and furnished with metallic lining. The feed pump is arranged on the opposite side of the cylinder steam chest, and is worked direct from the slide-block. We may here observe, that though this method of running the pump is certainly the simplest, yet it is adopted by comparatively few engine-makers, because when the engine is running at high speeds, the pump piston is bound to agree with the slide-block in velocity, when the pump is apt to jar and knock with each successive stroke. The feed pump is double acting with clack-

*) Communicated to "Iron" d. 30 Nov. 1878, page 677.

valves; the water in the inlet pipe is always kept open to prevent the pump from drying up, whilst the feed into the boiler is regulated by a second pipe. The relative proportions of the engine working parts are given in the annexed Table, which likewise indicates that these engines are made in eleven different sizes, varying from 3—40 horsepower.

Sizes.	Horse-power.	Cylinder diam. in in.	Stroke in in.	Revs. per minute.	Fly wheels	
					Diams. in in.	Face in in.
0	3	$3^1/_2$	6	250	9 and 20	$3^1/_2$
1	6	5	10	175	24 „ 40	5 and 6
2	8	6	10	175	40 „ 40	6
3	10	7	10	175	30 „ 42	8
4	12	8	10	175	30 „ 44	8
5	15	8	12	150	30 „ 48	8 and 10
6	20	9	12	150	40 „ 54	8 and 12
7	25	10	12	150	44 „ 54	8 and 12
8	30	10	16	130	48 „ 60	10 and 12
9	35	11	18	110	60 „ 60	12 and 12
10	40	12	18	110	60 „ 72	12 and 15

10. The Görlitz Machine-works and Iron-Foundry, of Görlitz.*)

In the Engines built by this Firm, the hollow casting style — box-pattern — is retained, for reason that it not merely allows the most advantageous use of the metal, and facilitates accessibility for cleaning and repairing purposes, but also gives a pleasing appearance to the design. The Wall-engines supplied by these Engineers, are illustrated in Figs. 64 and 65. The crank shaft of such engines is almost invariably coupled to the mill-driving shaft, and as the latter is generally fitted a good distance above the floor-line, the cylinder is arranged below the crank-shaft. Mill-shafts driven by wall engines, generally run near and parallel to the wall, hence the crank-shaft of the engine will have to be placed as shewn in Fig. 64. On the other hand, if the mill-shaft to be driven, is fixed to the ceiling or to a column, then the wall-engine shewn in Fig. 65 will be adapted to this purpose, as its crank-shaft runs perpendicularly to the wall.

Taking a constant cylinder cut off at $^7/_{10}$th. stroke, and a steam pressure of 6 atm., these wall-engines are built in the following sizes:

Working capacity { Normal	2	3	5	6
Working capacity { Indicated	2.5	3.5	5.5	6.5
Cylinder diameter in in.	4.32	5.11	6.29	6.88
Stroke in inches	7.08	7.87	9.84	11.81
Revolutions per Minute	180	180	150	125
Piston-speed per Sec. in ft. in.	3 ft. 6 in.	3 ft. 11 in.	4 ft. 1 in.	4 ft. 1 in.
Flywheel diam. in ft.	2 ft. 1 in.	2 ft. 7 in.	3 ft. 3 in.	4 ft. 1 in.
Approximate engine-weight in cwts. ..	6.8	7.8	16	18

*) By a printer's error, an omission occured in Vol. 2 in the description of the Horizontal Condensing-Engine fitted with Collman valve-gear and illustrated on Plate 55 of our second volume. As this engine was made by the Firm here alluded to, we may make good this omission by now observing that the Collman-valve gear is somewhat modified by the "Görlitzer Maschinenbau Anstalt and Eisengiesserei". The transverse section of the cylinder represented in Fig. 1 (Plate 55) gives evidence of the altered arrangement of the valves and of the motion-gear. The exhaust valves are driven by cams and lever combination. But, as in the Collman arrangement, so also in the present, the motion of the exhaust

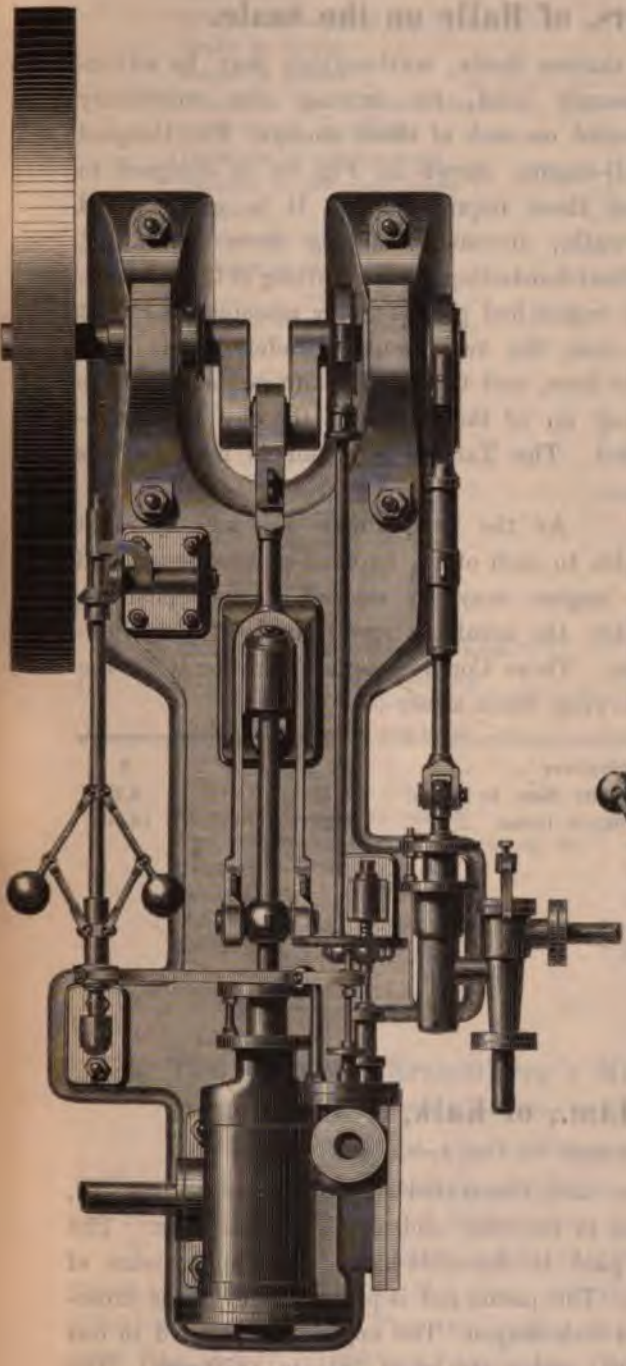


Fig. 64.

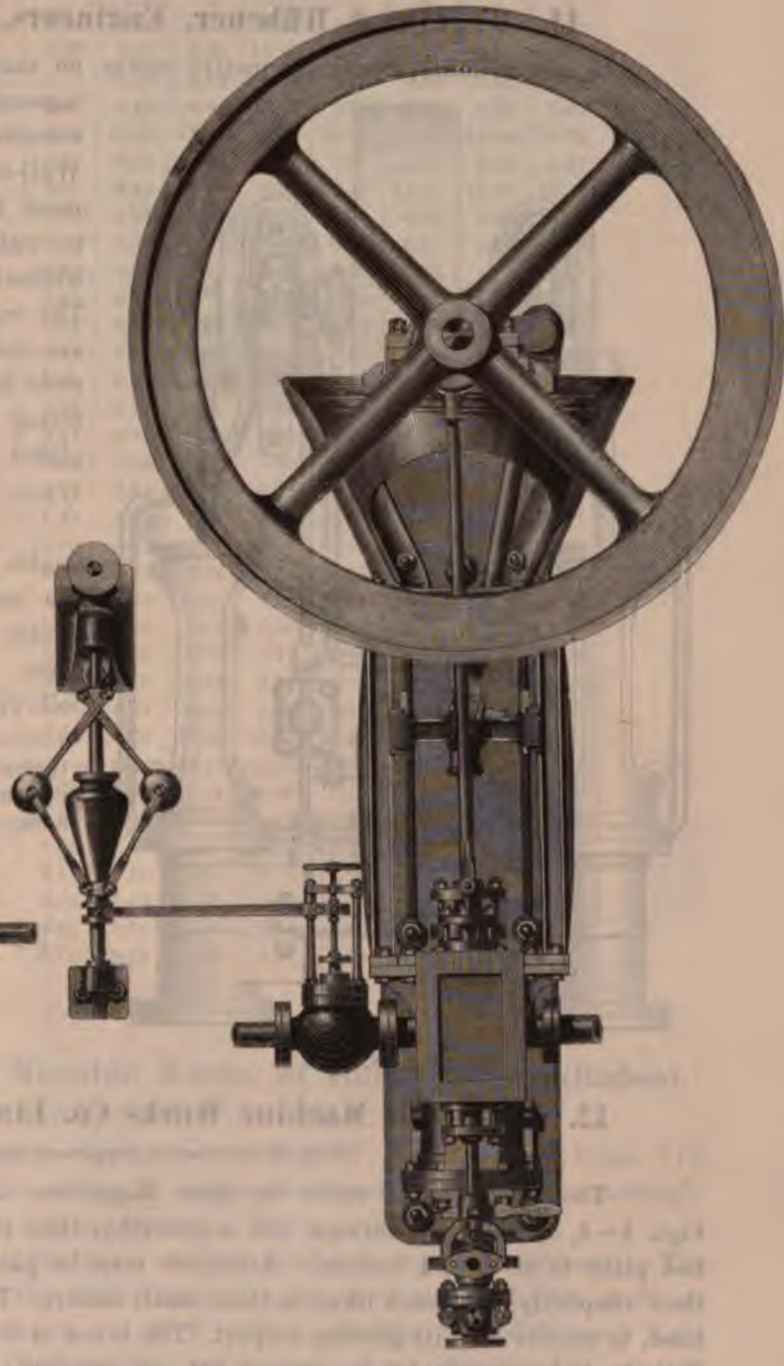


Fig. 65.

valves may be derived from the inlet eccentric, whereby the altered position of the valves do not demand extra gear. Again, by giving the cams suitable forms, the working of the exhaust valves is brought more under command.

In the admission-valve mechanism, the knee-lever, shewn on an enlarged scale in Fig. 8 (Plate 55) is alone altered, as this illustration fully corroberates. The Collman valve-gear is being introduced in this Country by Messrs. Appleby Bros., Engineers of London.

11. Wegelin & Hübener, Engineers, of Halle on the Saale.

In certain mills, requiring motive power on various floors, wall-engines may be advantageously used, for driving the machinery situated on each of these storeys. The Coupled Wall-engine, shewn in Fig. 66 is designed to meet these requirements. It is easily fixed to walls, in sizes varying from 4—8 *HP*, without demanding extra strutting of the columns. The engine-bed plate is very massive, and to it are cast, the two front cylinder covers, the slide bars, and the crank-shaft pedestals. The fitting up of the engine is thereby much simplified. The Tangye governor is used in this type.

As the two cranks are set at right angles to each other, no dead-centres occur, and the engine may be started in any position, whilst the resulting speed is kept very uniform. These Coupled-engines are built in the following three sizes:

Horsepower	4	6	8
Cylinder diam in inches	4.13	5.11	6.29
Stroke in inches	8.26	10.23	12.60

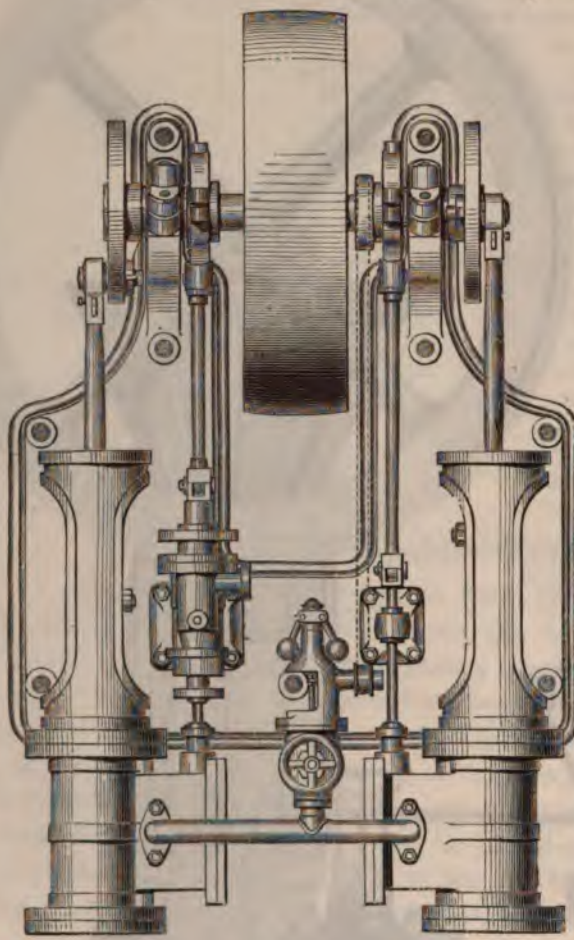


Fig. 66.

12. Humboldt Machine Works Co. Lim., of Kalk, near Cologne.

(With illustrations on Supplement-Plate VI, Figs. 1—4.)

The Wall engine made by these Engineers, and illustrated on Supplement-Plate VI, Figs. 1—4, is in its appearance less noteworthy, than in its solid and simple construction. The bed plate is of the ∩ section. Attention may be paid to the slide-bars, which on account of their simplicity, are much liked in these small motors. The piston-rod is prolonged over the cross-head, to receive here its guiding-support. The latter is fork-shaped. The engine represented in our Figs. 1—4, has a cylinder-diameter of $10^1/_4$ in. (260 mm.) and a stroke of $18^1/_2$ in. (470 mm.). The advance-angle = 28°. Piston, and slide-rod with its bolts, are of steel. The slide-valve and its sliding-surface are of the form shewn in Fig. 4.

The annexed Table gives the chief dimensions adopted in the construction of these Engines:

Horse-power	1	1.5	2	2.5	3	4	5	6
Cylinder diameter in in.	4.25	4.72	5.11	5.51	5.90	6.49	7.00	7.40
Stroke in. inches	7.87	8.66	9.45	10.23	11.02	12.60	13.39	14.17
Height of piston	1.77	1.97	2.13	2.28	2.52	2.76	2.95	3.15
Breadth of the (2) piston rings	0.39	0.43	0.47	0.47	0.51	0.59	0.63	0.67
Inside length of cylinder	9.84	10.82	11.81	12.79	13.78	15.75	16.73	17.72
Thickness of cylinder-metal	0.47	0.51	0.51	0.55	0.59	0.63	0.63	0.67
Diameter of the cover-flanges	8.07	8.81	9.29	9.92	10.47	11.41	12.20	12.75
Thickness " " " "	0.59	0.63	0.63	0.71	0.71	0.79	0.87	0.87
Cover-bolts; diameter of Cylinder-	0.47	0.47	0.59	0.59	0.71	0.71	0.79	0.79
Diameter of piston-rod	0.79	0.87	0.94	1.02	1.10	1.18	1.26	1.34
" " connecting-rod	0.63	0.71	0.79	0.87	0.94	0.98	1.06	1.10
Width of steam supply-pipe	0.83	0.94	1.02	1.10	1.18	1.30	1.42	1.54
" " " exhaust "	0.06	1.22	1.30	1.42	1.54	1.69	1.85	1.97
Width of ports a	0.39	0.43	0.43	0.47	0.47	0.91	0.91	0.55
" " " a_0	0.79	0.87	0.87	0.94	0.94	1.02	1.02	1.10
" " bridge b	0.47	0.51	0.51	0.55	0.55	0.59	0.59	0.63
" " cavity w	1.42	1.58	1.58	1.65	1.65	1.81	1.81	1.89
" " lap d	0.75	0.81	0.81	0.89	0.89	0.96	0.96	1.04
Length of steam ports	1.42	1.65	2.21	2.21	2.24	2.56	2.87	3.11
Area of ports a in sq. in.	0.55	0.73	0.96	1.03	1.05	1.31	1.47	1.70
Valve-travel in inches	1.14	1.26	1.26	1.34	1.34	1.46	1.46	1.61
Diameter of the eccentric	4.25	4.64	4.64	4.91	5.31	6.14	6.14	6.69
Width " " "	0.83	0.83	0.94	0.94	1.06	1.06	1.18	1.18
Diameter of the cylinder leg bolts	0.59	0.59	0.71	0.71	0.79	0.79	0.87	0.94
" " " cross-head pin	0.71	0.79	0.83	0.91	0.98	1.06	1.14	1.22
" " " crank-pin	0.83	0.94	1.02	1.10	1.18	1.30	1.42	1.58
Length of the crank-rod in in.	19.69	21.66	23.62	25.59	27.56	31.50	33.47	35.43
Diams. " " " "	0·83–1·02	0·94–1·18	1·02–1·30	1·10–1·38	1·18–1·10	1 30–1·58	1·42–1 77	1·54–1·89
" " " crank shaft	1.77	1.97	2.13	2.28	2.48	2.72	2.91	3.11
Fly-wheel diam. in ft. and in.	3 ft. 2 in.	3 ft. 6 in.	3ft. 10in.	4 ft. 1 in.	4 ft. 5 in	4ft. 10in.	5 ft. 3 in.	5 ft. 7 in.
Sectional area of fly-wheel rim in. sq. in ..	4.88	6.03	7.07	8.21	9.41	11.26	13.12	13.82
Height of bed-plate	2.13	2.36	2.56	2.76	2.95	3.23	3.47	3.70
Breadth " " "	2.52	2.83	3.07	3.31	3.54	3.86	4.17	4.40
Thickness of bed-plate	0.63	0.71	0.77	0.83	0.89	0.98	1.04	1.10
Diameter " foundation-bolts	0.71	0.79	0.87	0.94	1.02	1.10	1.18	1.26

13. The Prince Fürstenberg's Machine Works, of Immendingen (Baden).

(With illustrations on Supplement-Plate VII, and Figs. 1—5.)

The Double inclined-cylinder Engine, represented in Figs. 1—5 (Supplement-Plate VII) working on to one crank shaft, is adapted to driving an independent machine direct, and accordingly our illustration shews a 6—8 horse-power engine, driving a Printing-machine.

The cylinder diameter is 7·67 in. (195 mm.) and the stroke = 9·45 in. (240 mm.). The steam-pressure is taken at $3^1/_2$ atm., and the engine cuts off at $^9/_{10}$ths stroke, and runs at 90 revolutions per minute. The two engine-frames are of **I** section, standing 4·13″ (105 mm.) high, with ribs of 0·47 in. (12 mm.) thickness. Both engines are worked off one eccentric-disc, so that one of the rods is hinged on to the disc, as clearly shewn in Fig. 3 (Plate VII). Owing to the one-sidedness of the advance angle (= 15°), a small inaccuracy occurs, which is however not heeded, as the flywheel (of 242 lbs. = 110 kg. weight) corrects any irregularities in the engine-speed. The eccentricity = 1·18 in. (30 mm.). No inner lap has been given; outer lap = 0·35 in (9 mm.) and the advance (corresponding with the dead-centre) = 0.

$$\left.\begin{array}{l}\text{The sectional area of the steam admission-port} = \frac{1}{18{\cdot}9} \\ \text{,, ,, ,, ,, ,, ,, exhaust- ,, ,,} = \frac{1}{12{\cdot}5}\end{array}\right\}\text{ of the cylinder bore-area.}$$

The cranked main-shaft is 2·95 in. (75 mm.) at its bearings, being reduced to 2·60 in. (66 mm.) diam. at the connecting-rod coupling. At one end of the main-shaft, the flywheel (33·08 in. = 840 mm. diam.) is keyed on, whilst the other end, carries a pinion of 7·43 in. (189 mm.) diam. (3·54 in. = 90 mm. on the face, and 1·65 in. = 42 mm. pitch) which gears into a circular rack of 3 ft. 8 in. (1125 mm.) diam.; this rack being turned on its rim, adapts itself as a strap-pulley, when so required.

The locomotive slide-bar arrangement is here retained. The crosshead pins are 1·18 in. (30 mm.) diam. and the connecting rod diameters = 1·30 in. (33 mm.). The front cylinder-covers are provided with extra metal at the stuffing boxes, for fixing the slide-bars, which are secured at their other extremities by cast iron-straps, bolted to the engine frame. The width of the slide-bars = 2·95 in. (75 mm.), and their thickness in centre and at their strengthened ends = 1·77 in. (45 mm.).

The engine-frames are connected together, and the whole is bolted down by six bolts of 1·18 in. (30 mm.) diam. to the foundation.

14. Joseph Evans & Sons, of Wolverhampton.

The accompanying woodcut Fig. 67 represents a 14 horse-power High-pressure Engine, fitted

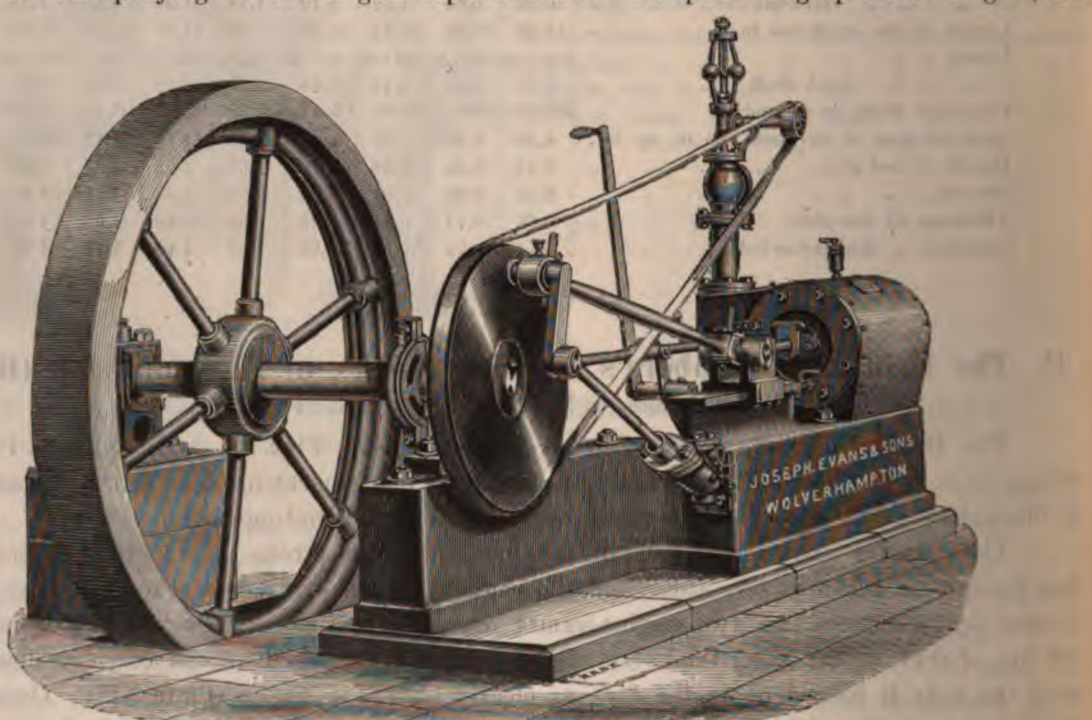


Fig. 67.

with Pickering's high-speed governor, of which Fig. 68 gives an enlarged view. The form of the bed is characteristic, and the same remark applies to the idea of using the crank-disc as governor driving pulley, and to working the feed pump from a counter-crank. The slipper guide is cast with the bed, and the cylinders are jacketed. The slide valve is worked by a separate eccentric, arranged to cut-off at two thirds the stroke. The piston rod, connecting pins, etc. are of steel, and the moving parts are made adjustable to take up wear. They are made in the following sizes:

Nominal Horse Power	3	4	6	8	10	12	14	16	20	22
Diameter of Cylinder .. inches	$5\frac{1}{2}$	$6\frac{1}{2}$	8	9	10	11	12	13	14	15
Length „ Stroke .. inches	10	12	16	18	20	22	24	26	28	30
Revolutions per Minute	144	120	90	80	72	65	60	55	50	48
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Diameter of Fly-Wheel	3 3	4 0	4 6	5 0	5 6	6 0	6 6	7 0	8 0	9 0
Weight „ „ „ approx. cwts.	4	7	10	14	20	22	24	28	35	40
Diameter „ Shaft .. .. inches	$2\frac{3}{8}$	$2\frac{7}{8}$	$3\frac{3}{8}$	$3\frac{5}{8}$	$3\frac{7}{8}$	$4\frac{1}{8}$	$4\frac{3}{8}$	$4\frac{5}{8}$	$4\frac{7}{8}$	$5\frac{1}{8}$
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Length of Shaft	3 0	3 6	4 0	4 6	5 0	5 6	5 6	5 6	6 0	6 0
Diameter of Steam Pipe .. inches	1	$1\frac{1}{2}$	$1\frac{1}{2}$	2	2	$2\frac{1}{2}$	$2\frac{1}{2}$	3	3	$3\frac{1}{2}$
Diameter of Exhaust Pipe inches	$1\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4

In designing the governor, it was sought to obtain the requisite centripetal force and stiffness without making the springs too heavy. It consists in the peculiar construction of the spring, and also in the shape of the curve given it, by the manner in which the ends and middle portion are secured, so as to keep those parts at all times parallel with the centre of motion. By this arrangement, steel can be used so thin, that all liability to break, or tendency, to "set," or lose its elasticity, is dispensed with; while, by using two or more strips together, the required centripetal force is secured. The peculiar curve obtained by this arrangement is called a double cyma, by the use of which, two or more strips, firmly secured together, will work freely, without any tendency to buckle or interfere with each other's action.

Fig. 68.

As may be seen by the engraving, the ends of the springs are secured to flanges, the lower of which, — resting on steel washers, and having a collar to prevent its rising, — is capable of only a rotatory motion, while the upper one, being at liberty to move lengthwise as well as to rotate, receives its rotatory motion from the lower one, through the springs, and communicates any lateral motion due to the varying centrifugal force immediately to the balanced valve, to which the Governor is firmly secured by the bracket, a part of which forms a long bearing for the horizontal spindle, which communicates motion from the power to the Governor through the mitre gearing. These governors have an arrangement for shutting off the steam instantaneously in the event of the governor belt failing. The arrangement consists of a jockey-pulley carried by a lever arm, so that it rests on the governor belt, a breakage of the belt allowing this pulley and arm to fall, and by so doing disengaging a spring, which at once closes the throttle valve.

15. West & Co., of London.

The so called "box-engines", for which a certain demand has now sprung up, are well adapted to direct driving purposes, owing to the uniformity of their motion, and their high speeds. To attain this evenness of running, by balancing the moving parts, these engines are provided with several cylinders, often working on the Wolff or Compound principles. The West Rotary Engine, here illustrated in Figs. 69—72 makes an exception however to our last remark, inasmuch as all the six cylinders placed side by side, are equal-sized and are supplied with live steam; the valve gear in each of the cylinders, may be looked upon as consisting of a slide valve moved by one eccentric.

The engine rests on a bed-plate carrying a box-casting, in which the six equal cylinders are arranged round a circle. The piston *A* of each cylinder, which is made as light as possible, carries a conical end-piece, which always remains in contact with the disc *B*. The latter is mounted on the axle *F*, the one end *D* of which is ball-formed, whilst its other end, runs in the crank *G* keyed to the main-shaft *H*. The piston-pressure is partly taken up by the ball-formed pin *D*, and partly by the rolling acting of the disc *B* on to the turned conical surface *E* of the cover. Three of these single acting pistons are constantly at work, so producing a uniform rotation of the shaft *H*. As no dead-centres appear in this construction, no fly-wheel is required.

The arrangement of the valve-gear may be seen on referring to Figs. 70—72. Only one eccentric *I* is used and it is keyed on the shaft *H*. It is surrounded by a loose ring, rigidly connected to an outer ring *K*. This ring, which acts as a slide-valve on each of the steam-ports, is formed by two angular rings, the opposite flanges of which are pressed steam-tight either against the steam-ports or against the cover, by the steam-pressure existing in the steam-space *C*. The live-steam enters at *L* into this space *C*, whilst the spent steam passes out through the chamber *M* into the inner part of the casing, and thence on to the exhaust pipe *N*. The pistons can rotate round their axis, whereby an even wear of their disc-surfaces is ensured. Fig. 72, gives us an insight into the arrangement of the steam-ports, and of the exhaust-ports and crank *G*, whereby the cover *E*, disc *B*, and piston *A* are presumed to have been removed. Practice has shewn the weak part of this construction to be the disc *B*, which owing to the pressure of the pistons on to its surface, has been broken. These six-cylinder engines are built in the following minimal- and maximal-dimensions:

Indicated HP. (piston speed 5 ft.; cut-off 1/2 stroke)		Revolutions (piston-speed 5 ft.)	Cylinder diameter.	External diameter of engine.	Weight in cwts.
steam-pressure 3 atm.	steam-pressure 5 atm.				
3	5 1/2	720	2 in.	11 in.	1 1/2
87	152	223	10 in.	3 ft. 2 in.	34

16. Horizontal Engine-types.

Under this heading, we propose discussing various engine constructions, which owing to the repetition of many of their characteristic peculiarities, are best treated under one section.

The different forms given to engine-beds, are one of their characteristic features, and ac-
ing to the latest practice, the requirements which are placed on this constructive portion, are

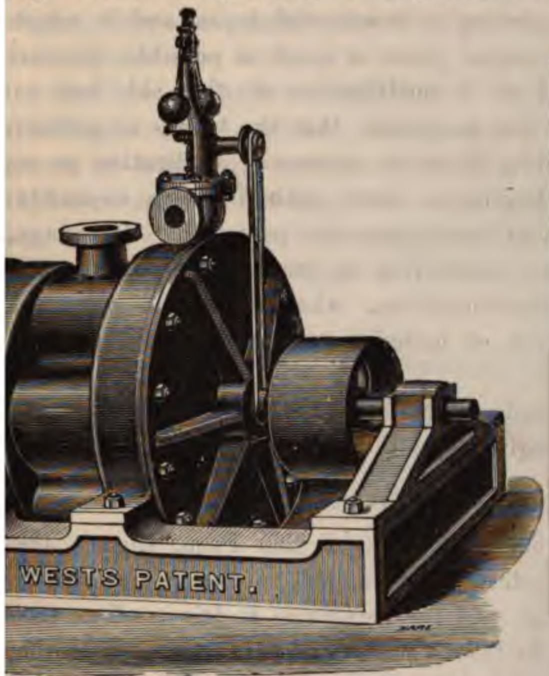


Fig. 69.

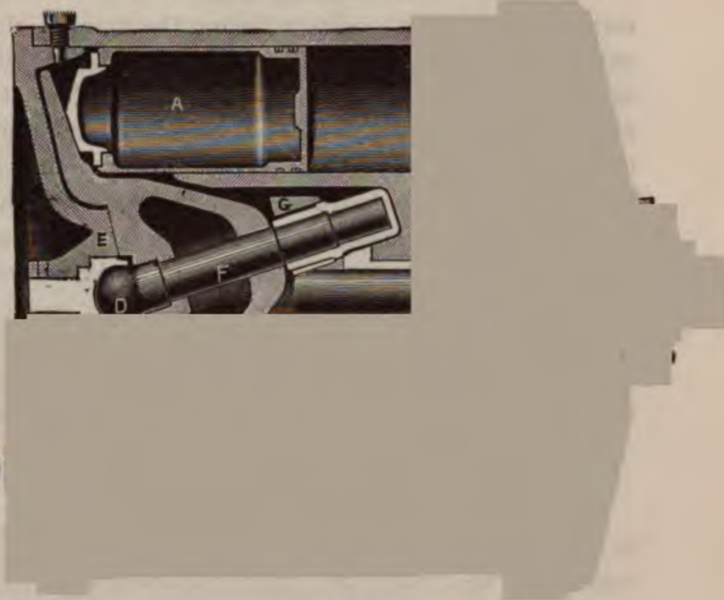


Fig. 70.

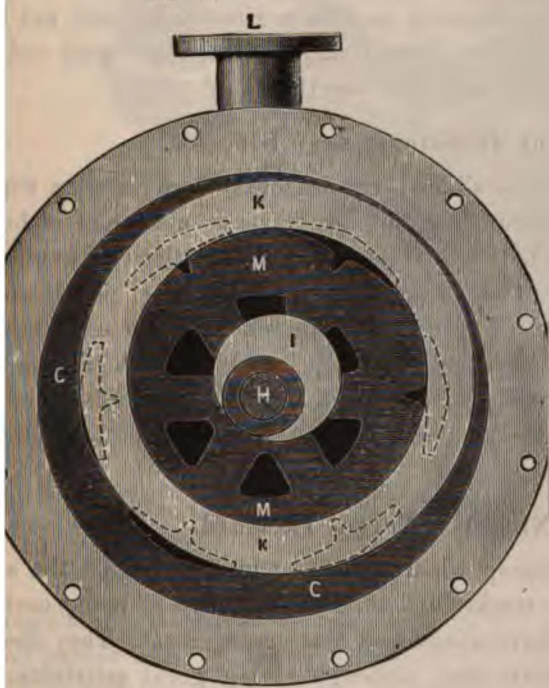


Fig. 71.

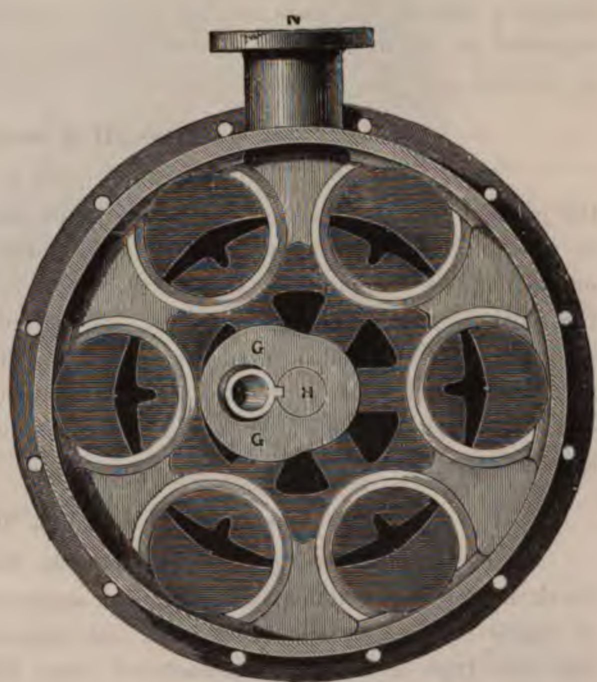


Fig. 72.

they should both serve as a support to the various engine-parts, and combine solidity, and be rigidly
ed on their foundation; for this reason, the most solid frame construction, recommending itself

in particular to the larger engine-sizes, is the one, in which the bed is allowed to rest with its entire base, on the masonry foundation.

In the small engines, known as of the exporting or commercial types, and in which primary importance is paid to reducing the number of engine parts as much as possible, the carrying out of this forementioned consideration, has led to a modification of the old box-pattern bed, under due regard to aesthetic forms. Thus it has happened, that the trunk- or girder-frame which was first introduced on Corliss-engines, rapidly found an increasing application on engine-types to which it appeared less adapted. Some Engineers, have with a lavish expenditure of metal added the semi-trunk to the box-bed, without obtaining any perceptible advantage, for not only is much metal so lost in their box-beds — answering no purpose — but many of their horizontal engine types still require separate stone-foundation, wheel-race, and extra outside pedestal support, whereas this extra labour and cost of material are not incurred in our best engine-building practice.

We will begin this section with a few examples taken from the practice of some of those Engineers, who show the so-called box-pattern. Beginning with the firm of:

a. W. Tasker & Sons, of Andover.

The horizontal engines (built in 9 sizes from 4—20 *HP.*) of this Firm, show *) the flat box-pattern bed. The cylinder and crank shaft pedestals are bolted to the latter, which also carries the slide-bar end. The main-shaft is cranked, and the feed-pump is driven off an eccentric from this shaft, which is made of sufficient length to take a pulley on either side. These engines are controlled by a Watt's governor, driven by strap- and bevel-gear. It is a pity, that the constructive refinements, such as they present themselves in more modern engine-types, have not been regarded in the design now under discussion, or else we should find the castings much reduced in number, and the working centres more immutably connected together.

b. John Mac Dowall & Sons, of Johnstone, near Glasgow.

These Saw-mill Engineers, have made a simple slide-valve horizontal high-pressure engine, the general design of which seems neatly proportioned. The flat box-frame is used, and is bolted to the foundation by eight bolts. The cylinder is bolted to this bed, and has the feed-pump cast outside it, on the opposite side of the valve-box. This pump, placed horizontally, is driven off the motion-block. The motion-bars are bolted to the engine frame on separate end-supports. The one crank-pedestal used, is made on the improved angle principle, which allows the solid part of the block to receive the thrust at each centre. The flywheel is massive, and the Watt's governor is used to control the engine-speed. These engines are built in ten different sizes ranging from 4—56 horse-power.

c. Chas. Burrell & Sons, St. Nicholas Works, Thetford.

These Engineers, recognising that the feed-pump when worked at high-speeds off the slide-block is apt to jar and knock with each successive stroke, and that the retention of many castings in engine-building entails extra work and expense, have abandoned this arrangement. They observe that this type of engine, manufactured some 25 years ago, although giving great satisfaction at that time, is now quite out of all modern practice. Consequently they are now making Horizontal

*) Vide their Catalogue No. 76. — **) Vide their Catalogue d. 1876.

Engines of a type in which the bed-plate, crank shaft-bearing, front cylinder cover, and guide-bars, are all in one casting, with the cylinder overhung. The governors are high speeded, and the engines have disc cranks and are made from 6 *HP.* to 25 *HP.* singly or up to 50 *HP.* if coupled in pairs.

The bearings and wearing surfaces are very large; the guide-blocks are adjustable. The eccentric-bands are of cast-iron with wide surfaces. The force pumps are of short stroke, and are drawn by a separate eccentric, and all pump valves are of large diameter, and low lift, and with spiral wings, so that they revolve partially with every stroke of the pump. The connecting-rod has solid small end with brass adjustable by a wedge, and lock nuts, and at its large end has a square brass, with let-in solid wrought iron head, such as is adopted by many leading locomotive builders.

d. The General Engine & Boiler Co., of London.

If the horizontal engine-type designed by this Company, as shewn by our Fig. 73 is unique in design, it shares the advantage of simplicity and forms an ever rigid unyielding support for the various moving parts of the engine. This last-mentioned advantage is gained by the strong

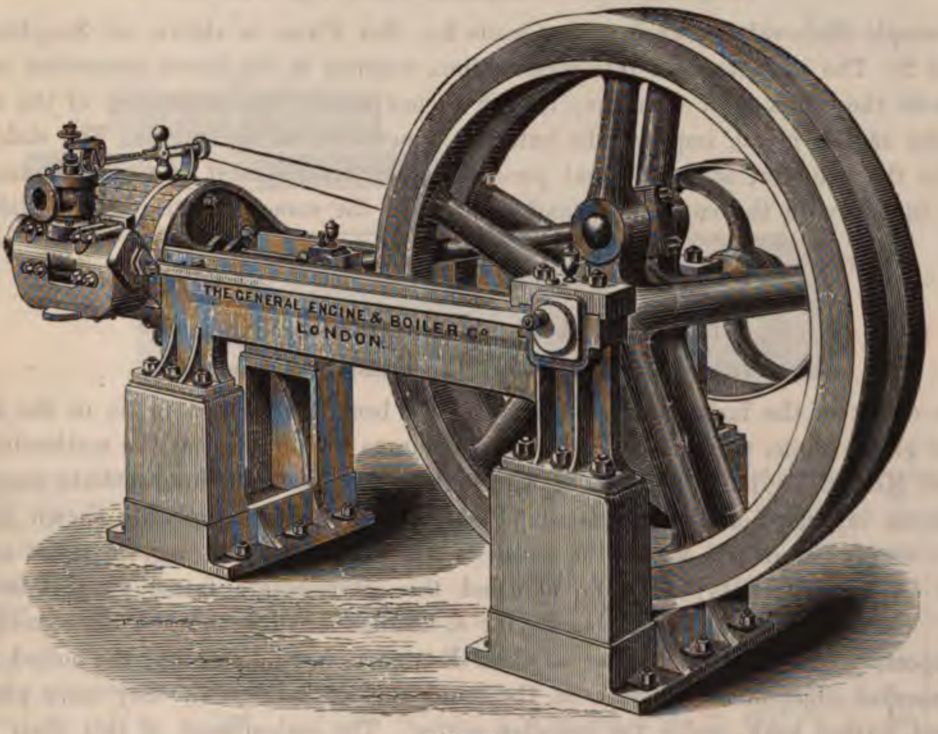


Fig. 73.

rectangular engine frame adopted, and in this example we find again the front cylinder-cover, the slipper-guides and the main-shaft bearings, comprised in one casting, which casting is however bolted to cast-iron legs. These standards are recommended, for raising the engine, to avoid the necessity of a fly-wheel race. The distribution of the steam is effected by a cylindrical piston slide-valve.

An additional peculiarity in this engine, is the employment of two fly-wheels; by counterweighting these two wheels, the reciprocating parts are carefully balanced, and the engine is thereby adapted to high-speeds. The cylinders are steam-jacketed, and are neatly cased to prevent heat-radiation. To these engines, the commercial name of "Express-engines" has been given, and they are recommended by the makers for use, when from 2—20 horse-powers are required. In the following table of dimensions, the nominal horse-power is taken to be such that the engines exert about the same actual power, as ordinary engines. The indicated horse-power is calculated with steam of 50 lbs. pressure and cut-off at about half-stroke.

Nominal Horse-power		2	3	5	7	9	12	16	20	25	35
Indicated „ „		3	5	8	13	17	24	33	45	60	85
Diameter of cylinder	in.	3½	4½	5½	6½	7½	8½	10	12	14	16
Length „ stroke	in.	5	6½	8	10	12	14	16	20	24	28
Revolutions per minute		300	270	250	220	200	270	150	120	100	85
Diameter of Main-shaft	in.	1¼	1½	2	2¼	2½	2⅞	3½	4¼	5	5½

e. Alexander & Sons, Engineers, late of Cirencester.

(With illustrations on Supplement-Plate I, Figs. 1 and 2.)

A simple Slide-valve geared engine made by this Firm, is shewn on Supplement-Plate I (Figs. 1 and 2). The advantage of this construction, consists in the direct connection of the steam-cylinder, with the crank-shaft bearings, though to our mind, the shortening of the engine-trunk would besides saving metal, improve the external appearance of the engine. The slides are bored concentric to the cylinder, and somewhat peculiar is the arrangement of the feed-pump, which is shewn cast in one with the engine-bed, and worked off the same eccentric as the slide-valve.

f. Taylor & Challen, of Birmingham.

(With illustrations on Supplement-Plate I, Figs. 5 and 6.)

The defect of the last-mentioned example, has been pronounced to lie in the bending tendency of the girder-frame, which is apt to occur, owing to the pressure of the motion-block upon it. This induced Messrs. Taylor & Challen of Birmingham, to place an intermediate support for the frame as shewn in Figs. 5 and 6 (Supplement-Plate I). Practice has probably shewn this supposed defect to be merely imaginary, where the trunk is made sufficiently strong, to resist such bending strains, for in the latest types we do not find this intermediate frame support invariably re-introduced. Certain it is, that Messrs. Taylor & Challen have somewhat abandoned the intermediate support, yet recognising as several other Engineers have done, that the bolted overhanging cylinder presented objectionable strain on the trunk and cylinder-joint, they have placed the cylinder-support further back, under the cylinder centre. The embodiment of this their latest practice is shewn in Figs. 74 and 75 giving elevation and plan of one of their horizontal-engines, but as this engine works with a separate expansion-valve, we will merely now draw attention to the altered engine-frame, and confine our present description to the engine shewn on Supplement-Plate I. The cylinder is made of hard strong close grained metal, and the cross-head and crank-pin bushes are adjustable. The governor is driven by bevel-gear straight off the crank-shaft, and is of a high-speed sensitive class; it can be set to work at different speeds, and it operates on an equilibrium valve. The piston is fitted with metallic packing adjustable by springs. The guide is circular, and is bored exactly in line with the cylinder. These engines are fixed to their foundation by six hold-down bolts, and they are made to the following

Fig. 74.

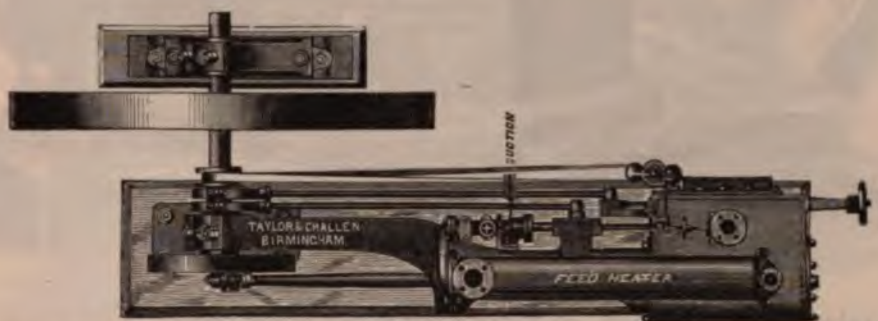


Fig. 75.

dimensions:

Nominal horse-power	$2^1/_2$	4	6	10	15	20	30
Diameter of cylinder in inches	5	6	8	10	$12^1/_2$	15	18
Length „ stroke „ „	10	12	16	20	24	30	36
Revolutions per minute	175	150	120	100	85	70	60
Diameter of fly-wheel in ft.	$2^1/_2$	3	$4^1/_2$	6	8	9	10
Width „ „ „ „ inches	$2^1/_2$	$3^1/_4$	$5^1/_2$	$6^1/_2$	8	9	10
Weight „ „ „ „ cwts.	$2^1/_2$	3	$7^1/_2$	15	25	40	60
Diameter of crank-shaft in inches	2	$2^1/_4$	3	$3^5/_8$	$4^1/_2$	5	6
Length „ „ „ „ feet	3	$3^1/_4$	$3^3/_4$	$4^1/_2$	5	$5^1/_2$	6
From centre of shaft to back of cylinder in ft. and in.	4' 4"	5' 2"	6' 10"	8' 6"	10' 3"	12' 2"	14' 6"
Height to centre in inches	7"	10	12	14	17	20	24
Approximate total weight in cwts.	$5^1/_2$	9	25	47	63	90	150

g. W. N. Nicholson & Son, of Newark on Trent.

Nicholson & Son's so-called Universal Horizontal Engine, as illustrated in Fig. 76, has the cylinder, steam chest, and slide bars, formed in one casting, the cylinder and slide-bars being bored out at one setting to secure perfect alignment. To the end of the slide-bars, is bolted a Y-shaped casting carrying the crank-shaft pedestals which are of angular pattern; the lower part of this casting is formed with feet for bolting down to a feed-water tank, which is the only foundation required. The cylinder overhangs the end of the tank, and is supported only at the front end on a bracket cast with the tank, so avoiding any injurious strain, from unequal expansion. The slide valve is provided with slotted reversing disc. The governor is of the high-speed type acting direct upon

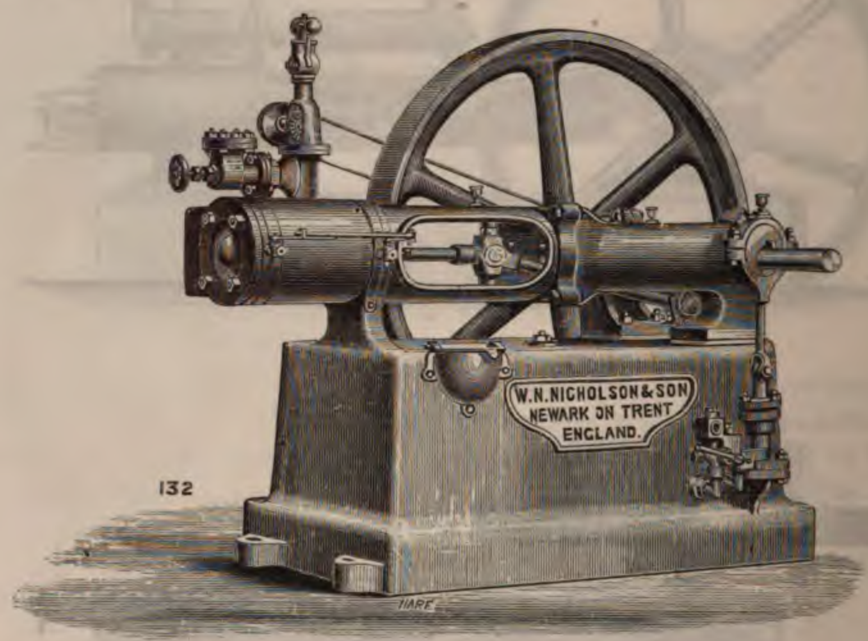


Fig. 76.

an equilibrium valve, with adjustment for varying the speed of the engine. Feed-pump is fitted with over-flow cock, suction-delivery and back-pressure valve, and heating pipe passes a portion of the exhaust steam into the feed-water. The crank-shaft passes through, to enable power to be taken off either side.

The same pattern of Engine when mounted on a Boiler, forms a Portable Engine; for this purpose, a flat topped saddle-bracket is attached to the Boiler, to carry the Y-shaped casting with crank-shaft pedestals, whilst the cylinder rests on a guide on the fire-box top to allow for expansion and contraction.

h. Robey & Co., of Lincoln.

A similarly designed engine frame to the one we noticed in Gibbon's engine — see pg. 24 — is reproduced in our Fig. 77, representing the horizontal engine-type made by Robey & Co., of Lincoln, though the cylinder is here supported in a more efficient manner. Our woodcut explains itself, so that we pass on to:

i. The Reading Ironworks, Lim. Reading.

In the construction of their horizontal "Reading-engine Class", (made in 5 sizes answering to 6, 8, 10, 12 and 16 nominal horse-power), these Engineers cast the bed-plate and main crank-shaft bearing in one piece. The cylinder as in the preceding examples is carried on a foot. The front cylinder cover and gland are formed in the bed-plate casting, as well as the guide bars. The guides of the cross-head virtually form four bars of equal width, and the cross-head

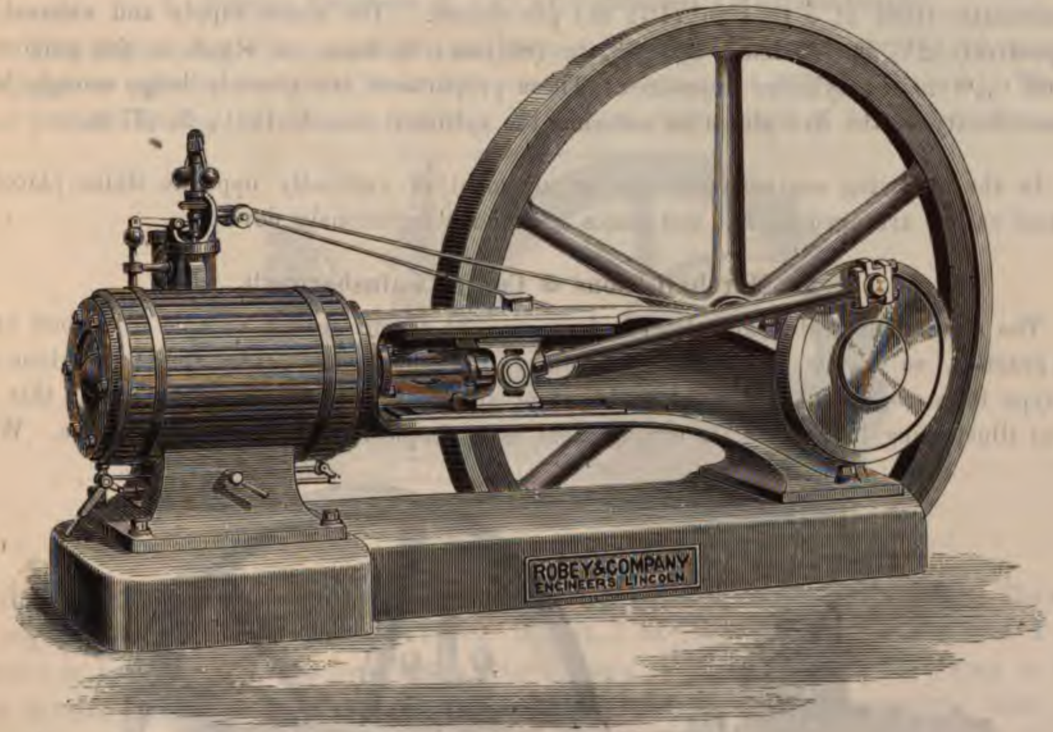


Fig. 77.

shoes are capable of adjustment, so as to keep the piston-rod in line, whichever way the engine runs. The bottom shoe is furnished with a catch-oil receptacle.

Characteristic, and in fact laudable is the feed-pump arrangement, the plunger of which is worked by a continuation of the slide-valve rod through a stuffing box in the end of the valve chest. Care is thereby taken to make the one eccentric rod specially strong to carry the extra work. The eccentric and strap are of cast-iron, and the Porter governor controls the throttle valve through the medium of a couple of segment wheels, one of which is adjustable on its axis.

j. A. F. Brown, of New-York.

(With illustrations on Supplement-Plate V, Figs. 5—7.)

An additional example of an horizontal engine fitted with girder frame is afforded by A. F. Brown of New-York, for a description of which we are indebted to Prof. Radinger's german report on the Philadelphia Centennial Exhibition. We illustrate it on Supplement-Plate V, Figs. 5—7, whence it will be seen that a very simple appearance is given to the engine by the wide trunk-frame hiding the valve-rods etc. The slides of the cross-head are trapezoidal in form, and made adjustable by wedges. The cast-iron crank is brought close up to its bearing, the originality of which is seen on referring to Fig. 5 (Plate V). The eccentric is arranged to lift out, and by means of a lay-shaft, the motion of this eccentric is brought closer to the cylinder. The long valve-chest has a divided slide inside. This 35 *HP* engine had a cylinder 12 in. (305 mm.) in diam. and a stroke of 2 ft. (610 mm.) and running at 84 revolutions per min. the mean piston-speed calculates itself at 5 ft. 7 in. (1·71 m.) per second. The steam supply and exhaust pipes, are respectively $2^1/_2$ in. (65 mm.) and $3^1/_8$ in. (80 mm.) in bore, or stand in the proportion of $^1/_{22}{}^{nd}$ and $^1/_{15}{}^{th}$ to the cylinder cross-area. These proportions are scarcely large enough, because the mean-velocity of the live steam on entering the cylinder exceeds $121^1/_3$ ft. (37 m.).

In the following engine-types, the arrangement of vertically opposite slides placed in a cylindrical casing arranged on flat bed-plates have been ingeniously devised.

k. Marshall, Sons & Co., of Gainsborough.

The engine illustrated and described on pg. 134 of our second Volume is a good example of this practice, so that we take this opportunity of referring the reader thereto. Alone as the engine-type there represented is fitted with patent automatic expansion-gear, we take this opportunity of illustrating in Fig. 78 its arrangement as a simple slide-valve geared engine. We may

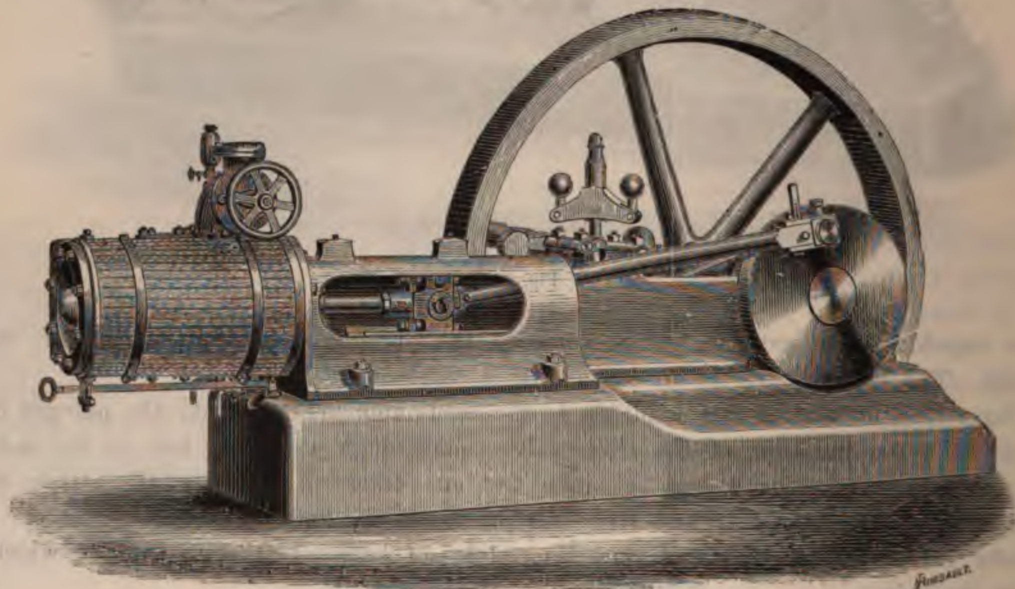


Fig. 78.

observe that the present design is a modification of an older design with box-bed pattern and inside crank. The cylinder is cast separate with an inner lining of very hard metal, which simultaneously forms the steam-jacket. The slide- and piston-rod are of steel, and the slipper block is made adjustable. The difference between this engine and the one previously illustrated in Fig. 163 (Vol. II) lies in the governor, and in the addition of an adjustable eccentric for obtaining variable expansion.

These engines are built in the four following sizes:

Horse-power	4	6	8	10
Cylinder diameter in inches	$6^3/_4$	$8^1/_2$	$9^1/_2$	$10^1/_2$
Stroke in inches	12	12	14	16
Revolutions per minute	125	125	110	95
Diameter of fly-wheel in ft. and in. ..	4 ft. 7 in.	5 ft. 2 in.	5 ft. 8 in.	6 ft.

l. Decker Brothers & Co., of Cannstadt (Württemberg).

This Engineering Firm constructs the horizontal engine, shewn in our Fig. 79, in one size, answering to a cylinder bore of 4·72 in. (120 mm.) and a stroke of 7·87 in. (200 mm). The engine runs at 180 revolutions per min., so throwing off a mean piston-speed of 3 ft. 11 in. (1·2 m.) per sec.

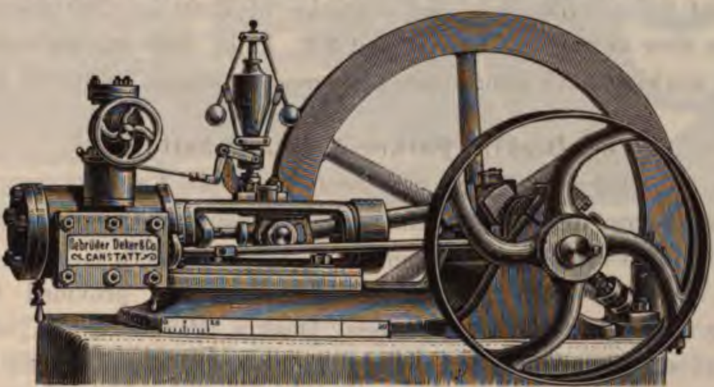


Fig. 79.

Its normal power, when working at 6 pressure over atm. in the boiler, amounts to 5 *HP.* The standing room required for the engine (incl. fly-wheel) is 5 ft. 7 in. (1700 mm.) in length and 2 ft. 9 in. (850 mm.) in breadth, and its approximate weight comes to $^1/_2$ ton (500 kg.). Owing to its solid design, greater powers can be obtained off these engines with higher steam-pressures; thus, working at $7^1/_2$ atm. pressure in the valve-chest, (corresponding to 8 atm. in the boiler) and cutting-off at $^7/_{10}{}^{\text{ths}}$ stroke, the engine would develop 8 *HP.* A working pressure of $3^1/_2$ pressure over atm. in the valve-chest, yields an engine-power of 3 *HP.*

m. T. Maude, late of the Lansdown Engine Works, Oldham.

(With illustrations on Supplement-Plate I, Figs. 3 and 4.)

Somewhat lighter in construction, than the preceding two examples, is the horizontal engine made by T. Maude, and illustrated by us on Supplement-Plate I, Figs. 3 and 4. The slides of the motion-bars are flat, and the two crank-pedestals are on the angle principle, the bed itself being fastened down by 6 hold-down bolts.

The following table gives the cylinder diameter and stroke of this engine-type in the nine different sizes to which it was built:

Horse-power	1	$1^1/_2$	2	$2^1/_2$	4	5	6	8	10
Cylinder diam. in inches ..	3	4	$4^1/_2$	$5^1/_2$	6	7	8	9	10
Stroke in inches	6	6	$8^1/_2$	$8^1/_2$	$10^1/_2$	12	12	16	16

n. The Maschinen- and Waggon-Fabriks Gesellschaft (formerly H. D. Schmid), of Simmering, near Vienna.

(With illustrations on Supplement-Plate V, Figs. 1—4.)

Borrowing our illustrations on Supplement-Plate V, Figs. 1—4, from "Riedler's Maschinen-skizzen", representing the Horizontal engine-type made by this Company, the specially solid bed-plate, resting with two broad surfaces on the foundation, is particularly attractive. Towards the cylinder-end, the bed is raised, to take up the overhanging cylinder, and to case the slipper-guides. The other end of the bed has the two pedestals cast on. An eccentric is keyed on each side of the crank, resulting in a symmetrical arrangement of the design, as the slide valve is thereby worked on the one cylinder-side, whilst feed pump is worked on the other side. This engine has a cylinder diameter of 6·5 in. (166 mm.) and a stroke of 12·60 in. (320 mm.); as its revolutions per minute = 85, the slow average piston speed of 2 ft. 11 in. (0·90 m.) per second results. Cutting off at $^3/_4$ stroke and working at 5 atm. steam-pressure, the engine is stated to develop 4 *HP.*

o. Deakin, Parker & Co., of Salford.

(With illustrations on Supplement-Plate I, Figs. 7 and 8.)

As in one-direction running engines, the vertical pressure of the slide-block exerts itself only in one direction, the double slide-bar arrangement is not absolutely needed in such constructive examples, and one slide-bar or slipper-guide is found ample, provided the sliding surfaces are made sufficiently large and strong. Messrs. Deakin, Parker & Co., of Salford, use this slipper-arrangement as shewn on Supplement-Plate I, Figs. 7 and 8, and fix it in the lower portion of the U bed-frame cast with the crank-shaft pedestals. The cylinder is of the overhanging type.

p. J. Korösi, of Andritz, near Gratz.

(With illustrations on Supplement-Plate V, Figs. 8 and 9.)

Our illustrations on Supplement-Plate V, Figs. 8—9, of Mr. Korösi's engine-type are taken from Riedler's Maschinenskizzen. The bed-plate extends under the full length of the engine, and is so designed as to allow itself to be bolted to the portable boiler-types. The cylinder bore = 4·63 in. (211 mm.) and stroke = 12·44 in. (316 mm.). The crank makes 85 revs. per min. so yielding a piston-speed of 2 ft. 11 in. (0·89 m.) per sec. Between the two crank-pedestals, we have an eccentric of 1·30 in. (33 mm.) eccentricity for driving the slide-valve on the one side, whilst on the opposite side, a second eccentric works the feed-pump of 3·15 in. (80 mm.) stroke, which is bolted to the engine bed. The diameter and face of the fly-wheel, adapted to belt-driving, are respectively 3 ft. 6 in. and 7·87 in. (1065 and 200 mm.).

q. W. H. Uhland, of Leipzig.

(With illustrations on Supplement-Plate II, Figs. 6—8.)

Some years ago, Mr. W. H. Uhland designed an engine type, which we represent on Supplement-Plate II, in Figs. 6—8. It was intended to adapt itself to small portable Engine- and boiler-arrangements. Its boiler stood on the engine-bed plate *A*. The prolonged piston rod simultaneously answers as pump-piston, and therefore the stuffing box of the feed-pump serves as motion guide to the steam piston. The piston-rod has consequently the fork-form over its entire length. A feed water heater is placed under the engine, which consists of a cast-iron casing, in which two copper pipes allow the feed-water to circulate.

r. Chaudré, of Paris.

The motion guide arrangement, adopted by Mr. Chaudré, of Paris, and represented in the

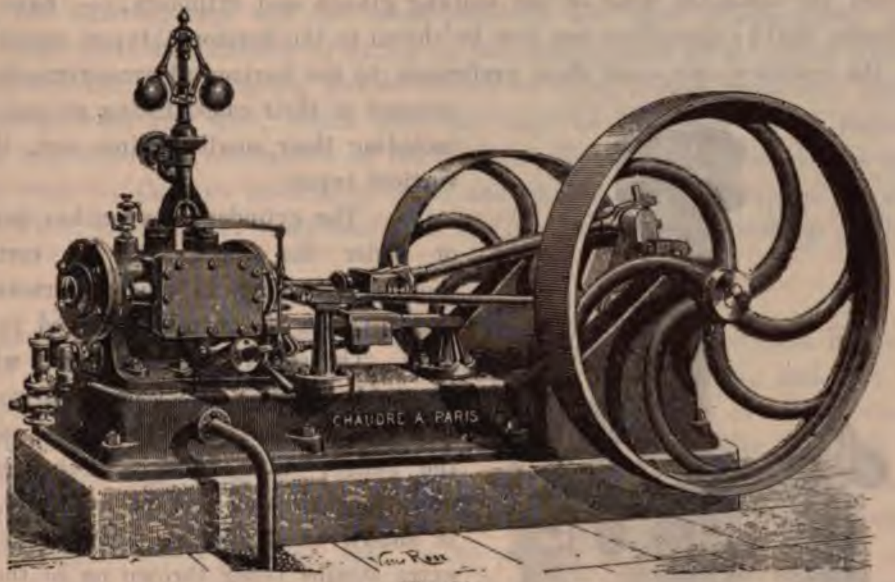


Fig. 80.

annexed Fig. 80, adapts itself to small steam-motors. It consists of a rectangular slide-bar upon the four longitudinal surfaces of which, the motion-block slides. This motion bar is supported in a very ungainly manner.

s. H. Flaud, of Paris.

(With illustrations on Supplement-Plate VII, Figs. 6—13.)

The Two-cylinder High-speed Engine of Mr. H. Flaud, of Paris, is shewn in Figs. 6—13 (Supplement-Plate VII). Running at 150 revolutions per minute it develops 30 *HP*, and is best suited to driving fans, pumps etc. Each cylinder is 9·84 in. (250 mm.) in diam. and 10·23 in. (260 mm.) in stroke.

The governor is fitted up horizontally, and is driven by belting. The governor spindle has a spiral-spring coiled round it, which with one end presses against a rigid collar, whilst its other end lies against the governor sleeve, so as to counteract in this manner the weight of the balls. This horizontal arrangement is preferable to the vertical governor, inasmuch as the vibrations, presenting themselves in upright spindles, are thereby avoided. The governor works on to a circular valve (detailed in Figs. 11 and 12), fitted in the steam-pipe *E*. The steam exhaust pipe is shewn at *F*.*)

17. Vertical Engine-types.

Vertical Engine-types share the advantage over horizontal arrangements, that the frame, connecting the cylinder with the crank-bearings, can be placed on one bed-plate, whose position enables it to receive the various strains thrown direct on to it; in addition, the uneven wear of the cylinder, due to bending of the piston-rod, or to the weight of the piston, does not take place in engines of the vertical type. These two reasons, impeded the more general introduction of the

*) Another novel form of Horizontal Engine is Messrs. Alex. Shanks & Son's so called "Anglian Engine", for an illustrated description of which, the reader is referred to "Iron" issue, d. 8 July 1881, pg. 40.

horizontal arrangement, until the using of solid bed-plates, rendered a bending of the latter an impossibility, whilst more careful construction and fitting up — if they have not entirely removed the one-sided wear of the stuffing glands and cylinders, — have still reduced wear to such limits, that no opposition can now be shewn to the horizontal types, especially for large engines. On the contrary, we must shew preference to the horizontal arrangements, because on account of their easier fitting up and attending to, including their smaller prime cost, they excel the vertical types.

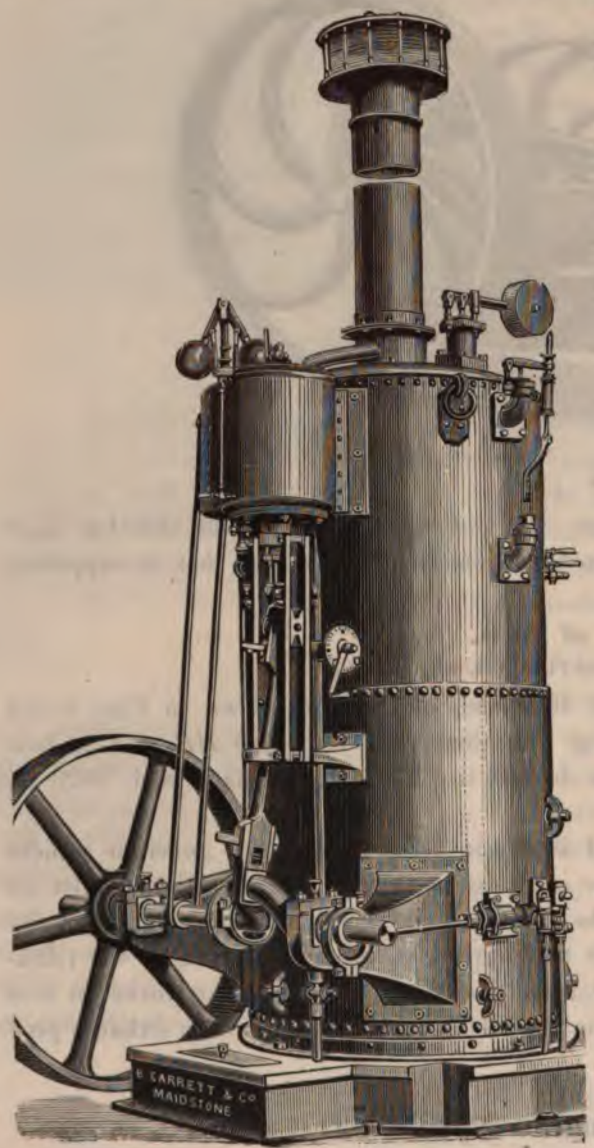


Fig. 81.

The cylinder may either be placed over or under the crank-shaft in vertical engines, though according to modern practice, the first named course is generally resorted to in the larger sizes. The small vertical motors, which we shall discuss here under one section as we did with the horizontal types, are mostly so connected with the boiler, that though both separate, they nevertheless stand on one bed-plate. Preference is shewn to this plan, on account of avoiding extra strains being thrown on to the boiler shell already heavily taxed, so preventing the boiler-plates to expand or contract according to the tendency of their variable temperatures. We will explain our meaning, by beginning with:

a. B. Garrett & Co., of Maidstone.

In the annexed Fig. 81, we represent the Combined vertical engine and boiler arrangement of Messrs. B. Garrett & Co., of Maidstone. The boiler is mounted on a strong iron foundation-plate, which is chambered for ash-pan and water-tank, and so simultaneously dispenses with the requirement of masonry foundation. This is probably the main advantage shewn by this constructive arrangement, but we cannot commend the engine-portion as worthy of imitation for various reasons. In the first instance the old method of making the boiler shell answer the purpose of engine-frame, has been here retained, whilst so many engineers have discarded the similar practice, for reasons that it was not only putting extra duty on the boiler, but the unequal expansion and contraction of the boiler-shell, renders it not at all suited to forming the foundation-plate of an engine, where so much depends on keeping all the working centres at the one original distance apart. A second defect we find with this engine-design, as gauged by modern practice, is the independent connection existing between cylinder, slide-bar legs- and crank-shaft pedestal

The importance of combining these three centres into a perfectly rigid connection has been fully recognised, yet in this design no provision beyond bolting is introduced to secure this object; for, the cylinder, the slide-bar legs and the crank-pedestals are each independently bolted to the boiler-shell. Apart from the difficulty of fitting up this arrangement at the outset with the required degree of accuracy, the ever recurring strains thrown on these centres must soon make themselves felt in increasing wear and tear, which evil can only be increased as we stated before, by the additional expansion and contraction of the boiler-shell, to which these centres are fixed. We fear for these reasons, that no amount of good and careful workmanship as exercised by the forementioned Firm, can possibly compensate for the injurious effects attaching to this design.

Barrows & Stewarts, of Banbury.

A somewhat similar arrangement to the preceding, is the combined Engine and Boiler design adopted by Barrows & Stewart. The engine frame is ⌋ formed, and this frame is cast with the slipper slide and with one of the crank-shaft pedestals. The overhead inverted cylinder is bolted to the vertical upright, which in its turn is bolted to the boiler. Though this separate mounting recommends itself more than the preceding example, still the working parts, would be considerably reduced in number, were the cylinder with its chest, as well as the vertical governor stand, and second crank-shaft pedestal, cast in one piece with the frame, instead of separately. The retention of these constructive principles, which a more enlightened modern practice is now supplanting, is not commendable. Watt's governor is used, and it is driven direct by bevel gearing off the crank-shaft. The engine-frame is bolted to the boiler-stand, which does not form a water-tank, and as the flywheel is not kept sufficiently high off the ground, a wheel race is required.

c. Reading Iron-works, of Reading.

(With illustrations on Supplement-Plate VIII, Figs. 1 and 2.)

The so-called *A*-frame pattern engine of these Works, has now been several years before the public and though shewing a considerable advance on the previous constructions, its design from a modern stand-point is antiquated, and is surpassed in gracefulness by more recent constructions. We illustrate this engine type on Supplement-Plate VIII, Figs. 1 and 2, though we must here assume the base-plate to be continued for the boiler to stand upon it. The frame consists of two uprights bolted to the base-plate, on to which the cylinder is similarly bolted. Widmark's governor is placed over the valve-chest, and is driven by strap. The governor-weight is composed of two close-lying parts, which when the engine is stopped, appear to form a sphere. The cranked main shaft extends over the width of the base-plate, and receives the fly-wheel at one end, whilst a belt pulley is keyed on its other extremity. The feed-pump, fixed to the bed-plate, is driven by the slide-eccentric.

d. Alfred Dodman, of King's Lynn.

A somewhat similarly formed vertical engine-frame is adopted by Mr. Alfred Dodman, of King's Lynn, whose combined engine and boiler we illustrate in Fig. 82. In other respects, the engine-construction, shews no special characteristic features, so that we pass on to:

e. Picksley, Sims & Co., of Bedford-Leigh.

This Engineering Firm have lately designed the combined Engine and Boiler arrangement shewn in the annexed Fig. 83.

Availing ourselves of the description sent us, this Engine is self-contained, and can be detached and removed from the base plate, and if neccessary, supplied with steam from any other boiler. The working parts of the Engine, viz: crank, eccentrics, slides, connecting rod, etc., are placed inside a hollow vertical pedestal, which protects the working parts and tends to keep them free from dirt. The slide blocks are adjustable by means of taper wedges, bolts and lock nuts, and their working faces are made of the best hard gun metal. The engine is provided with self-acting continuous force pump for supplying water to the Boiler, which is, in conjunction with a feed pipe supplying hot water from the tank, contained in the base plate, this water being heated by the exhaust steam from the cylinder. The exhaust steam can either be partially utilized, or

Fig. 82.

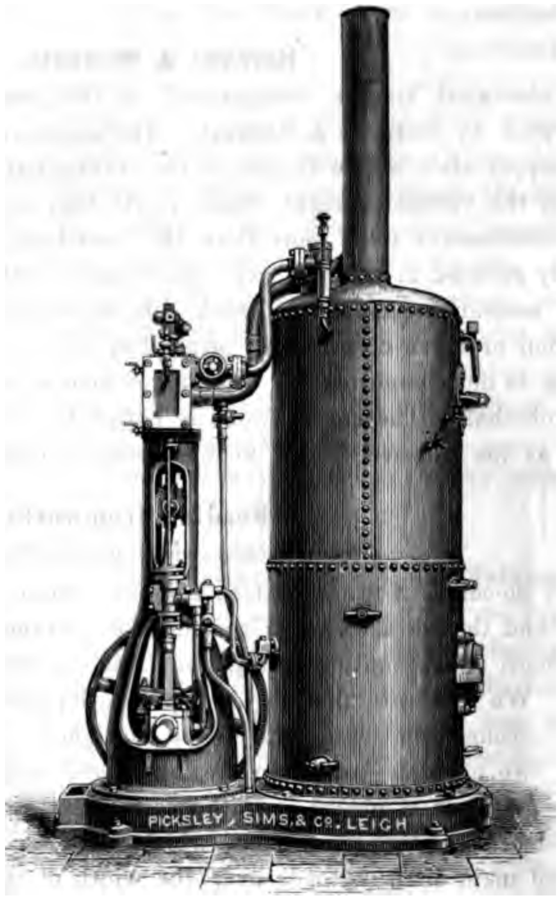


Fig. 83.

entirely conducted to the atmosphere, according to requirement, as it may be turned on or off by means of a tap placed at the exhaust pipe junction. The pump plunger and rod are made of wrought steel, in one solid bar. The pump glands, pump valves and check valves are made of the best hard gun metal, and a gun metal cock is supplied to the pump in the usual manner. The pump is provided with a tap by which the supply to the Boiler can be cut off when required, the water returning to the tank instead of being conveyed to the Boiler. The same tap also acts as a drain to the pump, so that all water can be emptied from it after finishing work, avoiding the danger of breakage during frost. The crank shaft is manufactured from the best forged scrap iron, and is of the locomotive form. The connecting-rod is manufactured from the same material;

in shape it is T-ended, and is provided with best gun-metal bearings, made adjustable for taking up wear and tear. The eccentric-straps are made from the best hard gun-metal, and are likewise made adjustable for taking up wear and tear. A reversing motion is provided to the slide eccentric. All bearings in this Engine are of full length and large diameter, and are furnished with lubricating boxes. The cylinder, which is made of the best hard cold blast iron, rests upon a vertical column which contains the working parts of the Engine, thus ensuring rigidity in working; this is further contributed to, by the plummer-blocks which form a part of the pedestal, giving steadiness in the bearings. An improved self-acting oil-cup is provided to the cylinder for lubricating the piston and valve face, and drain-taps are placed in suitable positions. The action between the Engine and Boiler is regulated by a stop-valve and hand-wheel. The Governors are high speeded.

f. Vernon & Ewens, Central-Ironworks, of Cheltenham.

These Engineers have recently brought out a type of combined vertical Engine and Boiler, which is illustrated by Figs. 84 and 85. The engines have few working parts, and if desired may

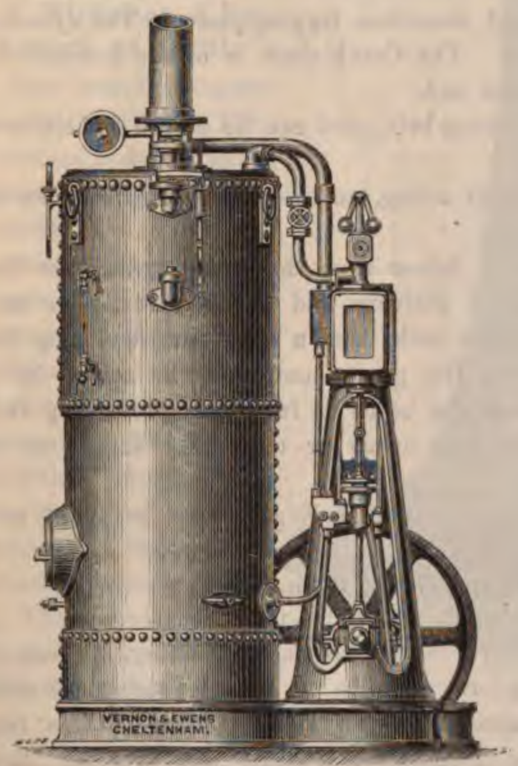


Fig. 84.

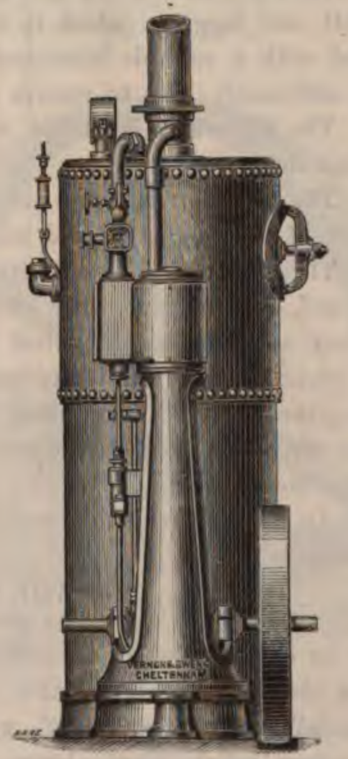


Fig. 85.

be fixed in any place apart from the boiler. The boiler is Smith's patent, and is fitted with circulating water tubes. We here find the lantern-frame re-introduced for the engine standard, and the following are particulars of the various sizes, which have been placed at our disposal by the makers:

Horse Power.	Diameter of Cylinder.	Length of Stroke.	Revolutions per Minute.
	inches	inches	
2	$4\frac{1}{4}$	8	180
3	6	12	120
4	7	12	120
5	$7\frac{3}{4}$	12	120
6	$8\frac{1}{2}$	12	120
8	$9\frac{3}{4}$	14	105
10	$10\frac{3}{4}$	16	95
12	12	16	95

The Engine consists of the steam cylinder bolted to the top of a strong and handsome cas -iron cylindrical standard, mounted upon a cast-iron feed-water tank. The "Standard" containing the whole of the working parts (the piston-rod guides being in the upper part, and the crank shaft pedestals forming the base), sustains the whole of the working strain of the engine, thus rendering the boiler much more durable.

The cylinders, which are unusually large in diameter for the nominal power, are covered with felt and lagging, which is enclosed in a neat sheet-iron lagging-plate. The cylinders are provided with a suitable lubricator and drain-cock. The Crank-shaft is of the locomotive form, and is sufficiently long to receive a pulley at either end.

The Fly-wheel is turned to receive the driving-belt, and can be placed on either end of the crank-shaft.

The Governor is of the quick-speed type, direct acting, and very sensitive, being an efficient regulator of the Engine's speed under varying loads.

The Feed-pump, fitted with brass plunger, is driven from the same eccentric as the Slide valve, and is furnished with suction and combined delivery and check-valves. In the same valve box as the latter are fitted a return feed-water cock, and a cock for regulating the feed-water heater. The return feed-water cock renders the pump continuous in action by simply allowing the water to be returned to the tank when the boiler is full, thus preventing the pump drawing air. The cock of the feed-water heater, either opens or closes the supply of exhaust steam to the feed tank.

An efficient reversing motion is provided, whereby the Engine may be made to run in either direction.

g. Marshall, Sons & Co., Engineers of Gainsborough.

(With illustrations on Supplement-Plate I, Figs. 9—10.)

In order to reduce the number of machine-parts in vertical engine-building, modern practice has cast the two uprights together, and the resulting form given to the engine-standards is either the "pyramidal", or "conical frame", which latter is also called the "lantern frame". This form has become very much liked, hence we find many English, American and German Engineers adopting it, though it has hitherto found less admirers in France. On Supplement-Plate I, Figs. 9—10, we represent the vertical engine arrangement of Marshall, Sons & Co., of Gainsborough. The upright frame is bolted to a very strong cast-iron bed, which we must suppose to be prolonged to the left in Fig. 10, so as to admit the boiler being placed thereon. The bed-plate serves as a water-tank for the feed-water, which is heated by the exhaust-steam. The feed-pump is worked by a separate eccentric, and the governor acts on a throttle-valve.

h. Robey & Co., of Lincoln.

A light and pleasing Vertical engine design is built by Messrs. Robey & Co., of Lincoln, and it is this construction which we represent in the annexed Fig. 86. In this arrangement, a crank-disc is used, and an additional strap-pulley may be keyed on the main-shaft outside the fly-wheel. The cast iron bed-plate also serves as a feed-water heater. These engines are constructed in sizes from $1^1/_2$ to 12 horse-powers.

Fig. 86.

i. W. N. Nicholson & Son, of Newark on Trent.

The vertical Engines now manufactured by this Firm bear a certain resemblance to the preceding example. The Engine and Boilers are mounted on a strong cast iron foundation extending under both, and forming a feed-water tank, into which is passed a portion of the exhaust steam for heating the feed-water. The Engine which is of the inverted cylinder type has the cylinders, steam chest, slide-bars, framing and crank-shaft pedestals, in one casting. The cylinder which is not jacketed, but felted and cleaded, is bored out with the slide-bars at one setting, in order to secure perfect alignment. The piston-rod is steel and the piston is fitted with double cast metal rings and springs. The cross-head is of malleable iron, with adjustable cast-iron shoes having large wearing surfaces. The crosshead-pin is of steel. The connecting-rod made of scrap-iron has adjustable gun-metal steps at each end; its small end is set up with a cotter and set-screw, whilst its large end is of the marine-pattern. The crank-shaft is of scrap-iron; it is forged out of round bar, and projects through crank-shaft pedestals on either side, to receive driving pulleys. The crank-shaft pedestals are fitted with gun-metal adjustable steps. The slide-valve rod, which is of steel, has its joint made with an adjustable gun-metal step to take up wear, and works through a guide attached to the framing. The slide valve eccentric, is fitted with slotted reversing disc and cast-iron straps. The governors, which are of the high-speed type, act direct upon the stalk of an equilibrium-valve, and they have an adjustment to regulate the tension of the spring, so that the speed of the Engine may be altered within considerable limits. The feed-pump is driven from a separate eccentric and is fitted with a cock in the overflow-pipe and also in the delivery pipe, between the check feed-valve and the Boilers, the handles of the cocks being coupled together by a link: this arrangement enables the pump to be always drawing water. A constant feed is so given to the Boiler, and all the three pump-valves can be examined and drawn under steam*). These Vertical Engines are made in the following sizes:

Nominal HP.	Cylinders. Diam.		Stroke.	Revs. per min.	Fly-wheel. Diam.		Face turned.	Weight.
1	4 in.	×	6 in.	220	24″	×	2″	$3\frac{1}{2}$ cwt.
2	$4\frac{1}{2}$ in.	,,	6 in.	220	27″	,,	4″	4 ,,
$2\frac{1}{2}$	5 in.	,,	8 in.	180	27″	,,	4″	5 ,,
3	$5\frac{1}{2}$ in.	,,	8 in.	180	32″	,,	4″	6 ,,
4	6 in.	,,	9 in.	160	36″	,,	$4\frac{1}{2}$″	8 ,,
5	7 in.	,,	10 in.	150	42″	,,	5″	9 ,,
6	$7\frac{3}{4}$ in.	,,	11 in.	140	52″	,,	6″	$10\frac{1}{2}$,,
7	$8\frac{1}{2}$ in.	,,	12 in.	130	52″	,,	6″	$12\frac{1}{2}$,,
8	$9\frac{1}{4}$ in.	,,	12 in.	120	60″	,,	6″	16 ,,
10	$10\frac{3}{4}$ in.	,,	15 in.	100	60″	,,	7″	20 ,,
12	$12\frac{1}{4}$ in.	,,	15 in.	100	60″	,,	8″	25 ,,

k. Ruston, Proctor & Co., of Lincoln.

(With illustrations on Supplement-Plate VIII, Figs. 5 and 6.)

A four horse-power engine of this Firm is illustrated on Supplement-Plate VIII, Figs. 5 and 6. It somewhat resembles, Marshall's design. The vertical boiler is placed to the right (Fig. 5) of the Engine, and is mounted on the same sole-plate, simultaneously serving as a feed-water heater and an ash-pan. The lower cylinder-cover sits on a planed recess in the frame, and is bolted to the cylinder by bolts passing through the frame-flange. The cylinder is $8\frac{3}{4}$ in. (222 mm.) in bore, and it has a stroke of 10 in. (254 mm.) and is also steam-jacketed. The slide-bars are turned, and the motion block-slides are made adjustable. The pedestal, close up to the crank, is cast with the engine-frame, whilst the other fly-wheel bearing is bolted to this frame.

l. Jacob Naylor, of Philadelphia.

(With illustrations on Supplement-Plate VIII, Figs. 7—8.)

Borrowing our sketch from Radinger's "Ausstellungs-Bericht", Figs. 7—8, (Supplement-Plate VIII) represent the vertical engine make of Jacob Naylor, of Philadelphia. It is built in six different sizes. The engine exhibited at the Centennial Exhibition had a sole-plate of 1 ft. 10 in. (560 mm.) in height, over which the fly-wheel ran, so that the second fly-wheel pedestal bearing could be bolted to this bed-plate. The cylinder of 12 in. (305 mm.) in bore, and 14 in. (356 mm) stroke, is bolted to the upright frame, (5 ft. 1 in. = 1560 mm. high), which is cast in one with the bearing and motion-bars, as well as with the bottom cylinder-cover. The wrought iron crank has counter-weight attached. The fly-wheel is 5 ft. (1520 mm.) in diam. and 12 in. (300 mm.) on the face. An oil-gutter cast round the sole-plate, facilitates the keeping clean of the floor.

m. Proctor & Wallis, of London.

In the vertical engines constructed by Proctor & Wallis, as shewn in the accompanying wood-cut Fig. 87, the two crank-shaft pedestals are cast with the engine frame. The dimensions of these Engines are as follow:

*) We may here observe, that this Vertical-engine type was exhibited for the first time at the Royal Agricultural Society's Show at Derby (1881).

Nominal Horse-power ..	$1\frac{1}{2}$	$2\frac{1}{2}$	4	5	6
Effective Horse-power ..	3	6	9	12	15
Cylinder diam in inches	$3\frac{1}{2}$	5	$6\frac{1}{2}$	$7\frac{1}{4}$	8

Fig. 87.

n. Fitchburg Steam-engine Co. (formerly Haskin Machine Co.) of Fitchburg, Mass. U. S. A.

The Fitchburg Steam-engine Co. constructs vertical engines in various patterns; nevertheless all shew the characteristic "lantern-frame", illustrated in the annexed Fig. 88. In the smaller engines, a cranked shaft is used; in the larger sizes, — made as illustrated over 12 *HP.* up to 50 *HP.*, — a crank-disc with separate hind-pedestal is used. As a 50 *HP.* engine the Firm designate the size corresponding to a 14 in. (356 mm.) cylinder-bore, with equal stroke, and running at 140 revolutions per min.; its fly-wheel is stated to be about 28 cwt. (1440 kg.) in weight, 5 ft. 3 in. (1600 mm.) in diam. and to be 1 ft. 6 in. (457 mm.) on the face.

o. Alexander Shanks & Son, of Arbroath. (N. B.)

The Gippeswyk engine, alluded to on pg. 26, may possibly have served as a model to these Engineers, who in the construction of their vertical engines, illustrated in Fig. 89, have imitated the forked engine-frame. The slide-bars, are not cast in one piece with the engine-frame but they are bolted to the latter, and are planed flat. As shewn in our illustrations, the feed-pump draws its supply from the wrought iron foot-plate forming a water-tank. The chief dimensions of these engines, are as follow:

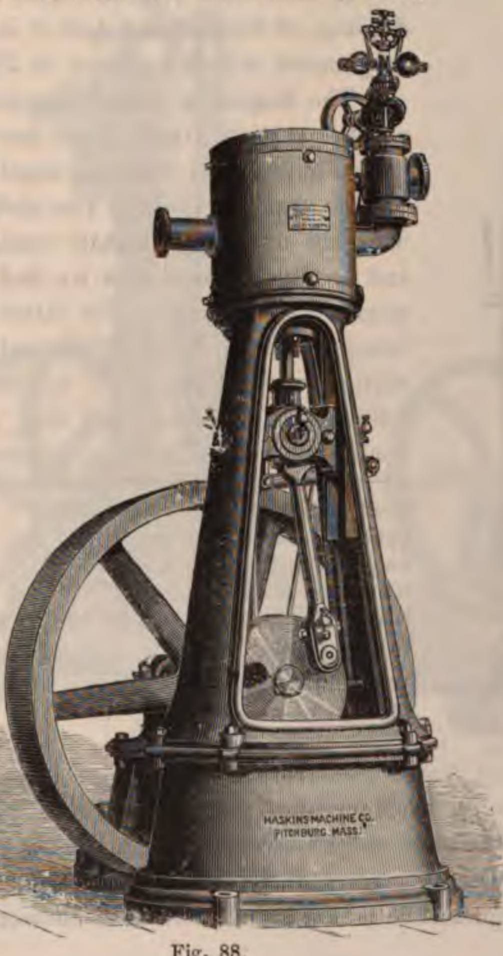


Fig. 88.

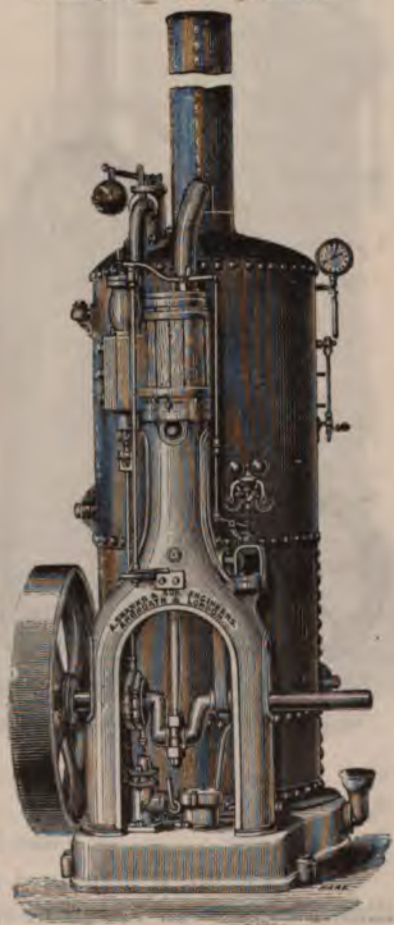


Fig. 89

Nominal Horse-power	2	3	4	5	6	8	10	12
Cylinder diameter in in.	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{1}{4}$	$8\frac{1}{4}$	$9\frac{1}{2}$	$10\frac{1}{2}$	$11\frac{1}{4}$
Stroke in. inches	9	10	10	12	12	14	14	16
Fly-wheel diam. in ft. and in. ..	2 ft. 11 in.	3 ft.	3 ft 3 in.	3 ft. 5 in.	4 ft.	4 ft. 9 in.	5 ft. 3 in.	6 ft.
Revolutions per minute	160	150	150	130	130	120	120	110

p. Weimer of Lebanon (U. S. A.) and Mitchell of Philadelphia (U. S. A.).

(With illustrations on Supplement-Plate VIII, Figs. 9—10, and Figs. 11—12.)

The United States with its well developed small-ware industries, builds small steam-motors to a large variety of patterns. Thus, somewhat similar engines are constructed by Weimer of Lebanon — see Supplement-Plate VIII, Figs. 9—10 — and Mitchell of Philadelphia — see Supplement-Plate VIII, Figs. 11—12. — The engine frames of both these engines remind one of the one-sided small steam-hammer type, and undoubtedly the two present a pleasing form. Mitchell's engine is 6 ft. $6^3/_4$ in. (2 m.) high over all. The cylinder is $6^3/_4$ in. (170 mm.) in bore, and $7^1/_2$ in. (190 mm.) in stroke. The valve-gear consists of separate slides for each piston-side; the crank-disc is balanced.

Fig 90.

q. Woods & Long, of Stowmarket.

A neat little vertical-engine is made by Messrs. Woods & Long, of Stowmarket and it is one of their combined arrangements which we shew in Fig. 90.

The Engine is completely detached, and if we mistake not the vertical frame forms one casting with the cylinder and slipper-guide, forming simultaneously double bearing for the cranked shaft. The slide-eccentric is mounted on one side of the crank-shaft made in the locomotive style, and on the opposite side we find a second eccentric which works the feed-pump. The latter is arranged on the circulating principle, to avoid the valves from sticking. These vertical engines are made in five sizes, answering to the following dimensions, and they are guaranteed to develop double the nominal horse-power stated in the following table:

Nominal Horse-Power	2	3	4	6	8
Cylinder Diameter in in.	$4\frac{1}{2}$	$5\frac{1}{2}$	$6\frac{1}{2}$	8	9
Length of stroke in in.	8	9	10	12	14
Revolutions per min.	180	160	150	120	110
Diameter of fly-wheel in ft. and in. ..	2′ 1″	2′ 4″	2′ 8″	4′ 3″	4′ 10″
Face of fly-wheel in in.	3″	$4\frac{1}{4}$″	$4\frac{1}{4}$″	6″	6″
Weight of Fly-wheel	c 1.1.0	c 2.1.0	c 3.2.21	c 5.0.0	c [illegible]
Diameter of crank-shaft	$1\frac{7}{8}$″	$2\frac{3}{8}$″	$2\frac{5}{8}$″	$2\frac{3}{4}$″	3″
Engine weight in cwts.	18 cwts	25 cwts	47 cwts	58 cwts	[illegible]

r. B. Herreshoff of London.

(With illustrations on Supplement-Plate VI, Figs. 11—15.)

To attain a high-speed running engine, B. Herreshoff designed and constructed the engine illustrated in Figs. 11—15 (Supplement-Plate VI). It is stated to work at 500 revolutions per minute and at 10 atm. steam-pressure; its cylinder-diameter is only $2^1/_4$ in. (57 mm.) and its stroke 3 in. (76 mm.); cutting off at 0·66 stroke, it develops 4 *HP.* The cylinder was formed out of a solid steel-block, and piston, piston-rod, crank-shaft (with eccentric forged on), and cross-head pin are also made of steel; on the other hand, phosphor bronze has been used for the sole-plate, the frame, and the cylinder-cover. Steel bolts are exclusively used with bronze nuts. To the front pedestal, the feed-pump is bolted, which is worked from the motion-block. To reduce weight as much as possible, the following parts were made hollow, viz: Crank, and eccentric-rod, and even the motion-block with its pin (Fig. 15) which is probably the most original part of the design. A characteristic of this engine-build, is that the nuts of the crank-bearing are made with fusible metal linings, so that in case of this bearing getting heated, these linings melt, and so loosen the cover. The slide-valve chest with its cover cast on, is bolted to the cylinder.

s. Ransomes, Sims & Jefferies, Orwell Works, Ipswich.

Messrs. Ransomes, Sims & Jefferies have introduced a Vertical Engine which we consider well worthy of attention. The design, as may be seen by the engravings, Figs. 91 and 92 is exceedingly neat and the Engine part is quite separate from, and independent of the boiler; in the combined boiler and engine arrangement, shewn in Fig. 91, the two are mounted on a strong foundation plate, which serves also as a tank for the feed-water. These Engines are well designed, and all the various parts have evidently been well thought out, in order to make them as simple and effective as possible, and at the same time, easy of management.

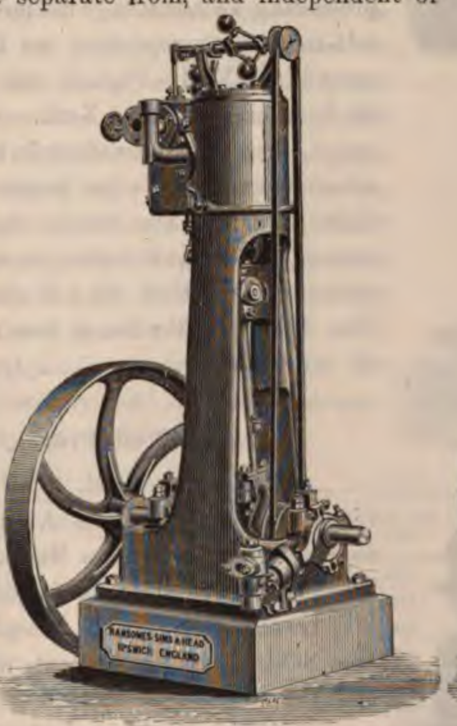


Fig. 92.

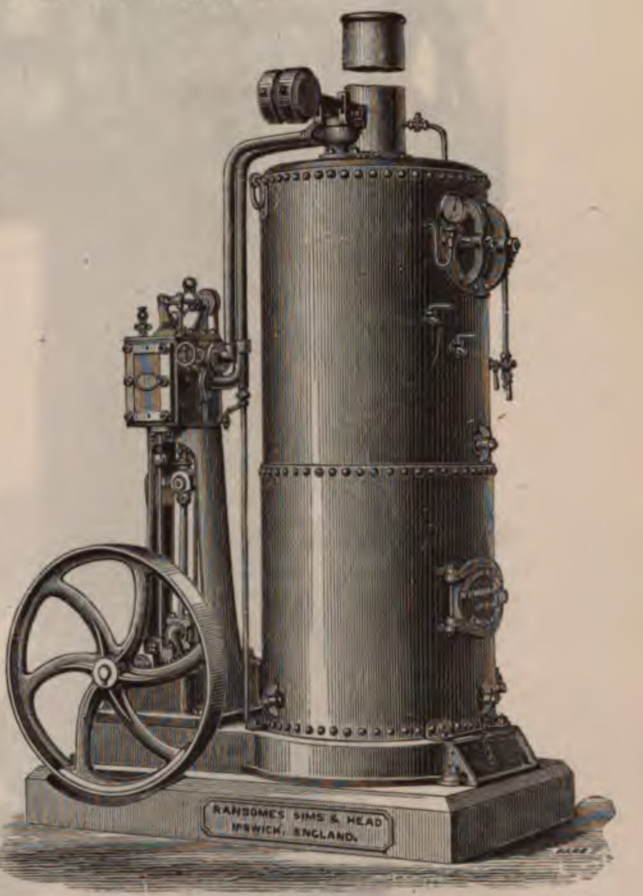


Fig. 91.

This construction takes up but little room and being made in various sizes, it is very convenient for a great many purposes, where economy in prime cost is an object, and where there is not sufficient space to put down an Horizontal Engine with a Cornish Boiler — a remark which applies more or less to the vertical engine type in general.

These Engines are made in nine different sizes. Messrs. Ransomes, Sims & Jefferies have adopted the plan advocated for some time past of selling these Engines by the size of the cylinders, instead of by the nominal horse power.*)

t. G. Petau, of Paris.

(With illustrations on Supplement-Plate VI, Figs. 5—6.)

The Vertical Engine here referred to, has its sole-plate extending right under it, whilst the cylinder is bolted to the frame in the usual manner. The steam-pipe abuts in the cover of the valve-chest, and has the throttle-valve attached to it. The exhaust-pipe passes through the engine bed-plate into the chimney. The motion-block is of the slipper pattern. The nominal working capacity is stated at 8 *HP.* The cylinder diam. is 7·87 in. (200 mm.) and its stroke 12 in. (300 mm.). The engine-speed is quoted at 110 revs. per min.

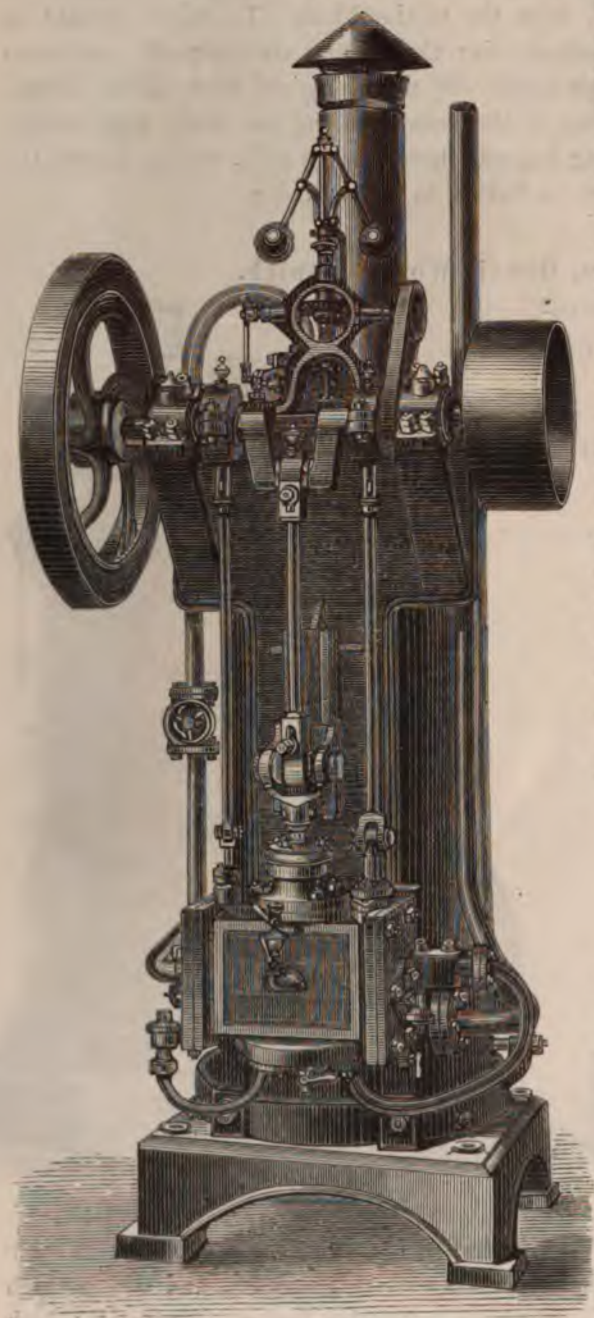


Fig. 93.

u. R. Wells, of New-York.

(With illustrations on Supplement-Plate VIII, Figs. 3 and 4.)

As an example of a two-piston engine, presenting an advantageous power development and self-balancing properties, we illustrate on Supplement-Plate VIII, Figs. 3 and 4, the engine type of R. Wells, of New-York. The action of the upper piston is transferred by two piston-rods, which pass through the lower piston by a steam-tight packing. The cranks are set at 180° apart, owing to which the pistons move in opposite directions, and thus do not obviate dead centres. The steam-distribution is controlled by the action of one eccentric.

v. Buffaud Frères, of Lyons.

An arrangement, totally differing from the types previously discussed, is shewn in Fig. 93, as belonging to Messrs. Buffaud Frères, of Lyons. The engine bed-plate is bolted at the top to the boiler, and rests on a sole-plate at the bottom. The steam-cylinder is cast with the valve-chest and the feed-pump.

Owing to the cylinder being much exposed to cooling, it is isolated by an air-jacket, from the pump. The feed-water heater is cast to the bed-plate behind the cylinder. These engines are constructed in the following sizes:

*) Messrs. Ransomes, Sims & Head's, Vertical Engine and Boiler mounted on wheels is described and illustrated in "The Engineer" d. 17 Dec. 1880, pg. 455.

Nominal *HP.*	1	2	3	4	6	8	10	12	15
Cylinder diam. in inches ..	3.74	4.72	5.11	6.29	6.88	7.47	8.07	10.04	11.41
Stroke in inches	4.32	6.29	7.87	7.87	10.23	12.60	14.96	14.96	16.54
Revolutions per minute ..	150	140	115	115	110	100	95	75	75

w. W. N. Nicholson & Sons, Trent Iron Works, Newark on Trent.

The vertical engines built by these Engineers are of the design shewn in Fig. 94, which represents their combined Boiler and Engine arrangement. Though separate from the boiler, the engine is mounted on the one bed-plate, and shares the same defect as the preceding example. The cylinder, (provided with a steam-jacket) and valve-chest form one casting with the engine uprights and pillow-blocks. To give greater solidity, the two uprights are connected together by a top curved bracket, and the V-formed slide-bars are bolted to these uprights. A second eccentric is used to work the feed-pump. The piston is fitted with double cast metal rings and internal springs. The governor has been patented by this Firm, who claim for it, that it is made in five parts only. The vertical engine type described by us on page 51 is a decided improvement on the present construction. Comparing this engine-design with other makes, we cannot but think that greater simplicity of design, and greater fewness of parts are presented by many other engines now in the market, so that we merely add the main dimensions to which these engines are made:

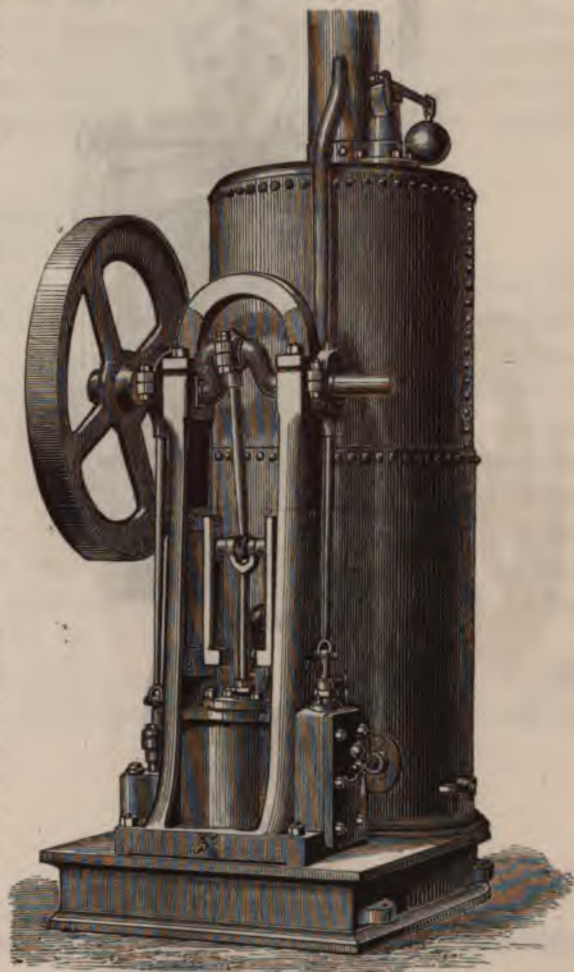


Fig. 94.

Horsepower: Indicated.	Horsepower: Nominal.	Cylinder: diameter.	Cylinder: stroke.	Revs. per min.	Fly-wheel diam.	Fly-wheel face (turned).	Engine weight.
3½	1½	4 in.	6 in.	200	24 in.	3 in.	3 cwt.
6	2½	5 „	8 „	180	27 „	4 „	5 „
8	4	6 „	9 „	160	32 „	4 „	7¾ „
10	5	7 „	10 „	150	36 „	4½ „	8½ „
12	6	7¾ „	12 „	140	42 „	5 „	10½ „
15	7½	8½ „	12 „	120	52 „	6 „	12½ „
18*	9	9¼ „	14 „	100	66 „	6 „	16 „

The indicated horse-power of Nicholson's engines is here calculated at 40 lbs. pressure, speed 240 feet per minute, cut-off at $^5/_8$ths stroke, and the nominal horse-power is taken at half the indicated Horse-power.

* This engine-size is made exceptionally with inverted cylinder, which as we have stated before, gives greater stability to the running of the engine.

x. The Saxonian Marine-engine and Machine-Building Works, of Dresden.

Our Fig. 95 introduces a design, which has been well received on the Continent. A di metrically placed engine-frame, surrounds the boiler without being attached thereto, whilst bot

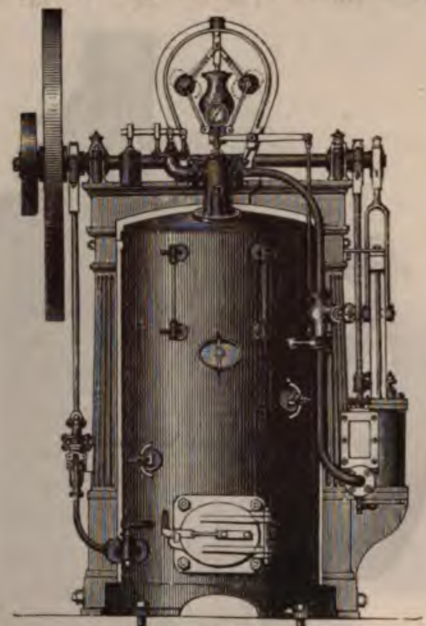


Fig. 95.

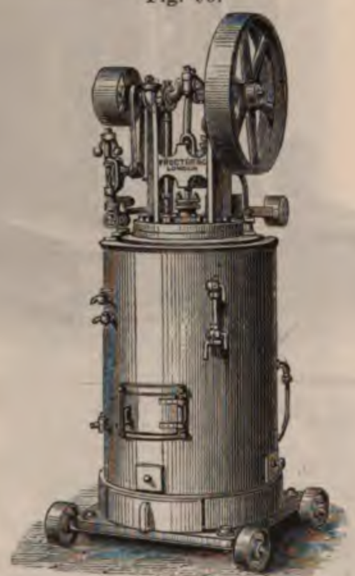


Fig. 96.

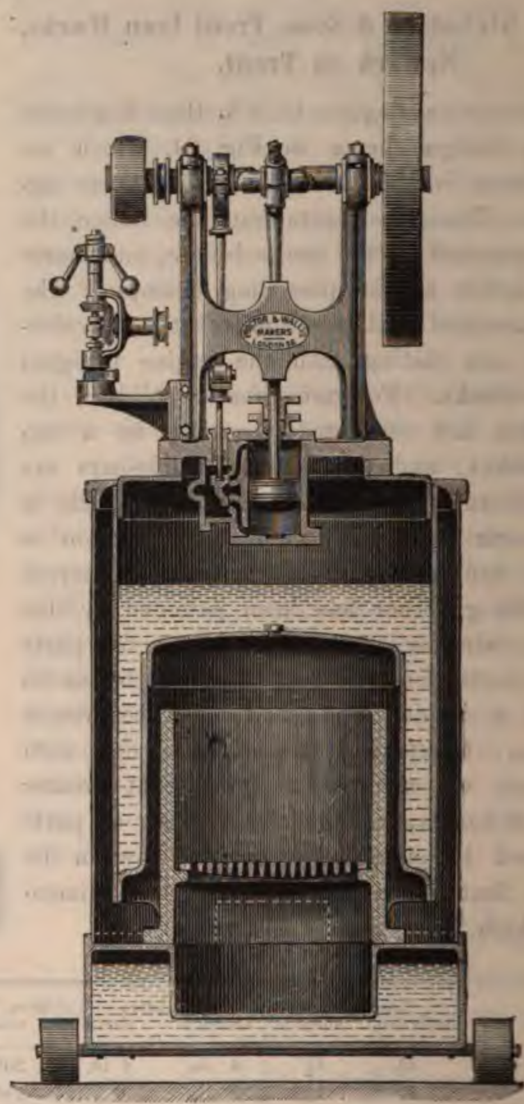


Fig. 97.

enjoy one bed-plate in common. To the one side of this frame, the cylinder with its valve-gea is bolted, whilst the other side supports the feed-pump, and the governor is made to crown thi arrangement.

y. Proctor & Wallis, of London.

Under the name of Baxter-engines, an engine-type has been largely introduced in th United States of America; its special feature consists in inserting the steam-cylinder int the crown-plate of the vertical boiler. We illustrate this construction, as formerly made by Messrs. Proctor & Wallis, of London, under the name of Talbot-engine, and our Fig. 96, shews the external, whilst Fig. 97 illustrates the internal arrangement of this engine. The cylinder is supported with its upper flange — simultaneously serving as engine bed-plate — on the boiler crown; it is thus inserted below the latter, and is most ingeniously placed to prevent radiation. This arrangement of the engine on the middle of the boiler, not merely allows the latter to expand and contract at will, but as the moving parts coincide with the boiler-axis, side thrust or vibrations are not caused.

z. L. Bréval, Engineer of Paris.

(With illustrations on Supplement-Plate VI, Figs. 8—10.)

We conclude this chapter by illustrating an oscillating engine on Supplement-Plate VI, Figs. 8—10, which is built by L. Bréval of Paris. It is presumed to be arranged over the front wheels of a Portable-engine, and as it is entirely cased in, it is termed by its maker "Cryto-dynamique" — i. e. hidden power. As in all oscillating engines, the admission and emission of steam takes place through the pivots *A* and *B*, which communicate with the bed-plate, and the boiler or chimney. The slide works in the ordinary style; to compensate for the oscillations, the eccentric works on a strap carried by the valve-box cover, the valve-spindle being attached to the other end of this strap. The feed-pump casting is bolted to the cylinder, and is worked from the piston-rod head. The suction-pipe is placed at the side of the pin *B*, whilst the force or feed pipe passes through the interior of the pin *B*; in this manner, the feed-water is heated by the exhaust-steam and the pipe is not influenced at all by the oscillations.

The engine illustrated is termed a 6 *HP.* engine (nominal). The piston is 7 in. (180 mm.) in diam. and its stroke = 12 in. (300 mm.). Working at 6 atm. steam-pressure, it runs at 100 revs. per min.

III. Engines working with one Slide, but with variable expansion.

1. E. R. & F. Turner, of Ipswich.

(With illustrations on Supplement-Plate IX.)

The simplest way, to secure variable expansion when using only one slide-valve, is to employ an eccentric, whose stroke and advance-angle are adjustable. For this purpose, the eccentric is fastened by set-screws through eccentric grooves of a circular disc keyed on to the crank shaft, which grooves allow the advance-angle and the eccentricity to be altered. This arrangement, of course, merely allows adjustment when the engine is stopped.

But, with the aid of certain mechanisms, this shifting of the eccentric can also be automatically accomplished by the governor, whilst the engine is running.

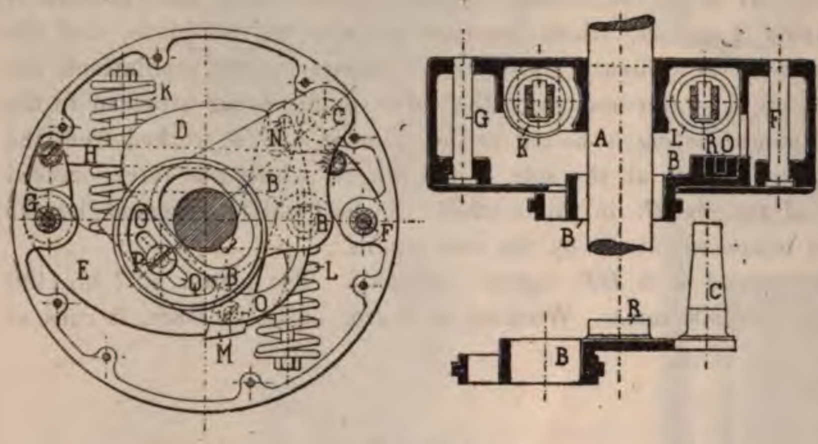
We purpose now describing these arrangements, by taking the valve-gear of Messrs. E. R. & F. Turner first, observing that it works in connection with Hartnell & Guthrie's governor.

The governor-casing is keyed fast on the crank-shaft *A*, whilst the eccentric *B* with large play, is slid over the same, and hung by means of an arm or carrier *C* on a pin, placed radially opposite the eccentricity, as represented in Figs. 98—100.

Briefly described, the governor may be said to consist of a disc, keyed to the engine crank shaft, in the same manner as a pulley. Two weights are suspended on pins to this disc, and rotate with it round the crank-shaft in a vertical plane. These weights are controlled by spiral springs, to prevent their flying out too readily. The weights are connected by a coupling link, so that the centrifugal force of the two weights acts together.

The slide-valve eccentric forms in reality a part of the governor. Connected to the weights is a curved lever or quadrant, the curvature of which passes through a slot in the boss of this eccentric.

D and *E* are the weights, *F* and *G*, the pins on which they swing. *H* the link connecting the weights with each other. *B* is the eccentric, having a slotted eye, through which the crank shaft passes; it is fastened to the carrier *C*, by bolts, and swings from the centre *C*. *Q* is the quadrant fastened by the screw *P* to the weight *E*; the arm of this quadrant slides through a swivel pivot *R*, on the eccentric carrier *C*. *L*, *K*, are the springs which control the motion of the weights.



Figs. 98—100.

The action of the governor is as follows: — Any variation in the work on the engine, say the sudden variation which follows the completion of a heavy cut by a circular-saw, naturally tends suddenly to increase the speed. This causes the weights to fly out by centrifugal force, and to overcome at once the restraint of the spiral springs. The weights in flying out, carry with them the quadrant or curved lever, which is fixed to them in such a way, that in altering its position it shifts the slide valve eccentric, and diminishes its stroke, thus lessening the travel of the slide valve, and reducing the steam-supply. When the saw-cut again comes on, the reverse takes place. The spiral springs draw the weights close together, and the stroke of the slide-valve is instantly increased, so that the required steam supply is obtained. In other words on the Engine being put in motion, the centrifugal force tends to drive the weights *D* and *E* outwards, but they are prevented from flying out too readily by the restraining force of the spiral springs *L* and *K*. The weights in flying out, carry with them the quadrant or curved lever, which is fixed to them in such a way that in altering its position it shifts the slide-valve eccentric and diminishes its stroke, thus lessening the travel of the slide-valve and reducing the steam-supply.

We illustrate an Engine fitted with this valve-gear on our Supplement-Plate IX. Its cylinder is $6^1/_2$ in. (165 mm.) in bore, and its stroke = 10 in. (254 mm.); the cylinder is steam-jacketed and cast in one with the valve chest. The crank-shaft pedestal is connected with this cylinder by an ⊏-frame. An 8 *HP* (nominal) engine is stated to work at 8 atm. steam-pressure, and to run at 270 revs. per min. so throwing off a mean piston speed of $7^1/_2$ ft. (2·3 m.) per sec. The flywheel serves as belt-pulley, and takes up the forementioned governor on its inner side.

2. Satre & V. Averly, of Lyons (Deprez' patent).

(With illustrations on Supplement-Plate 3.)

Deprez' variable expansion gear, as fitted to a Condensing-engine, constructed by Messrs. Satre & V. Averly, of Lyons, is illustrated on Supplement-Plate 3. As the detail-drawing (Fig. 5) shews, the valve has large laps; the valve spindle is very long, extending almost up to the eccentric, where it is connected to a frame *A* surrounding the fixed eccentric *B*, which is keyed diametrically opposite the crank. This frame is guided perfectly straight, by a second guide, so that it can only move horizontally. The frame has a circular link *C*, with a sliding-block *c*, connected to the pin of the short eccentric-rod *D*.

If we now investigate the position of this mechanism as represented in Fig. 1, we shall find that the sliding-block lies in the prolongation of the axis of the valve-rod, and consequently motion will be imparted to the frame, and to the valve-rod and to the valve, corresponding to the symmetrical declination of the eccentric. This answers to the earliest cut-off at $^1/_{10}$th stroke, On looking at Figs. 1 and 2 we note that both valve and piston are exactly in their central position, whilst steam has already been cut-off, and we see that a change is taking place in the steam-exhaust, because the inner valve edges lie exactly over the port-edges.

Continuing to notice some of the chief positions of the slide as illustrated in Fig. 101, — in which the dotted line indicates the travel of the valve in the forementioned position of the sliding-block, — we arrive at the following conclusions: The valve begins to open the steam port at *c*, when the piston has to travel $^1/_{10}$th of its stroke up to its dead centre (the piston is travelling in the direction of the inscribed arrow *K*); on reaching this dead-centre, the port is opened out to about $^4/_{10}$ths of its width, whereupon the port opening is again reduced, when on reaching $^1/_{10}$th of the new stroke-travel, steam is cut-off and expansion begins. Therefore the slide path may be represented as being divided into equal parts, in relation to the dead-centre.

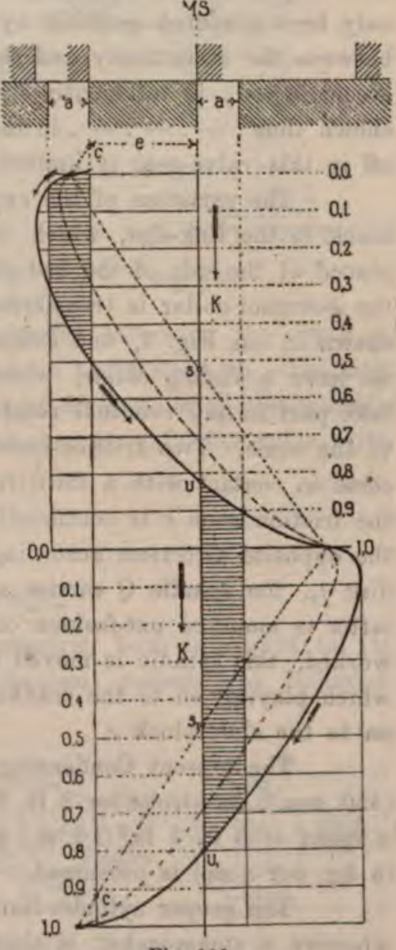


Fig. 101.

With regard to the exhaust, it begins at *s*, or when the piston is on half-stroke, hence it follows, that steam is only expanded during about $^4/_{10}$ths of its travel, beginning then to escape. Simultaneously compression begins on the opposite piston-side, as shewn by s_1 in the lower portion of the diagram. This peculiar distribution of the steam, in no wise effects a continuous action of the piston, but on the contrary the latter would soon come to a stand-still. However, as soon as the sliding-block is moved upwards, the steam-distribution is changed, and the piston is able to move. To explain this matter, let us refer to the position shewn by Fig. 5, in which the slide-block is in the highest point of the link-slot, corresponding to a cut-off at $^1/_{20}$th stroke, and to the curve *fully* drawn in our Fig. 101. The largest valve-declination results from this position of the sliding-block.

When the valve assumes its largest declination, the piston has only travelled over the first fifth of its stroke. In continuing its stroke, it receives the steam cut-off at half its course. Exhaust commences at u, when the piston has run over 0·82 of its stroke, and this emission continues up to u_1, where the piston has to travel another $^1/_5$ of its course ere it reaches its other dead centre. In the valve position represented by our Fig. 5, the piston is at half-stroke. This illustration similarly points out the effect of the eccentric-rod on the motion of the valve, for if the positions of the valve were to depend solely on the eccentric, then the valve would likewise be in its central position, as we observed to be the case with the piston; Fig. 5 shews however, that the slide has been motioned beyond it. This modification of the eccentric movement has only been rendered possible by the use of a very short eccentric-rod, for as the ratio existing between the eccentricity and the eccentric rod length is large, the effect of the inclination of the eccentric rod, is sufficiently brought to the fore, to produce a variable slide-motion. The curve shewn thus . — . — . — . in the diagram, answers to a cut-off at $^3/_{10}$ths stroke. The range of cut-off in this valve-gear is limited from $^1/_{10}$th — $^1/_2$ the piston stroke.

The variation of the expansion, depends therefore on the different positions of the slide-block in the link-slot, which can be varied both by hand and by the governor. The latter is placed at the side of the bed-plate, and is driven by belting off the crank-shaft. The motion of the governor-collar is transferred to the sliding-block by an intermediate transmitting mechanism, shewn in our Fig. 1, and composed of the following parts: To the end of the governor lever r, we have a sliding collar, which encircles the vertical spindle Q in such a manner as not to take part in any eventual rotation of this spindle, whilst it transfers any movement of this lever to the same. Two friction-cones q and q_1, are mounted on this spindle, which cones alternately come in contact with a third friction-cone s, according to the rise or fall of the spindle Q. As the friction cone s is continually revolving, so the spindle Q is forced to revolve in the one or the opposite direction, according as the upper or lower cones q or q_1, are in contact. Under the disc q_1, the spindle Q carries a worm p which gears on to a wheel p_1 — vide Fig. 2 —. The latter is mounted nut-fashion on to a spindle S, so that according to the direction in which it is worked, this spindle is moved inwards or outwards. This spindle S is linked to the rod S_1, which playing on to the cranked lever T and suspension link T_1, transfers the governor-motions on to the slide-block c.

The present Condensing-engine is of 25 *HP.* (nominal). The cylinder diam. = 17$^3/_4$ in. (450 mm.); its stroke = 2 ft. 6 in. (760 mm.). Running at 40 revs. per min. the piston attains a speed of 3 ft. 7 in. (1·1 m.) per sec., whereby an absolute steam pressure of 71 lbs. per sq. in (5 kg. per qcm.) is presumed.

The proper cylinder-lining is a part by itself, and is inserted inside the outer cylinder, whereby a steam-jacket is simultaneously obtained. The live-steam enters this jacket from the underside, and enters the valve-box by passing side-ways through the throttle-valve, as may be seen on referring to Fig. 3. An additional steam-cock v is added, which on setting the engine to work, is opened, in case the valve should just happen to have closed the steam-port. Two steam pipes, leading separately to each steam-port, branch off from this steam-cock.

3. Pius Fink, of Vienna.

In the annexed Fig. 102, R represents the crank, placed diametrically opposite eccentric D, the strap of which is directly connected and fixed to a link. The eccentric-strap is grasped at Q by a lever, oscillating round the fixed centre G in such a manner that the point Q nearly travels in the stroke-direction of the eccentric, whilst simultaneously the rotation of the shaft causes rotary oscillations of the link round this point. The slide-block end of the rod M, connected by link with the valve-rod, may be shifted up and down in the slot of the link, by turning the hand screw wheel shewn in our figure. As a consequence, the travel of the valve becomes changed. If the link slide-block is low in the link-slot, we have a large expansion, for then the valve-motion is derived, almost as if from one eccentric keyed at an advance-angle of 90°. When the slide-block is placed in higher positions, the motion of the link makes itself felt, and this link may be looked upon as approaching a right angled bell-crank; consequently the motion may be attributed to a second eccentric following the crank at 90° ($\delta = 180°$). The combination of these two motions is imparted to the slide-valve. The link is curved to a radius equaling the length of the rod M; the oscillating centre Q is advantageously placed in the centre-line of the link. The working of this valve-gear is only favorable with early cut-offs.

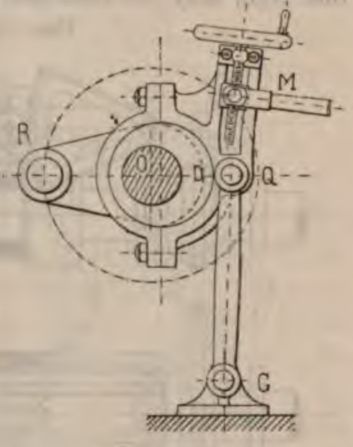
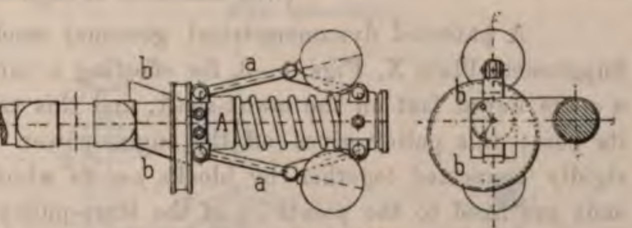


Fig. 102.

4. Robey & Richardson, of Lincoln.

We have a very simple arrangement of displacing the eccentric, both in regard to its advance-angle and to its eccentricity, in the direct expansion mechanism, patented by Robey & Richardson, and adopted by Messrs. Robey & Co., of Lincoln. We represent this arrangement in Figs. 103 and 104.

The governor is placed direct on the crank-shaft, so that the governor balls rotate in a vertical plane. The ball rods $a\ a$ are linked to the movable collar A to which two wedge-formed sliding blocks $b\ b$ are attached in such a manner, that with each change in the engine-speed or governor ball position, these blocks slide accordingly on the planed surface of the crank-shaft, parallel to the axis of the latter. The eccentric has corresponding slots, into which these slide-blocks play, causing the eccentric to be more or less shifted from the crank-shaft centre, whilst the eccentric is otherwise prevented in taking part in the axial motion of these blocks. In this manner, we obtain a simultaneous variation of the advance-angle and of the eccentricity.

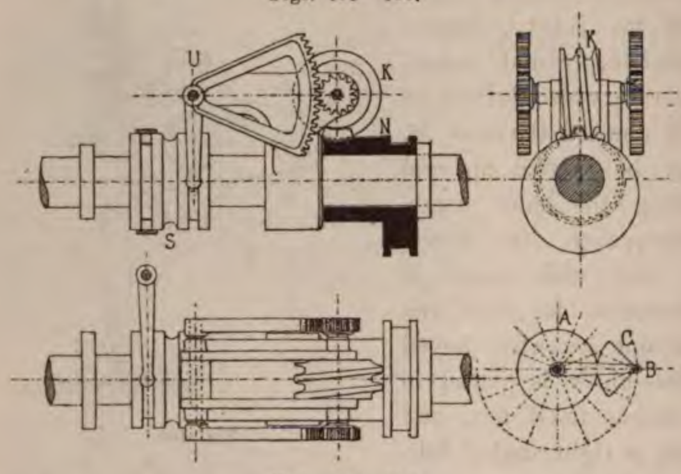


Figs. 103 and 104.

5. Wilh. Kalka, of Nicolai.

Kalka's Valve-gear, as patented in Germany, merely effects a turning of the eccentric, whereby the advance-angle is only changed. This valve-gear, illustrated in the annexed Figures 105—108, may be described as follows:

Figs. 105—106.



Figs. 107—108.

The crank-shaft carries a loose toothed wheel A between two arms B, keyed fast on this shaft. A wheel-segment C is inserted between these arms on a counter-shaft, in such a manner that the segment and wheel, gear into each other. The segment being the driver, the latter will make equal revolutions to the crank-shaft. If we now conceive the counter-shaft to be rotated by some external means, (even when the main shaft revolves,) then an accelerated or retarded motion may be thereby given to the loose wheel, and the last named may in fact be reversed by choosing a suitable gear-ratio. This variable motion, is transmitted on to the eccentric of the slide-valve in the following manner: — see Figs. 105—107. — The sleeve S may be shifted along the main shaft either by hand or by the governor, whilst the engine is running; this straight motion is converted by a transmitter U — by wheel-gear — through worm K, into a circular motion. This worm, gearing into the toothed boss of the loose eccentric, causes the latter to be turned, thus effecting a corresponding change in the advance-angle.

6. A. Siepermann, of Lübeck.

(With illustrations on Supplement-Plate X, Figs. 1—3.)

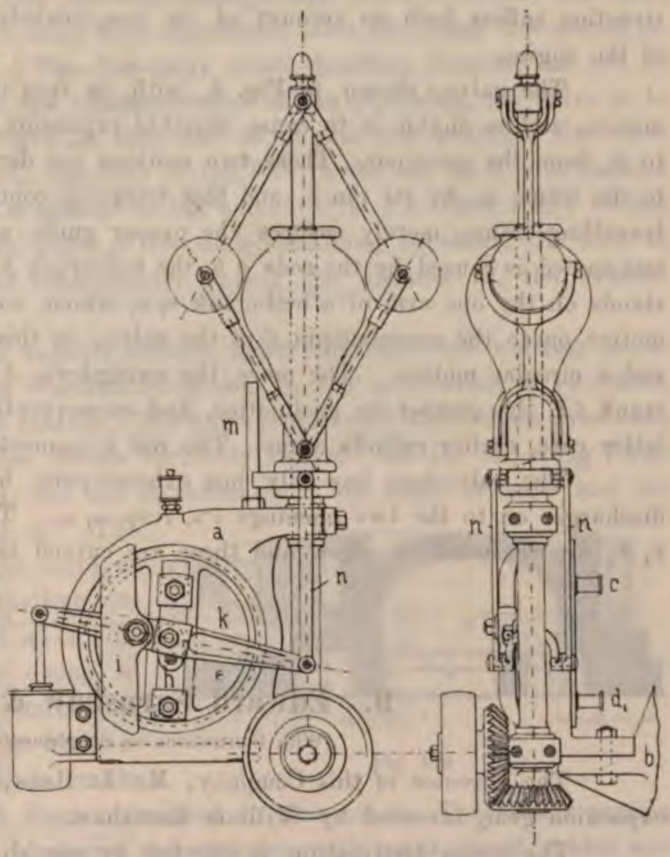
A patented dynamometrical governor mechanism is applied to the Engine illustrated on Supplement-Plate X, Figs. 1—3, for effecting a variable valve-motion. The two halves of a casing a a are keyed fast on the crank-shaft, and this casing takes up a belt-pulley b running loose on its boss; this pulley gives off the engine-power. The forementioned casing-halves are moreover rigidly connected together by blocks e e, to which the springs d are attached; the other spring ends are fixed to the points e e of the strap-pulley.

The casing revolves in the same direction as the crank shaft, whereas the loose belt pulley drawn by the springs d, has a tendency of lagging back; this tendency becomes more manifest, the greater the resistance is, which it has to overcome. According as this resistance is, it will command a certain position of the casing to the strap-pulley, and this relative position is communicated to the collar g, sliding on the fly-wheel shaft, by the simple wheel gear f. An ordinary forked lever grasps this collar, which when moving, causes the bevel wheel h to revolve; this motion becomes communicated to a balanced horizontal lever connected by guide-rod to the eccentric-rod. The eccentric, owing to the action of the forementioned governor, is motioned in a Fink-link, whereby the stroke of the valve is altered.

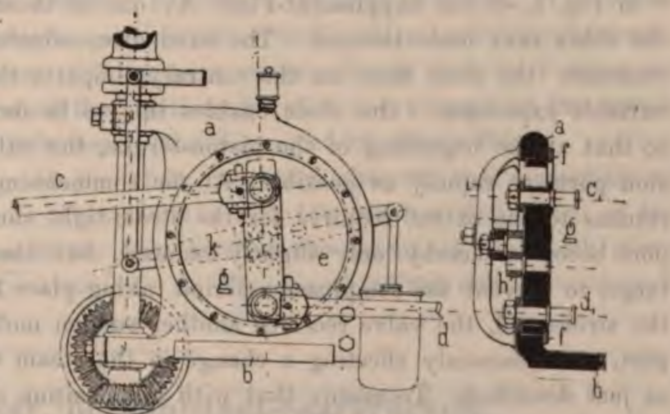
7. The "Cyclop" Machineworks, of Berlin.

A mechanism effecting a variable slide travel governed by the governor, was designed by A. Ruthel, Engineer of Berlin, and it is this gear which we represent in Figs. 109—112, in the improved construction of the "Cyclops Machineworks" of Berlin.

We give front, side, and back elevations of this gear in our illustrations. The frame *a* is bolted through its flange *b* to the side of the engine bed-plate, and in Fig. 111, *c* is supposed to be the eccentric rod whilst *d* leads to the valve-rod. We find inside the frame *a*, a rotary disc *e*, held in position by the ring *f*, fitted in with countersunk screws. In the slot of this disc, we have a sliding-block *g*, which carries on its back the two pins c_1 and d_1 of the forementioned rods; on its front side we have a small crank *h* connected with a double lever *k*. This lever has its fulcrum on a strap *i* cast in one with the forementioned casing *a*; it communicates at the one end with the rods *n n* leading to the governor collar, whilst its other extremity communicates with an oil-brake. When the sliding block is centrally placed, the declinations of the pins c_1 and d_1 are equal; but if the governor actuates the sliding block *g* by the forementioned lever, then the two pins c_1 and d_1 are also simultaneously motioned in such a manner that their distances from the point of oscillation of the disc *e* become altered, so causing the valve-stroke to be lengthened out or shortened. A catch on the bolt *m*, prevents the rods *n* from taking part in the rotation of the governor-collar. Our drawings presume the mechanism to answer to the lowest position of the governor balls.



Figs. 109—110.



Figs. 111—112.

8. Druitt-Halpin, of London.

(With illustrations on Supplement-Plate III, Figs. 1—6.)

On page 165 of our second volume we briefly referred to Mr. Halpin's Valve-gear, and we now illustrate the same on Plate III, Figs 1—6. Although very ingeniously conceived, this construction suffers both on account of its complicatedness, as well as owing to the minute details of the engine.

The valve, shewn in Fig. 6, with its face in Fig. 5, receives an alternate to and fro motion, and to enable it to cause variable expansion, an additional rotary movement is imparted to it, from the governor. These two motions are derived from an eccentric *a*. The slide is fixed to the frame *d*, by its pin *c*, and this frame is connected to the eccentric-rod. The to and fro travelling frame, merely ensures the proper guide and position of the slide; the rotation of the last-named is caused by the rods *g h*, the bell-crank *h i k*, and the swing-lever *l*. This swing lever stands on the one arm of a bell-crank *m n*, which, with the assistance of the rod *o* transmits the motion on to the eccentric-pin *f* of the valve; in this manner, the valve receives both a straight and a circular motion. The more the swing-lever *l* is pushed outwards in the slot of the bell-crank *i k*, the greater its declination, and consequently the greater the turn of the valve. In this latter case, earlier cut-offs ensue. The rod *p* connects the swing-lever *l* with the governor.

The valve-face has only one exhaust-port; but each steam-passage on the other hand, discharges on to the two openings *s s*, resp. s_1 s_1. The finger-formed edges of the valve, *k k* and k_1 k_1 are the working edges, and these are curved to the same radius as the corresponding ports.

9. Edward Earnshaw & Co., of Nürnberg.

(With illustrations on Supplement-Plate X, Figs. 4—10)

The Director of this Company, Mr. L. Haas, has for a number of years used a variable expansion gear, invented by William Earnshaw.

The steam distribution is effected by one slide, arranged on the cylinder back, perpendicularly to the engine-axis. This motion is generated by two non-circular discs, shewn at *a* and *b* in Fig. 5, of our Supplement-Plate X; one of these (*a*) is keyed fast on a vertical axle, whilst the other runs loose thereon. The fixed disc, effects the steam-distribution, which is to remain constant; the loose disc, on the contrary, imparts the governor motion to the slide, so securing variable expansion. One slide enables this to be done, inasmuch as it moves by sudden starts, so that at the beginning of the piston-stroke, the valve opens out the steam-admission and emission ports as rapidly as possible. At the commencement of the expansion-period, the slide merely returns to the extent required for the steam-tight shutting off of the admission port; the exhaust port becomes thereby only slightly reduced, but the remaining open exhaust-area is sufficiently large, to prevent the compression-period taking place too soon, as our Fig. 113, explains. Towards the stroke-end, the valve receives another sudden motion, which completely shuts off the exhaust-port, simultaneously effecting a change in the steam distribution, which then again repeats itself as just described. To ensure that with the position of the valve (Fig. 113) corresponding to the expansion-period, no steam-admission or emission may take place in the passage *A*, the external valve edge must cover the port *A* by *k*, whilst the internal valve-edge must overlap the same by *h*.

The non-circular discs with the surrounding frame of the valve-rod, are drawn in Fig. 5, Supplement-Plate X. To describe the curves, we have added Fig. 10. At the commencement of the stroke, the valve is to move to the extent of say x from right to left, as also shewn in Fig. 113. Therefore, if a point of the valve be at n just before the stroke-commencement, then on starting, this point may be at m, and $m\,n = x$. At this moment, steam enters through the full port-area, and the valve remains stationary. Expansion must now commence, after the crank has moved to the extent of angle δ from its dead-centre. The disc-curve must therefore describe an arc of radius $o\,m$, during this rotation. Then, with the commencement of the expansion, the valve is to be motioned to the extent of $a + k$ from right to left, and as in this new position, the valve remains stationary close up to the stroke end, the form of the disc in the arc 1—2 is a circular arc, whose centre is at o, and whose radius is smaller to the extent of $(a + k)$ than $o\,m$. Owing to the distance of two points on the opposite edges of the disc, remaining constant, the form of the second half of the disc gives itself, and consequently during the distance 13, the exhaust becomes reduced.

To obtain expansion, a change of the angle δ without disturbing the other working parts, is all that is required. This is attained in a constructive sense, by the application of two discs, one of which *(a)* is fast, whilst the other *(b)* rotates. We have represented these discs over each other in Fig. 8. The rotary or expansion disc shewn vertically shaded, has the following form: An arc of radius $o\,m$ surrounds the angle α; the arc of radius $= r$ the angle of 180^0 and the remaining portion has a radius $= r + a + k$. The horizontally shaded area in Fig. 9, gives the form of the rigid disc a. We notice here, that the earliest cut-off depends on the choice of the size of the $\measuredangle\, \alpha$. In Fig. 9 the disc b, is turned to the $\measuredangle\, \beta$; owing to $\measuredangle\, \beta > \measuredangle\, \alpha$ the circular border-line is interrupted, which has however no effect, as the valve lies horizontally. The motion of the slide only ensues in crank-position 1 (Fig. 5) when the borders of both discs correspond to each other. The shaded portion of Fig. 5, indicates the opening of the steam admission and emission with latest cut-off, which cut-off therefore varies between the limits of 0·1 and 0·9. The Trick-valve shewn in Fig. 6 is generally used in this arrangement, and in the position drawn in our Fig. 7 the slide is at rest. The distribution of the steam takes place in the following manner according to Fig. 5: In the crank-position 1, expansion begins, in 2 compression commences, in 3 we have steam-emission and in 4 steam-admission. The two discs — Fig. 5 — determine the positions 2 and 3, on account of the curves in question just covering each other; hence it is merely the disc a, which effects this.

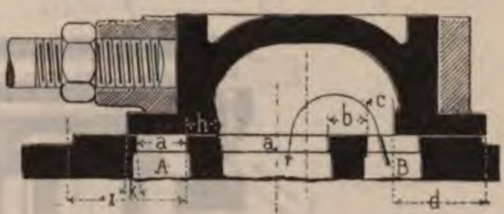


Fig. 113.

Concerning the proper dimensioning of the slide, we may observe, that according to Fig. 113, the extent of the travel $x = c + d$. In order that with the greatest declination of the valve, the exhaust port a_0 may remain open at the very least to the extent of the width a, we must have $a + d \overline{<} b + a_0$, hence $a_0 \overline{>} a + d - b$. The length of the slide $L = k + a + 2\,b + a_0 + c + d$.

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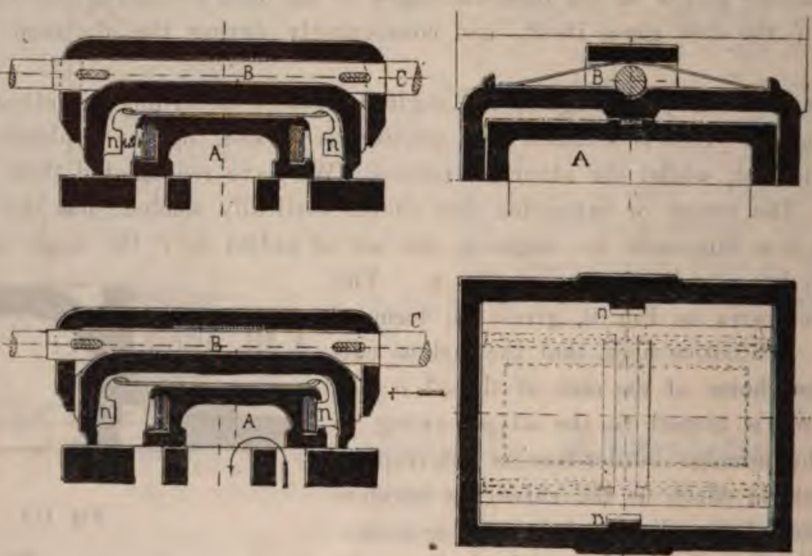
10. Ehrhardt & Sehmer, of Mahlstadt-Saarbrücken.

The slide-valve, patented by these Engineers, belongs to this division in this respect, that its construction and application were designed with a view of evading the defects the slide-valve presents, when working with early cut-offs, and variable expansions. Inasmuch as the external valve-gear may form any kind of expansion-gear, we may confine our remarks to the slide itself.

The slide-valve, shewn in our Figs. 114—119, must be looked upon as an improved Trick-valve, with this difference that in the present case, the exhaust is made independent of the variable function of the admission, so as to prevent inadmissible compression. In order to effect, a moderate advance of the steam-exhaust, and a moderate compression, when working with early cut-off, this valve is divided into two parts, each of which forms a D-slide. The inner valve *A* covers the exhaust port, and merely effects the steam-exhaust; on the other hand, the outer valve encircles the inner slide completely, and effects the steam-admission. It is connected with the external valve gear mechanism by the rod *C*. The outer valve is consequently worked direct, whereas the inner



Figs. 114—119.

slide is dragged by the former; a certain amount of play-space is always between the two valves, so that a double-admission takes place as in the Trick valve.

The motioning of the inner slide which is guided on ledges, is due to projecting lugs n cast on the outer valve; these lugs are made, so that they may always leave the necessary width of the exhaust-port between the two valves. To deaden the noise ensuing from this tappet-motion, two flat steel-springs are used to form an elastic cushion. This same principle of drag-valve, may also be employed for piston or disc-valves.

In the position represented by our Fig. 114, both valves are on their centres, whereby the reciprocal contact is eliminated; this could however never occur whilst the valve was working. On the other hand, Fig. 115 represents the manner, in which the valve *A* is dragged in the direction of the inscribed arrow, so that the admission port is already long closed, whilst the exhaust still continues.

The circular diagram of this valve is shewn corresponding to cut-off at half-stroke, in Fig. 120. It allows itself to be drawn, in respect to the admission, precisely as the diagram of the ordinary slide does, and in our illustration r = the eccentricity, whilst δ = advance-angle. The inner lap is not directly marked from o, but once in a positive, and once in a negative direction to the radius of a circle Os, the radius of which equals the extent of the valve-drag s. If we observe, that according to Fig. 114, the outer slide has to move to $(s + i)$, so that the exhaust may begin, whilst this exhaust port is just closed when the outer slide has moved to the extent of $(s - i)$, we get a circle of radius $(s + i)$, whose negative part in the point of intersection with the valve-circle, marks the commencement of the steam-exhaust, whilst a circle of radius $(s - i)$ indicates the termination of the steam exhaust. The duration of this exhaust, may be surmised from the shaded under-portion between the crank-positions 3 and 2. The favorable steam-distribution of this valve-gear, is at once apparent. Cutting off at half-stroke, we receive an expansion of 46 per cent, whereas the premature steam-exhaust merely extends over 4 per cent of the stroke, while compression is limited to $7^1/_2$ per cent. Consequently, the steam-exhaust during the piston-stroke calculates itself to $92^1/_2$ %.

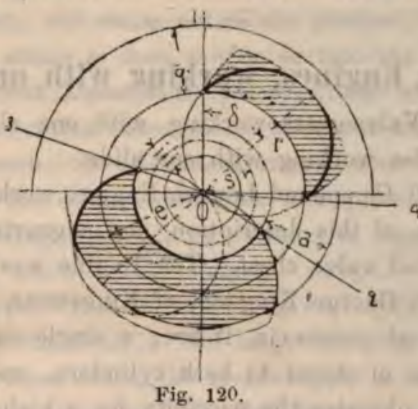


Fig. 120.

We are enabled to see the action of this valve-drag in a still more satisfactory manner in the elliptic diagram drawn in our Fig. 121. Here the steam-admission is indicated in the upper portion, such as we should find it with the Trick slide-valve; the valve paths are to be taken two-fold, to receive the true steam-passage area; the latter is smaller than the area of the port a. Our illustration teaches us, that this cross-section is rapidly attained, and after remaining constant, also diminishes very rapidly. The bottom part of the Figure, refers to the exhaust. When the valve B, has travelled from its central position MS, to the extent of $(s + i)$ to the right, the exhaust begins gradually to increase, till already before its greatest deviation $= r$, is reached, the port a is fully opened out. The inner slide A, remains in this position, till the valve B, has travelled over the distance $2s$, which corresponds to the piston-positions from 0·15 to 0·73 stroke. From this position, the motion of the inner slide is again indicated by a curved line, whereas the movement of the outer slide proceeds uninterruptedly as shewn by the dotted curve. After a travel $= (s - i)$, behind the central position MS, the port is closed. If it be desired to repeat this action during the next piston-stroke, the two slides will now be moving towards the left, and the motion of the inner slide will have again to be traced by the ellipse.

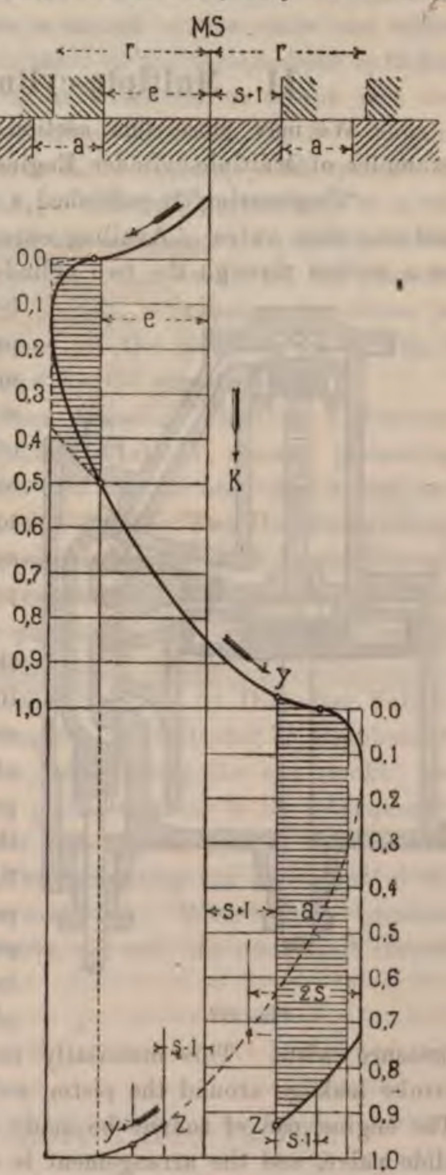


Fig. 121.

For moderately high-speeded engines — of a normal piston-speed of $6^1/_2$ ft. — the Ehrhardt slide may be said to effect an almost perfect steam-distribution, and on account of its simplicity it adapts itself both to Stationary-, Locomotive-, and to Winding-engines etc. It possesses the additional advantage of being steam-tight in a remarkable degree; for should the admission-valve not lie flat and tight, a direct leakage of steam cannot take place, inasmuch as the steam will then escape just on to that side of the piston, where it is being required — i. e. on the effective steam-pressure side.

11. Multiple-cylinder Engines, working with one Slide.

We may close this section on Valve-gears working with one slide, by adding a few examples of Multiple-cylinder Engines, also working with one slide.

"Engineering"*) published a small Compound Launch Engine, working with two cylinders and one slide valve. Availing ourselves of this description and engraving, our Fig. 122 gives us a section through the two cylinders and valve chest. The Engine was designed and patented by Mr. George Kingdon, of Kingswear, near Dartmouth. The principal points in it are, a single valve governing the admission of steam to both cylinders, and a grooved piston rod which obviates the necessity for a high-pressure gland, thereby effecting a considerable saving of space as compared with the ordinary type of tandem engine. Both cylinders are arranged to carry the steam through about nine-tenths of the stroke, and their areas are made proportional to the number of expansions required.

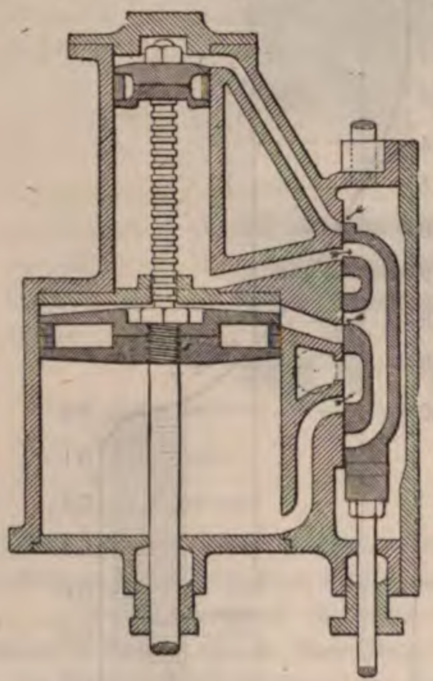


Fig. 122.

As will be seen, there is no receiver; the steam passes through the slide valve, from the high to the low-pressure cylinder, and while doing so is prevented from cooling by the steam at boiler pressure with which it is surrounded. The rod of the high-pressure piston is formed with annular grooves and projecting rings, which rings fit the wall of the aperture in the partition plate between the two cylinders, and form a steam-tight joint at that part, whereby the usual stuffing-box is dispensed with. It will be noticed that it is only during the up-stroke that there is a material difference of pressure on the two sides of the central partition, and during that stroke the piston rod is moving towards that cylinder in which the higher-pressure exists. This materially increases the efficiency of the arrangement. During the down-stroke leakage around the piston rod from the upper to the lower cylinder is of no importance. The engine can of course be made either with equilibrium piston valve, or with the ordinary slide valve, and the arrangement is applicable to all forms of compound engines. In the case of the small engine shown by our engraving the cylinders are not steam jacketed, but engines of any size might of course be made so.

An engine of this construction has been running, "according to Engineering", for some months, and has given complete satisfaction as to work given out for the steam used, and also

*) d. June 25th 1880.

as regards saving of trouble and durability of working parts. In this engine 15 indicated horse power have been given out from a high-pressure cylinder of $3^3/_4$ in. diameter and 7 in. stroke.

The Engine of Mr. Dubuc of Paris, as illustrated on our Supplement-Plate 22, Figs. 1—4, works on the compound-principle. The steam distribution at each cylinder is effected by one slide, hence the steam-expansion is constant. The governor works on to a throttle-valve, whence the steam passing through the shut-off valve, enters the valve-chest of the high-pressure cylinder. After performing its duty, the steam enters the receiver, which is formed by the space cast under the cylinders, and the steam is then conducted into the valve chest of the low-pressure cylinder. After expanding to about atmospheric pressure, the steam is next allowed to escape into the atmosphere. This steam-action takes place, when the two cock-valves shewn in Fig. 3 — Supplement-Plate 22 — are open; the additional arrangement has been made to allow each cylinder to work independently of the other, when this is required. Thus, if the small cylinder is to work by itself, the valve leading to the large cylinder is closed, and the cock shewn in section under the receiver is opened, allowing the steam to escape. If, on the other hand, the low-pressure cylinder is to work alone, then the valve shewn in Fig. 1 is opened, so causing the steam to enter direct into the steam-chest of the large cylinder, whereas all the cocks shewn in Fig. 3 are closed. In all the three cases, the steam-supply is regulated by the throttle-valve.

The single acting Compound Coupled Engines of Messrs. Macabies Thiollier & Guéraud of St. Chamond, is of the trunk-type (as our Figs. 1—3, Supplement-Plate IV, shews), possessing neither piston nor cross-head. High and low-pressure cylinders are cast in one, and a cast-iron connecting rod is used, as the same is only subject to compressive strains. Two D-slides working off eccentrics, effect the steam-distribution. The port for live-steam is marked with 1, and through the port 2 the steam of the high-pressure cylinder of the one engine, is led to the passage 3^1 of the low-pressure cylinder of the other engine, because the pistons of the two engines run in opposite directions. The ports 4, exhaust into the open air.

The single acting Compound Engines built by Messrs. Valck-Verey of St. Dié, after Vallet's patent, well deserve the name of "box-engine"; one of these engines is illustrated on Supplement-Plate IV, Figs. 4—5. Though merely possessing one cylinder, still during the one stroke, the live steam is passed through the port 1 on to the ring-formed piston surface, to be subsequently led for the returning stroke behind the larger back piston-area through the port 2; the steam is next allowed to pass into the atmosphere through port 3. The connecting rod is formed in the style of a buckle, and the eccentric is motioned by a counter-crank-pin. With a boiler-pressure of 6 atm. and a 9·84 in (250 mm.) stroke, and running at 150 revs. per min. the main-shaft throws off $12^1/_2$ *HP.*

B. Engines working with two or more Slide-valves.

I. Expansion-valve working on fixed surface (Double-chambered Valve-chest.)

Valve-gears working with two valves, owe their origin to the fact, that the compression of the steam in front of the piston, such as we have found to occur in the valve-gears working with one slide, is detrimental with high expansion. As a rule, in these valve-gears, the distribution of the steam proceeds in such a manner, that the expansion valve only effects the steam cut-off, whereas the beginning of steam-admission as well as beginning and termination of the exhaust are regulated by the distributing or main-slide. The corresponding valve-gears may be classed into two divisions. In the one, we find two steam-chambers, placed over each other; the bottom chamber contains the main-slide, whilst the top chamber has the expansion-valve sliding on a kind of grid dividing these two chambers. In the second division, the expansion-valve is made to slide directly on the back of the through ported main-slide, and only one valve-chest is appended.

Engines working with these double-chambered valve-chests, are now seldom constructed, but the arrangement of one of these valve-gears is shewn in Fig. 123. The main-slide A is here, worked as usually from an eccentric (of an advance-angle $= \delta$, and eccentricity $= r$) whilst a second eccentric (of eccentricity r_0 and advance-angle δ_0) drives the expansion-valve. To learn the function of the expansion-valve, we may again apply the circular-diagram (Fig. 124). We have adopted the same lettering to the expansion-valve magnitudes, as we have before applied to the main-slide, excepting that we have appended an o thereto, as shewn in Fig. 124. Assuming the valve B to be on its central position, we have taken s to equal distance of the working edges 1 and 2

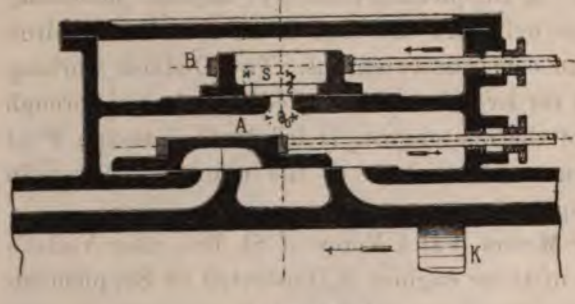


Fig. 123.

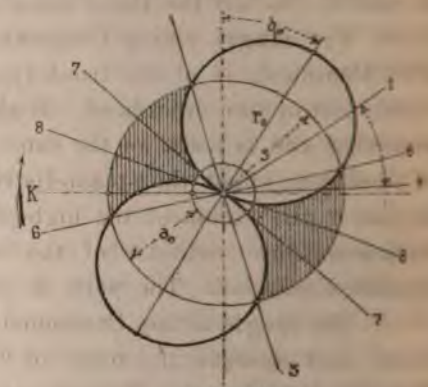


Fig. 124.

(Fig. 123). If a circle is described round O, to radius s, and a second concentric circle be similarly drawn to a radius equalling the port openings a_0 — (i. e. $s - a_0$) — then the points of intersection of these two circles, with the valve-circle, give us all the noteworthy positions of the slide. In the inscribed crank position — Fig. 124 — No. 6, steam-admission begins, which must always take place before the dead-centre. In No. 8 position, the port a is quite opened out, and in crank position 7 it commences to decrease, which contraction is completed with position 5, whilst exhaust now begins. If in our diagram, No. 1 indicate the crank-position at which the main-slide closes the admission-port, then it is evident that No. 6 may not come before No. 1, as otherwise steam would be given twice. Similarly, this position may not lie behind No. 4, in which the main-slide begins to open. For this reason, the obtaining of a *variable* expansion with this valve-gear type is confined to very narrow limits.

A plate is often used as expansion-valve, which plate in its central position, covers the port. To reduce the valve stroke, it is well to arrange several ports side by side, which are then covered by plates held together; in this manner we obtain the so called "grid-valves" as represented in our Fig. 125. Here, s merely denotes the external lap, with which the circle is described as in Fig. 124. The chief objection rightly raised against the double chambered valve-chest, is that the steam in the main-slide chest takes part in the expansion, whereby the injurious effects of the clearance-space are considerably augmented.

The expansion is most simply altered in these gears, by turning the expansion eccentric, — i. e. by changing the advance angle δ. It is advisable however, so as to extend the limits of expansion as much as possible, to alter the eccentricity r_0, simultaneously with the advance angle δ_0, in which case the centre of the valve-circle moves in a curve, or δ_0 and r_0 are not interfered with, but the distance s of the working edges of the valve is changed. All expansion-mechanisms may be traced back to one of these three cases, as will be rendered apparent in the following examples.

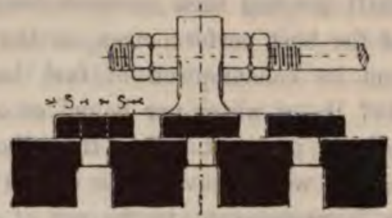


Fig. 125.

1. Maschinenbau-Actiengesellschaft (late Danek & Co.) of Prague.

(With illustrations on Supplement-Plate 4, Figs. 1—6.)

The Rolling-mill engine illustrated in Supplement-Plate 4, Figs. 1—6, and made by the forementioned Engineering Firm, merely allows the expansion-eccentric to be turned whilst the engine is stopped, and we thereby obtain a range of variable expansion between 10 and 50% of the stroke.

The main-slide is of the double-ported type, whereas as shewn by Fig. 4, the live steam may be conducted thereto in two ways; for according to the position of the oscillating valve — not inserted in our drawing — the steam is either taken to the main-slide *directly*, whereby the expansion-valve is not used, or *indirectly* through the expansion-valve, which occurs with the empty running of the rolls. The expansion-valve face-bearing is inclined, and furnished with three slits, over which a grid-valve slides. This arrangement has no doubt been adopted owing to the reduced friction due to the small eccentricity applied.

This massively proportioned engine has a cylinder bore of 31·10 in. (790 mm.) and a stroke of 49·5 in. (1260 mm.); running at 80 revs. per min., its average piston-speed calculates itself at (3·36 m.) per sec. To enable the valve spindles to be brought sufficiently close up to the cylinder, the eccentrics are keyed on a separate shaft driven by a couple of equally sized wheels (43·37 in. = 1100 mm.) off the crank-shaft. This eccentric-shaft runs in bearings cast with the bed-plate. Noteworthy is the design of the sliding-block, which is made flat at the top, but furnished with a gutter at its under-side to prevent the lubricating-oil from dripping off the sliding surface. Our Fig. 5, similarly shews the plan adopted for fastening the motion bars to the engine-bed, and in Fig. 6, we have a section through the crank-shaft bearing.

2. Davey, Paxman and Co., of Colchester.

(With illustrations on Supplement-Plate XI, Figs. 1—6.)

This expansion-gear, applied by the forementioned Firm to Portable Engines, is worked from the sliding collar of the governor.

The engine which we illustrate on Supplement-Plate XI, Figs. 1—6, was exhibited at Royal Agricultural Society's Show at Kilburn in 1879, and has not up to the time of writing, been improved upon. "The Engineer"* in commenting on this construction, states that it may

* d. 4 July, 1879, pg. 5.

be remembered that at the Cardiff Show in 1872, this Firm sent a portable engine for trial, which gave an excellent duty. It was the first racing engine ever made by the firm, and had not a crank shaft bearing been screwed down too tight, and heated in consequence, it would have made one of the best performances on the brake on record. Its mechanical time was 4 hours 18·17 min, and its consumption of fuel but 3·23 lb. of coal per horse per hour. The boiler evaporated 9·97 lb. of water per pound of coal, or about 1·33 lb. less than that of the first-prize engine, or, say, 11 per cent. less. Had the boilers been equally efficient, Messrs. Davey, Paxman & Co.'s engine would have made over $4^3/_4$ hours mechanical time. This excellent performance was due in large measure to the use of a gridiron cut-off valve worked by a double cam on the crank shaft. The expansion curve obtained by this means was very perfect; indeed no better diagrams were obtained. There were however certain drawbacks to this method of driving a cut-off valve; hence we merely shew it in Fig. 126. In the engine illustrated, Mr. Paxman has retained the good features of the gridiron cut-off while getting rid of the cam. The engine is 12-horse power, horizontal, of the girder type. The arrangements for setting up the crosshead bearings and those of the crank shaft are very ingenious and well worked out. The valve gear consists of an ordinary slide valve with full travel and very little lap or lead. It works as close as possible to a partition in the same plane, in the valve box. In this partition three ports are made, and over them slides a gridiron valve, which is the cut-off valve, as no steam can get to the main or distributing valve without passing first through the ports in the partition before mentioned. The cut-off valve is driven in the following way: — On a stud in the frame revolve two small eccentrics pinned to a toothed wheel, the rods of these eccentrics actuate a link uniting their ends, as shewn in our engraving, and this link drives the spindle of the cut-off valve. On the crank shaft is keyed a wheel just twice the diameter of that carrying the eccentrics, which last accordingly make two revolutions for one of the engine. The eccentrics are called positive and negative, and are so set that while one tends always to keep the cut-off valve open the whole time a steam port is open, the other tends equally to keep the gridiron ports shut whenever a main steam port is uncovered by the slide valve. According to the position of the link, one or other will have most control over the cut-off valve. A high speed governor of the Porter type is connected direct to the end of the link and shifts it to any required position. We have seen this engine under steam, and its action was in every way satisfactory; the wheels being carefully cut, run practically without noise; the governor acts freely. There is no complication of parts, and altogether this may perhaps be regarded as one of the most satisfactory automatic expansion gears of the many which have been brought out of late years, while the engine, taken as a whole, is strong, neat, and serviceable.

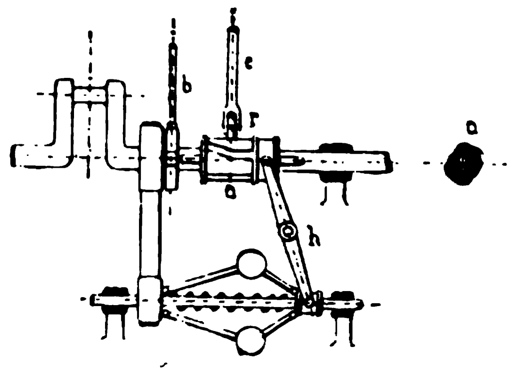


Fig. 126.

3. Ch. Beer, of Jemeppe.

(With illustrations on Supplement-Plate XI, Figs. 7—10.)

The three cylinder engine of Mr. Ch. Beer, illustrated in Figs. 7—10 (Supplement-Plate XI running at 187 revs. per min. developed 25—68 *HP.* according as the expansion-grade was altered from $^1/_4$ to $^8/_{10}$ths of the stroke; this change in the cut-off is effected by rotary-valves, arranged over the valve-chests containing the slide-valves.

Parallel to the crank-shaft, and outside the engine-casing, a second equally fast revolving shaft is arranged, on which three eccentrics are keyed, for working the three slide-valves. Moreover the governor is driven by equal bevel-gear from this last mentioned shaft; to the upper part of the governor spindle a bevel-wheel is fixed, gearing into another of double diameter; consequently the shaft of the latter will revolve at half the crank-shaft speed. It is easy to perceive from our illustrations, that the rotary cock-valves are worked by this slow-revolving shaft, and consequently, (and to balance these cocks as well) these valves have two symmetrical steam-ways inserted, which alternately fulfil the same functions.

To effect a variable expansion, the cock-steam-ways and their faces are cut-off obliquely, and therefore if a relative advance or retreat of any of these cocks takes place, the corresponding sliding surfaces are closed sooner or later. This changeable motion is transmitted by the governor direct on to the conical driving pinion.

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4. A. Salaba, of Prague.

(With illustrations on Supplement-Plate 4, Figs. 7—15).

It has already been observed that valve-gears, motioned in quick starts, may answer all the requirements attending a rational steam-distribution. The 40 *HP.* Engine illustrated in Figs. 7—15, Supplement-Plate 4, belongs to this category. The two halves of the divided main-slide, *C C* — appearing at first sight to move in one valve-chest, though actually working in a two-chambered valve-box — are brought as close up to the cylinder ends as possible; these two halves are mounted on the one spindle *A* — Fig. 12 —, which passes steam-tight through the valve-chest partition *B*. The passage of the steam from the one valve-chamber into the other is prevented by certain grooves cut in the valve-rod.

We find in the outer valve-chest *D*, — supplied with live steam through the inlet *F* —, the two expansion-valves *E E*, similarly fitted to one spindle and receiving their motion from the eccentric-rod *G*, by means of a certain mechanism placed in front of the valve-chest. This rod *G* works in alternate horizontal directions a block *H* of the form of a four-edged pipe, on the bracket *K*. This block *H* is furnished with two wedge-formed knock-pieces *J J*, the surfaces of which alternately come in contact with the inclined planes of a steel double-wedge *L*. The latter is so connected with the prolonged valve-spindle, that the two may take up a horizontal movement together, whilst an additional vertical motion may be assumed by this wedge, which vertical motion is effected by the rod *N* leading to the governor.

It follows from the preceding remarks, that the expansion-slides *E E* have no continuous movement, but on the contrary an irregular motion with each stroke, which lasts till the wedge *J* comes in contact with the double-wedge *L*. It is further evident, that the valve path or stroke will depend on the amount of play *s*, given between these knocking surfaces, or what is the same thing, the time during which the valve-ports remain open — i. e. cut-off — will similarly be dependent on this play *s*. The more this play *s*, is augmented, as caused by the governor raising the double wedge, the more will the motion of the expansion-valves be retarded, and cut-off will ensue correspondingly later, and vice versa.

Our wood-cut Fig. 127, gives us its valve-diagram, under an assumed cut-off at $^1/_4$ stroke. A is thereby the valve-circle of the main-slide, B and B_1 are the circles of the expansion-eccentric; if we observe, that the stroke of the expansion valve, is smaller by ($2 \times s$) than the eccentric stroke ($= 2\ r_0$), the expansion-valve on attaining its maximal-deviation, will not commence to return, until the eccentric has moved over a distance $= (2s)$. If we therefore describe a circle round the centre, to the radius of ($r_0 - 2s$), then we find in the two points of intersection with the circles B and B_1, the corresponding crank-positions C, and E, at which the expansion-valve begins to move. The commencement of the stand-still period of the expansion-slide, falls in the crank-positions D, and F; consequently motion ensues on the arc from C to D, and then from E to F, whilst between these intervals, the slide remains motionless.


Fig. 127.

If b, (Supplement-Plate 4, Fig. 12) represent the distance of the working edges in the neutral position of the slide, and if we describe a circle to a radius $= (s + b)$ round the centre, then this circle encloses an area (shewn horizontally shaded), the radial dimensions of which represent the width of the openings in the passages O, whereas the portion shewn vertically lined gives us the extent to which these ports are already covered by the valve. We perceive, that in the valve's extreme position, the one is *quite closed*, whilst the other port is *quite open*. According to the dimensions adopted, we obtain a minimum cut-off of 10% (with $s = o$) and a maximum cut-off of 72% (with $b + s = r_0$).

The Engine here illustrated has a cylinder of 15·75 in (400 m.) diameter, with a stroke of 27·56 (700 mm.), and it runs at 70 revs. per min.

5. The Allen-Engine.

(With illustrations on Supplement-Plate 5.)

The Allen-engine, owes its fundamental proportioning to Mr. Charles T. Porter of Boston. It attracted much attention at the first International Exhibitions of London and Paris, because, independently of its peculiar design, it worked at a speed, which up to that time had not been practically attained. A quick and yet noiseless working, in connection with a Porter-governor, reacting on an expansion gear, are the chief characteristics of the Allen-engine.

It belongs to the engine-group we are now discussing, inasmuch as its expansion-valve — performing the steam-admission — also slides on a stationary surface. Each part of this divided slide, which is designed far outwards on each cylinder-end, to shorten the steam-ports, consists of a rectangular frame, running steam-tight between its ports-surface and a back-partition; it is thus balanced, and in opening, simultaneously produces four passages for the steam.

We have repeated two designs of the Allen-engine on Supplement-Plate 5, of which Figs. 1—4, represent the older construction of Whitworth & Co., of Manchester, who have now discontinued its build. The far improved machine of Chr. Porter is shewn in Figs. 5—8, of the same Plate. As will be observed the two valve-gears applied to these engines differ greatly from each other. In the older design, the eccentric is keyed under an advance of 90° or dismetrically opposite to the crank on the crank-shaft; a Fink link *a* is attached to the eccentric strap, and it is placed under governor-control through the rod *b* and lever *c*. In addition, the rods d d_1 are also connected with this link, and these rods work the inlet-valves k k_1 by means of a crank mechanism and the spindles e e_1. Each of the admission-valves receives its own motion, which modified by the governor, necessitates these valves to open out the ports more or less, according to circumstances. A maximal declination of the link-block answers to the maximal cut-off at $^1/_2$ stroke. The upper end of the link is rigidly connected to the rod *f*, which through the intervention of the crank f_1 works the exhaust-valve spindles g and g_1. The divided exhaust-valves h and h_1 lie between the cylinder and the admission-valves, and are so designed as to offer two steam-outlets when opening.

This Engine, of 11·81 in. (300 mm.) cylinder bore, and 22·84 in. (580 mm.) stroke, can run at 150—200 revs. per min., which corresponds to the considerable piston-speed of (2·9—3·8 m.) 9′ 6″—12′ 5$^1/_2$″ per second.

In the new "Allen-Engine" — Figs. 5—8 — both the internal and external valve-gear, are altered. The two admission-valves, sliding between the cylinder-core and the valve-chest covers, are rigidly connected together and placed close up to the cylinder. The exhaust-valves are arranged on the other cylinder side, and are worked in a similar manner to the admission valves, and are consequently also balanced. The exhaust ports are larger than the inlet-passages, and are designed so low as to admit of the condensed steam freely passing off — vide Fig. 7 —.

As in the older design, so also here, the two valve-systems are worked by a Fink-link. The exhaust-valves receive their immutable motion from the end *a* of the link. Our Figs. 5 and 6 shew the connection effected through the rod *b*, the lever *c*, the lateral spindle *d* (passing through the engine-bed) and the valve-spindles on the other cylinder-side. On account of the uniform motion of the admission valves, only one rod *e* is connected to the link-block, whilst its opposite end is made to unhang for starting the engine by hand.

The engine shewn in Figs. 5—8, has a cylinder diameter of 16 in. (406 mm.) and a stroke of 30 in. (762 mm.). It runs at 125 revs. per min., and consequently its mean piston-speed equals (3·14 m.) 11′ 2$^1/_2$″ per sec.

6. Lindley's Patent cut-off gear.

This gear is a new application of the form of governor known as Hartnell's, which is applied by Messrs. Deakin, Parker & Co., to engines of moderate size, and running say 80 or 100 revs. per minute or more.

The Hartnell governor as made by the last mentioned Firm, for small engines is shown in Fig. 128, *a* and *a′* being flat steel links connecting the governor weights to the expansion-eccentric, the outward movement of the weights of course twisting round the eccentric, and thus altering the phase of its motion as compared with that of the main-eccentric, and cutting-off the steam earlier. This governor as described above and as shewn in Fig. 128, gives excellant results, when carefully made and the springs properly adjusted. At low-speeds however, say below 80 revs., the above described form of governor becomes less sensitive and less powerful and is consequently not well adapted, especially where the engine is required to run with regularity under any great variations of load; and the object of a recent patent taken out by Mr. Lindley, (a member of the Firm of Messrs. Deakin, Parker & Co.) is to enable the "drum" governor to be used on Engines whose speed is low — *e. g.* 40 or 45 revs. per minute.

In this arrangement the "drum"-governor is mounted on a lay-shaft, which is driven by suitable gearing at twice the speed of the crank-shaft of engine. The expansion eccentric is also mounted on this shaft, and coupled up to the weights by means of links as shewn in Fig. 128.

The expansion-eccentric therefore makes two revolutions, and the expansion-valve two reciprocations for each stroke of the engine. To enable this arrangement to give the proper distribution of steam, the valve-chest has a plate fixed in it, which is adjusted so as to bear steam tight against the back of the main-valve. In this plate on the inner side is a central port always in communication, with the steam-passages in the main-valve and through them to either end of the steam-cylinder as may be determined by the position of the main-valve.

On the outer face of the central-plate are formed one or more ports communicating with the central cavity, and against these ports slides the expansion-valve, which has cut-off edges corresponding to those of the ports in the plate. The cut-off valve is single acting; that is to say, steam is always cut-off at the same edge, consequently the steam is admitted through the plate and main-valve to the cylinder twice only in each revolution of the engine, or once in each stroke. The amount of steam admitted to the cylinder at each stroke depends on the position of the cut-off eccentric, thus at the earlier cut-off the expansion-valve is on the point of closing, as the main-valve opens to the cylinder, and at later cuts off, the main and cut off valves open simultaneously in which case steam is cut-off in the steam cylinder at about half stroke or less according to the amount of lead given to the valves; some of the advantages of this arrangement are.

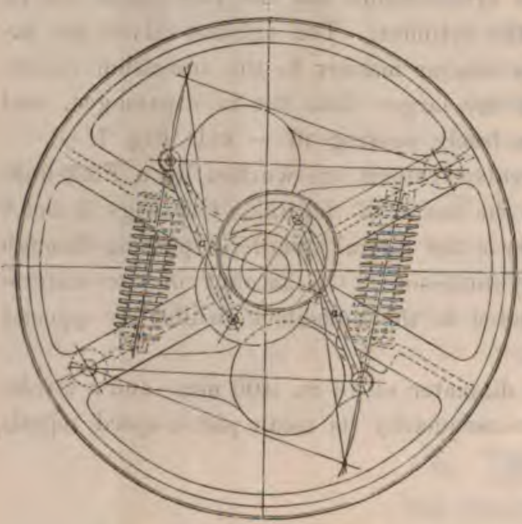

Fig. 128.

1st. The steam is cut off very quickly on account of the accelerated speed of rotation of the cut-off eccentric, and also because cut-off takes place during the period of quickest travel of the eccentric.

2nd. The governor is driven by gearing and thus there is no strap to break or slip.

3rd. The expansion eccentric being on a small shaft, is much smaller and lighter than usual, and therefore takes much less power to move it.

4. Any variation in speed required to make, the governor weights more through their whole path, and alter cut-off from earliest to latest point, is halved in the speed of engine and its regularity *consequently* increased.

In the 40 *HP.* (nominal) horizontal high-pressure condensing engine, fitted with this automatic expansion gear, and illustrated in side-elevation and plan in Figs. 129 and 130, the Bed is of strong cast iron, of "Box" section, with all seatings for cylinder, slide bars, pedestal, &c, truly planed.

The Cylinder is 20″ diameter, and suits a 42″ stroke; it is made of hard close grained metal, truly planed and bored. The covers are turned and polished, and secured to the cylinder by the necessary bolts and faced nuts. It has an extra deep stuffing-box, brass seated, with a turned and polished brass-bushed gland. In addition the cylinder is lagged with silicate cotton, and has mahogany strips and brass bands.

The piston is of cast iron, and provided with two broad cast iron rings expanded by means of a special rolled steel coil.

The piston rod is of Bessemer steel, $3^{1}/_{8}''$ diameter, and firmly secured to the piston and crosshead.

The slide valves are of the same close-grained metal as the cylinder, and worked by means of eccentrics. The expansion valve is balanced, and its movements are controlled as already explained. The valve spindles are of the best wrought iron, and are attached to two square cast iron slides working in a suitable bracket on the bed.

The governor is geared so as to run at twice the speed of crank shaft.

The crank shaft is of the best hammered scrap iron, finished bright, $7^{1}/_{2}''$ diameter, 6′ long, with a neck 6″ diameter, 10″ long, and outer bearing $7^{1}/_{2}''$ diameter, 12″ long.

The crank forms a polished cast iron balanced disc, shrunk and keyed on the shaft.

Fig. 129.

Fig. 130.

The crank pin is of Bessemer steel, 4″ diameter, 6″ long in bearing; it is shrunk and keyed into the crank. The crosshead is wrought iron with jaws slotted out of the solid and is finished bright all over.

The connecting rod is of the best hammered iron, with bright wrought iron straps, screwed gibs and cotters, and gun metal steps at each end. The length is $2^1/_2$ times the stroke.

The Fly-wheel is 80 cwts. in weight, and 14 ft. diameter, securely keyed to shaft, speed 60 revs. per minute. The Feed-pump is of ample size and is worked from the crosshead pin. The valves and seatings are of brass.

The Condenser is of ample capacity and is placed behind the cylinder. The air-pump is double acting; brass grids, guards, bolts, and india-rubber valves. The piston and rings are entirely of brass, and the air-pump rod covered with brass.*

II. Expansion-valves, working on the back of the main-slide. (Double-valves.)

This group comprises the so-called Double-valves, in which the expansion-valve *B* — Fig. 131 — slides on a double through-ported main-slide *A*. The latter, driven off an eccentric, would perform — if used alone — the same steam-distribution as a simple *D*-slide. If we presume the bottom slide to be stationary, and the top slide alone moveable, then the steam-admission and emission, will take place in precisely the same manner as we noticed in the preceding valve-gear group. But as the bottom slide also travels, we have here to distinguish, the relative movement of the expansion slide in regard to the bottom or main-slide. The arrangement of this valve-design may be seen from Fig. 128, though we must presume these valves to be uncoupled from their eccentrics, since when working, the two could never be in their neutral positions at one and the same time. The main-slide is worked off an eccentric (with eccentricity $= r$ and advance-angle $= \delta$) whilst the expansion-valve is driven off a second eccentric, whose eccentricity and advance-angle, we may respectively designate by r_0 and δ_0; the valve-circles of these two are drawn in our Fig. 132. The first of these circles, described over $O\ D = r$, as radius is the main-slide circle; the second circle of radius $= O\ D_0$ $= r_0$, refers to the expansion-valve circle; the chords of these two circles gives us the travels performed by each of these slides. The "relative declination", by which we understand the distance between the centre of the top valve, from the centre of the bottom slide, represents itself as the difference — resp. the sum — of the travel-increments. The first ensues, till one of the slides (moving in the direction of the inscribed arrow) returns on its central-position, which occurs with the expansion-valve in the crank-position $O\ T$, corresponding to the tangent of the expansion-slide circle; from this position, the sum of the travel-increments will represent the "relative declination", and will continue to do so, until the main-slide,

Fig. 131.

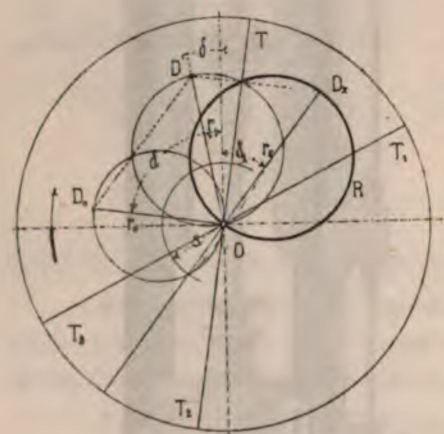

Fig. 132.

* A modification of the valves in this arrangement, permits of the ports being shortened, and of the clearance-spaces being reduced.

also passes over its central position; this occurs in crank-position $O\ T_1$, the tangent to the main-slide circle. Consequently, the relative slide-travel between the crank positions $T_3 - T$ and $T_1 - T_2$ equals the *difference* of the travel-increments, whereas during the intermediate crank-positions $T - T_1$ and $T_2 - T_3$, this value is composed of the *sum* of such increments.

If, according to this method, we draw in the *relative declinations* as radius-vector, then the same become encircled by a circle R — (providing we only take half a revolution into consideration) — which we may term the "*relative slide-circle*". The diameter and the position of this circle, may easily be determined in the following manner, without resorting to the forementioned process:

The ends D and D_0 of the slide-circle diameters, are connected together by a straight line, and through centre O a parallel is drawn thereto. The "relative slide-circle" diameter coincides in direction with this parallel line, and its length $O\ D_x = D\ D_0$. *By completing the parallelogram $O\ D_{\bar{0}}$, $D\ D_x$, over the eccentricities, we obtain the diameter and position of the relative slide-circle.* If the relative slide-circle be also drawn in the lower portion of our diagram, then the circle shewn in Fig. 132, gives us the declinations of the top-slide over the bottom slide to the right, whilst the bottom circle would indicate this to the left. As a rule, the circle $O\ D_x$ merely requires drawing in.

If we compare the diagrams of Fig. 124, and of Fig. 132, we arrive at the same results in each case; the difference is merely, that the eccentricity r_0 must be keyed on with *negative* advance, when the expansion-valve works on a stationary surface, whereas in place of $O\ D_0 = r_0$ we get the relative eccentricity $O\ D_x = r_x$, when the upper slide works on the bottom slide.

It follows, that if a circle be described round O to a radius equalling the distance s of the working edges — Fig. 132 —, then the points of intersection of this last named circle with the relative valve-circle, will indicate the positions of the crank, at which the ports of the main-slide will be opened or closed through the expansion-valve.

A change in the expansion, will also here take place by alteration of the three following magnitudes:

1ly by altering the distance s of the slide-edges working together;

2ly by altering of δ_x, the advance-angle of the relative (ideal) eccentric, and

3ly by altering its eccentricity r_x.

In ordinary practice, r_0 and δ_0 are simultaneously altered, whence it follows, that we have to deal with two different groups of variable expansion gears, in which

a) *the expansion is regulated by altering both throw and advance of the expansion-eccentric.* In these cases, the expansion-slide is usually only a plate;

b) *the expansion is regulated by altering the distance of those slide edges working together.* Here, the expansion-valve is usually of the divided type, i. e. consists of two adjustable plates.

We may first deal with the constructive examples of the first group. It is apparent, that the various mechanisms which are applied to alter the throw and advance-angle of those eccentrics working one slide, will also be applicable to the group now under discussion. As a rule however, link-motion is utilised to this end, and the link used is then either worked by one or two eccentrics. The application of the link-motion recommends itself, because it exercises in its various positions such an influence on the valve-travel, as if the slide were worked from one eccentric with changeable lead and variable throw. By balancing the expansion-valve, it may be regulated direct from the governor.

The valve-arrangements for these gears are of divers designs, still similarly to the distinction we have elsewhere adopted, we may also here distinguish expansion-valves, which in their central-position have opened out the port of the main-slide to the extent of s — vide Fig. 133 — from such, as overlap in this neutral position, the port of the main-slide, to an extent $= s$, as inscribed in Fig. 131; in the first named cases, the lead angle δ_0 is generally larger than $\measuredangle \delta$, whereas in the second category, the expansion-eccentric is keyed on under a negative advance-angle.

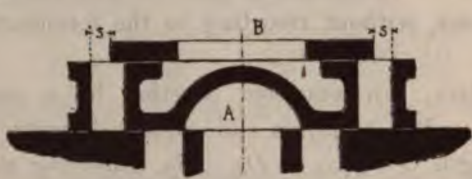

Fig. 133.

Fig. 134.

In drawing the corresponding diagram, it might appear doubtful, as to which side the parallelogram should be delineated, so as to obtain the "relative slide-circles" belonging to the valve-circles. In answer thereto, the rule applies, that: the diameter of the relative slide-circle is obtained, by drawing a parallelogram, whose diagonal is the main-slide eccentricity r, and whose side is the expansion-eccentricity r_0. If δ_0 and r_0 are now simultaneously altered, the relative slide-circle will be altered each time, its centre moving accordingly on a curve or on a straight line. By way of an example, this curve is an arc described from the diagram-centre, in the special case where the expansion-eccentric turns on the shaft.*)

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a. Expansion-plate, with variable throw and advance.

1. G. A. Biffar, of Fratte (Italy).

(With illustrations on Supplement-Plate XII.)

In the 16 *HP.* Horizontal Coupled Engine, illustrated on Supplement-Plate XII, the governor works direct and turns the expansion-eccentric. The eccentrics of the main-slides, are keyed on the crank-shaft running at 115 revs. per min.; the middle of the crank-shaft carries a worm-wheel, which gears into a second worm-wheel mounted on a separate shaft, carrying a bevel wheel, which in its turn drives the vertical governor-spindle; the latter is worked to make 230 revolutions per minute (double the crank-shaft speed). The weight of the Porter-governor has a worm-wheel 6·29 in. (160 mm.) in breadth, attached to its lower end, which always gears on to a shaft on which the expansion-eccentrics are keyed; the rising or falling of the governor-balls will thus react on the expansion eccentric, accelerating or retarding their throw. The transmission caused by this last pair of worm-wheels in inversely proportional to the first named couple on the crank-shaft, so that the expansion-shaft is made to rotate at 115 revs. per min.

As soon as the governor-balls rise, this effect makes itself felt on the continuous rotary movement of the expansion-shaft, by accelerating the motion of the latter, whereby the negative

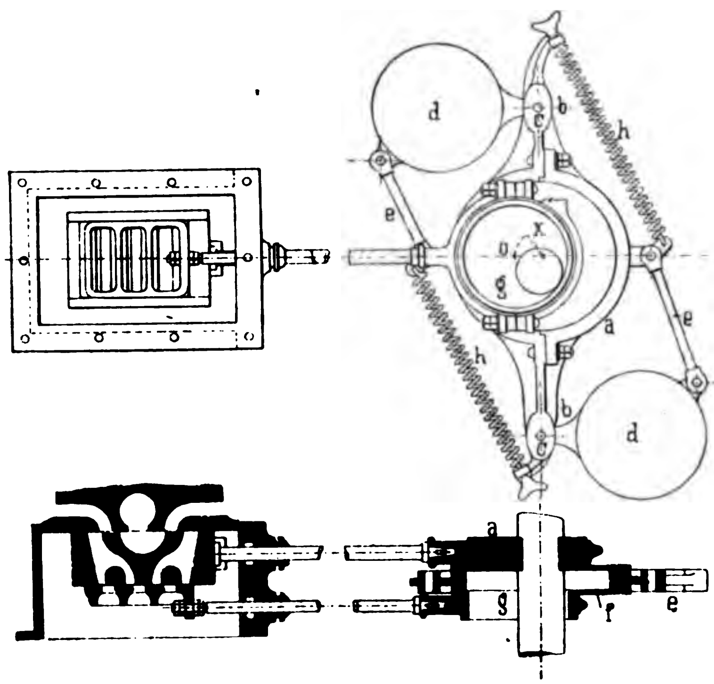
*) In dealing with the various valve-gears, these cases will be specially referred to.

advance-angle of the expansion-eccentric to the crank is augmented, and earlier steam cut-off ensues. Precisely the contrary occurs, with falling governor balls. By sliding the counter-weight on the governor-lever, the engine-speed may be altered for equal ball-positions, and this arrangement admits of a variable expansion of from $^1/_{12}$th to $^1/_3$rd of the piston-stroke.

2. Friedrich & Co., of Vienna.

A moderately simple expansion-governor, is illustrated in the annexed wood-cuts Figs. 135 and 136, and is constructed by Messrs. Friedrich & Co., of Vienna. The expansion-eccentric *g* is here connected with an eccentric-disc *f*, which under direct governor-control, alters through oscillating, both the eccentricity and the advance of the expansion-eccentric.

The circular-disc *a*, cast in one with the main-slide eccentric, has two arms *b b*, carrying two pins *c c*, which serve for suspending the weights *d d*. The eccentric disc *f* is connected in such a manner, with these weights *d d* by certain arms *e e*, that these weights after overcoming the tension of the springs, are able to turn it round, and as the expansion-eccentric is fixed to the disc *f*, the oscillation of the latter is transmitted to the expansion-eccentric.



Figs. 135—136.

The weights — shewn in their lowest position in our woodcut — when thrown outwardly — i. e. rising —, cause the eccentric-disc *f* to turn, and the centre of *o*, of the expansion-eccentric is thereby forced to move on the arc *o x*, but as in the position shewn it permits of the latest cut-off admissible taking place, it follows, that as this centre *o* is shifted and the advance-angle increased, so the resulting cut-off is hastened on to take place earlier. To this purpose, however, the expansion-valve when in its central-position, must close with a certain lap, the ports of the main-slide.

3. A. Ransome & Co., of London.

(With illustrations on Supplement-Plate 6, Figs. 1—5.)

For an illustration of the Horizontal Engine type constructed by Messrs. A. Ransome & Co., of London, the reader is referred to Supplement-Plate 6, Figs. 1—5, but as this engine was already described in Vol. II, page 154, we may pass on to:

4. Ch. Beer, of Jemeppes (Belgium).

(With illustrations on Supplement-Plate 10.)

The valve-gear applied to the heavy coupled Engines, illustrated in Figs. 7—22, on Supplement-Plate 10, effects the variation in its steam cut-off, by changing the advance-angle of the expansion-eccentric.

The steam-distribution to each cylinder is performed by six valves, two of these effecting admission, another couple performing emission, and the remaining two serving for the cut-off — i. e. expansion-slide —. By this arrangement the clearance spaces are reduced to a minimum. The admission slides are provided with two valve-spindles, to make way for the central expansion-valve spindle, and therefore we find three stuffing-boxes arranged side by side.

The admission and exhaust valves are worked from one eccentric, as our Figs. 13—15 shew, and this eccentric is mounted on the crank-shaft. The eccentric-rod (indicated by dotted lines) is connected through the lever *a*, to a small oscillating spindle *A* (Fig. 21), which is supported in a long sleeve on the engine bed; the other end of this spindle carries an arm, which is attached to the admission-valve spindles by two intermediate rods. The exhaust-valves are driven by lever and rod, off another spindle *B* running underneath the engine-frame, which valves are connected to the eccentric-lever in the same manner. The sliding surface of the valves, have two slots, to afford sufficient opening in respect to the small valve-travel; the inner slot becomes closed it is true, at the piston stroke end, still this exercises little effect with the slight piston-speed we meet in this example. The exhaust valves placed underneath, slide on special plates screwed on, so as to be pressed against their seating by the steam.

A third spindle *C* is used to drive the expansion-valve. It is mounted close up to the first spindle *A*, and receives its motion off a rod and lever *c* from an eccentric keyed on a lateral-shaft *K*. (Fig. 14). This shaft *K* is worked off the crank-shaft by the lay-shaft *n* and bevel-gear (Fig. 15). A friction disc *D* (Fig. 9) is mounted on this lay-shaft *n*, against which the disc *E* presses, owing to the weight of the governor to whose spindle-end, it is fitted; the disc *E* is therefore forced to participate in the rotary motion of the disc *D*.

The eccentric is turned by the following mechanism. The bevel-wheel *F* (Fig. 7), which drives the lateral shaft *K*, is not keyed fast on the latter, but works on a brass sleeve *H* (Fig. 11); this sleeve has a four fold thread, which fits into a similar thread on the shaft *K*. Moreover this sleeve *H* is supported by the governor-frame. The expansion-eccentric is also loosely mounted on the shaft *K*, being fixed (as shewn in Fig. 16), in this manner, the expansion-eccentric merely partakes of the rotary motion of its shaft. Each deviation of the lever *L* — Fig. 7 — motioned by the governor, effects an equal axial motion on to the shaft *K*, and this lateral movement, on account of the steep screw-pitch in the wheel *E* effects a partial turning of the same: in this manner an increased or retarded advance of the expansion-eccentric is obtained for both engines.

To vary the working-speed of the governor, the friction-disc D on the shaft n is made adjustable, thereby altering the velocity transmission between the discs D and E.

5. Arthur Rigg, Engineer of London.

(With illustrations on Supplement-Plate X.)

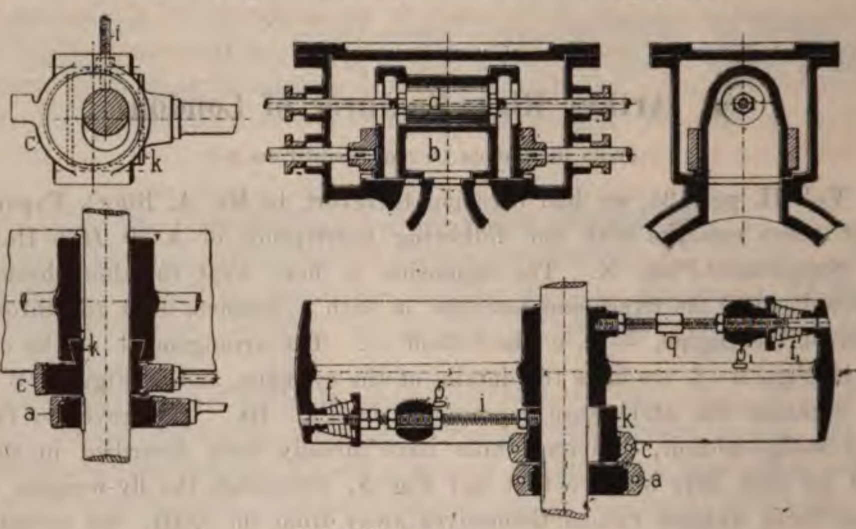
In our Vol. II, pg. 133, we had occasion to revert to Mr. A. Rigg's Expansion gear; we now supplement these remarks with the following description of a 10 *HP.* Horizontal-Engine, illustrated on Supplement-Plate X. The expansion is here kept variable through a governor, which is connected with the expansion-eccentric in such a manner, that the throw of the latter, alters the speed of the engine, — i. e. the cut-off —. The arrangement of the engine is shewn by Figs. 1—2; in Figs. 3—4, we have the details of the cylinder, and in Figs. 5—6 we have drawn the governor, whereas the slides are represented in Fig. 10. The governor forms an application of Dod's wedge-motion, and its details have already been described in the notice before alluded to, but we may here observe that our Fig. 5, represents the fly-weights in their lowest position. When these weights extend themselves away from the shaft, the eccentric is actuated, whereby its throw is increased, and cut-off hastened on. In constructing the diagram, which shews itself at its best under an angle of 90° between expansion-eccentric and crank, it should be remembered, that we have here to deal with a divided expansion-plate, covering the ports of the main-slide in their central position, whereas these, as we have already observed, generally are open during the neutral slide-position.

The live steam, enters first into the steam-jacket of the cylinder from its bottom side, so that any water, which may have accumulated in the steam pipes, is not taken into the valve-chest; a passage conducts the steam on to the top of the valve-chest. To prevent the spent-steam from cooling the cylinder metal, the exhaust passage is furnished with a special lining. The cylinder bore amounts to 10 in. (254 mm.); its stroke = 1 ft. 6 in. (457 mm.).

6. Carl Heinrich, Engineer of Prague.

We extract the expansion gear, illustrated in Figs. 137—141, from "Dingler's polyt. Journal". Its inventor, Mr. Carl Heinrich, designed it, with special regard to the requirements of High-speed Engines. The main-valve b is worked from a fixed eccentric a, whereas the eccentric c, drives the expansion-valve d; this eccentric c is slid on to the shaft, and has its hole bored with play, whilst rotary motion is imparted to it from the fly-wheel. For this purpose, a wedge-strap k, enables it to slide on the wheel-boss; a rod rigidly connected with the eccentric-ring and with the fly-wheel-rim, carries the governor weight g, the centrifugal action of which brings about the shifting of the expansion eccentric on its wedge-strap k. In this manner, the eccentricity as well as the advance-angle become altered, which action is best confirmed by our Fig. 137.

In order to bring back the weight g when the engine-speed is again slackened, we find a spiral-spring f introduced, and rendered adjustable by set-screw. Symmetrically arranged for balancing purposes, we find the counter-weight g_1 applied, which with regard to the variations of the centrifugal form, is similarly provided with spiral-spring. The nut *q* forming a counter-weight, serves for balancing the remainder of the working parts.

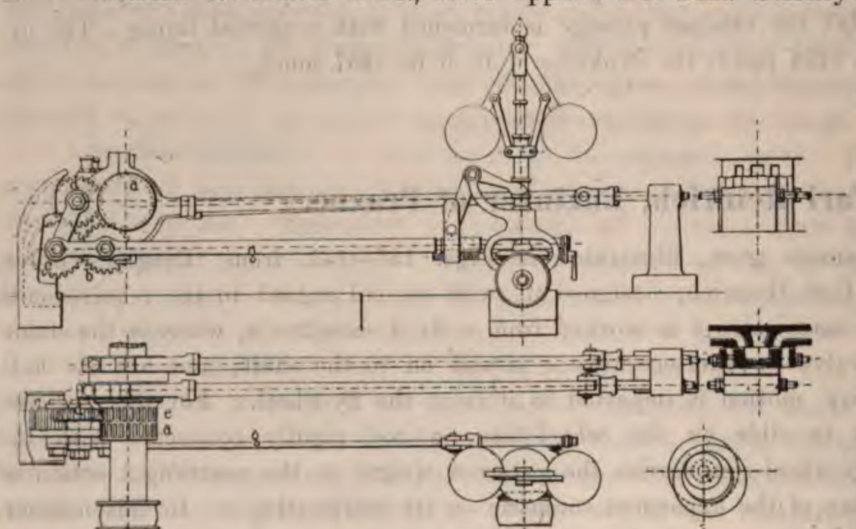


Figs. 137—141.

Moreover to balance the governor still more efficiently, the expansion valve is introduced in the form of a piston-valve, which runs in a cylindrical casing of the main-slide. As it is made sufficiently long, it merely requires grinding in, to fit steam-tight.

7. W. Foster & Co., of Lincoln.

Messrs. W. Foster & Co., have applied Mr. Sam. Starkey's Patent Expansion-gear*) to their Portable Engines, and it is this gear which we illustrate in the annexed Figs. 142—144.



Figs. 142—144.

We here find, the toothed wheel *a* mounted on the crank-shaft, gearing into a second wheel *b*, which in its turn gears into wheel *c*. The last named wheel is made sufficiently wide, so as to gear into a fourth wheel *d*, which transmits its motion on to a fifth wheel *e* mounted loosely on the crank-shaft. All these toothed wheels are made to one diameter, so that wheel *e* revolves equally fast with wheel *a*.

The wheels *b* and *c* are supported by a rod *g*, which is connected at one end with the

*) Vide Blue book Specification A. D. 1879, 26 May, No. 2092.

governor, and permits itself to be moved longitudinally, inasmuch as its other extremity is held suspended off the centre stud of the wheel *d*. We thus perceive, that the shifting of the rod *g*, will bring about a partial rotation of the wheel *b*, independently of the motion transmitted off the wheel *a*; we thus obtain a motion independent of that of the crank-shaft. This motion is transmitted through the wheel *c* and *d* on to *e*, which is thus advanced or retarded by a certain angle, in regard to the wheel *a*. If therefore the wheel *e* were fixed to the eccentric, an alteration in the advance-angle would result. But in order to simultaneously alter the throw, a small eccentric is cast on the wheel *e*, and on to which the expansion-eccentric may be said to sit, being guided in its motion by a bracket. In conclusion we may observe, that this gear may be applied with at least equal benefit to the working of cams for lift-valves, and that Messrs. W. Foster & Co., find its working very satisfactory in driving their tool-shop.

8. A. Duvergier, of Lyons.

(With illustrations on Supplement-Plate 7, Figs. 1—9.)

Reference was made in a foot-note on pg. 146 of our second volume to an engine exhibited by Mr. Alphonse Duvergier at the Paris International Exhibition of 1878. This French Engineer has constructed this engine-type in about 150 examples, reaching up to 23·62 in (600 mm.) cylinder-diameter. They are less noteworthy in the novelty of their construction, than in the clever and well thought-out arrangement of their details.

The valve-gear is link-motioned, to obtain the variable motion of the eccentric. The main-valve — Figs. 3 and 4 — worked from an eccentric *a*, extends in one piece over the entire cylinder length; hence the steam-passages are kept small, and the clearance-spaces reduced to a minimum. We find the expansion-valve, also cast in one piece, sliding on the back of the main-slide, with its travel rendered unequal according to the engine-influences. These variations in the expansion-slide, are brought about by the mechanism, shown in Figs. 3 and 4, and motioned from the main-slide eccentric *a*. To this end, the last named, carries a pin *b* on its ring, which connects a small guide rod, with a bell-crank *h* mounted loosely on its shaft. The vibrations of the up-lifted arm, are transferred by the rod *k* on to the link *c*, which oscillates on a fulcrum situated close up to its middle. The link-block *d* slides in the lower link-portion, and it is connected with the expansion-slide spindle through its tail-end. It is evident, that the link-block *d*, transmits a smaller travel on to the expansion-valve, the nearer it is to the link swing-centre, and vice versa.

The drawing in and away of the link-block from its swing-centre, is effected automatically by a rod and lever, inasmuch as the prolonged fork of the rod *e*, is connected to the rod *g* at the point *f*. But to render this alteration equally possible by hand, the rod *g* has a hand-wheel fixed at its upper end, whilst its lower portion is provided with a thread; on this thread, a nut *f* is screwed, which forms the forked end of the rod *e*; hence by turning the forementioned hand-wheel, the link-block may be raised or lowered in the link.

The action of this valve-gear explains itself in Fig. 145, the lines represented, being the centre-lines of the parts above named. The thick lines are presumed to shew the middle piston or crank-position *K*, whereas the dotted lines indicate the end positions. In Fig. 146, we have attempted to represent the range of expansion. $O\,D$ again refers to the main-slide circle, and *e* gives us the external lap-circle; the advance-angle δ_0 determines the direction of the expansion-valve travel. This travel is variable, whilst δ_0 does not alter. $O\,D_0$ is the valve-circle corresponding to the greatest declination of the expansion eccentric. If we draw the parallelogram OD_0

$D\,D_x$, then $O\,D_x$ is the diameter of the relative slide-circle; its point of intersection i, with the circle described to a diameter equalling the distance s of the working slide-edges, round O, yields in the prolongation of line $O\,i$ to $R\,m$ the position of the crank corresponding to the commencement of expansion; we have here the latest cut-off attainable. If we presume, the travel of the expansion eccentric diminished, then a smaller circle than $O\,D_0$ may be assumed to represent such a reduced travel. We have drawn this circle, corresponding to the earliest cut-off, and therefore

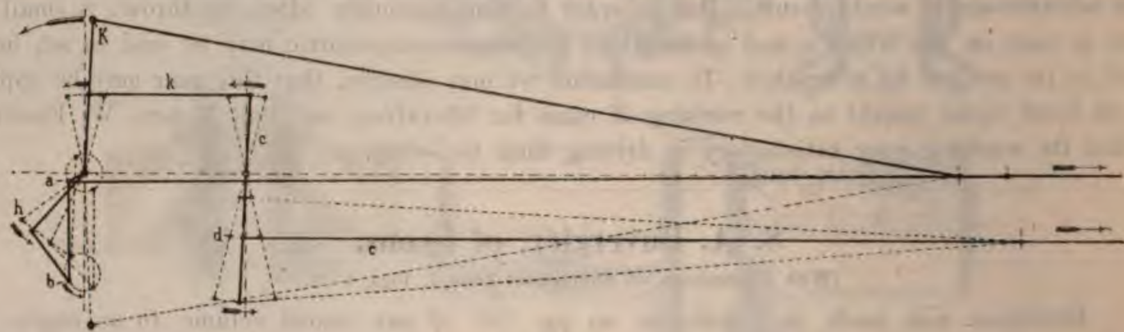


Fig. 145.

the corresponding relative slide circle's point of intersection i_1 with the circle s gives us the earliest cut-off attainable. The commencement of port-reopening takes place at u_1, which point is situated behind No. 1. It is evident, that the centres of the relative circles must lie on a straight line $M\,M$. Our diagram shews us some defects in this valve-gear, inasmuch, as with early cut-offs, the point i_1 shifts to the right, whereas u_1 (as the expansion-valve travel is small) moves equally more towards the centre. The point u_1, should however still come to lie behind position 1, whence it follows, that the lap for the main-slide must be made large, which however entails the defects of a strong compression.

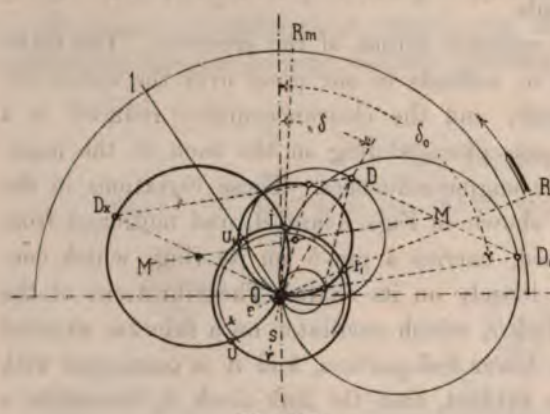


Fig. 146.

The cross-head is run in a slipper-guide; the cross-head as shewn in Fig. 8, of our Supplement-Plate 7, possesses a bottom-plate, with which the slide-plate proper, is bolted; when the latter is worn out, it can be easily renewed. We moreover draw attention to the peculiar fixing of the crosshead-pin and of the adjustment of the open connecting-rod end, represented in Fig. 9.

9. L. Breval, of Paris.

(With illustrations on Supplement-Plate 7, Figs. 10—13.)

The use of the link, worked from its own eccentric for altering the stroke of the expansion, is adopted by a number of Engineering Firms, in a more simple manner, than we find in the preceding example.

Borrowing our illustrations on Plate 7 (Figs. 10—13), from the "Portefeuille economique des Machines", we find in Breval's engine-type, a good example of a simplified engine-type. The eccentric drives the main-slide K off a rod L, whilst a second, oscillates the link O through the rod N. The prolongation of the link-block f, forms a nut for the screw e. This screw-spindle is guided in an eye g, of the link, so that by turning the hand-wheel h, the spindle itself is not raised or lowered, whilst such happens to the link-block; hence the magnitude of the link-block travel, may be regulated by hand. The expansion-slide is rigidly connected with the link by rod P.

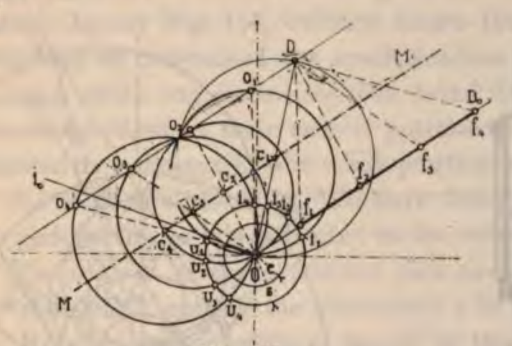


Fig. 147.

Fig. 148.

It follows, that the travel of the expansion-slide, will also be varied thereby, though only by hand, whereas the advance angle remains constant. Our diagram in Fig. 147, was drawn to the following constructive data: Advance-angle $\delta = 11^0\ 15'$ and $\delta_0 = 56^0\ 15'$; eccentricity of the two eccentrics 2·05 in. (52 mm.). The valves — vide Fig. 148 — are proportioned as follows: Inner and external leads, are respectively 0·20 in. and 0·04 in. (5 mm. and 1 mm.); distance s = 0·26 in. (6·5 mm.).

The earliest cut-off is determined by the ideal eccentricity $O f_1$, as the corresponding relative slide-circle described from c_1, must not again open the port before crank-position 1. The letters $i\,i_1$ denote the closing, whilst in $u\,u_1$ we find the re-opening of the ports.

As regards the general design of the engine, it shews the flat bed so commonly used in France. The cylinder-bore is 13·78 in. (350 mm.); its stroke = 25·98 in. (660 mm.).

10. Marshall Sons & Co., of Gainsborough.

In Fig. 149, the reader will find the expansion-gear, illustrated as applied to the engines we described on pg. 134, of our Vol. II.*) We find here, the link interposed between the expansion-eccentric and the valve-rod; the link is suspended from its top end. The expansion-valve rod, is gripped by a rod, under control of a very sensitive Wilson-Hartnell governor, and the different engine-loads may be taken into account, by the adjustable set-screw shewn in our engraving.

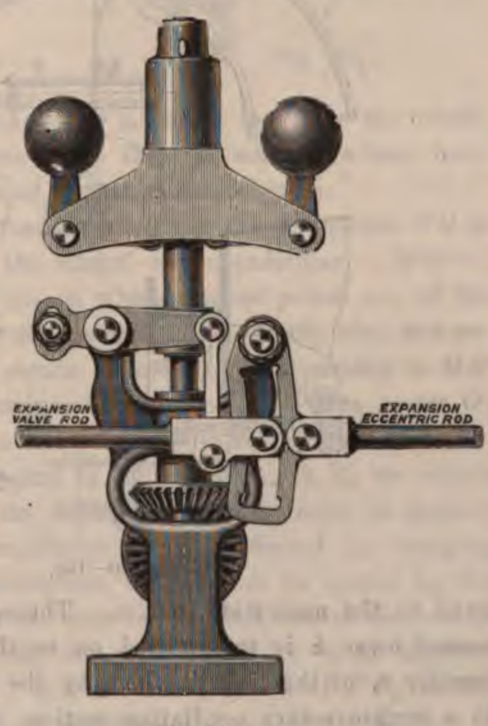
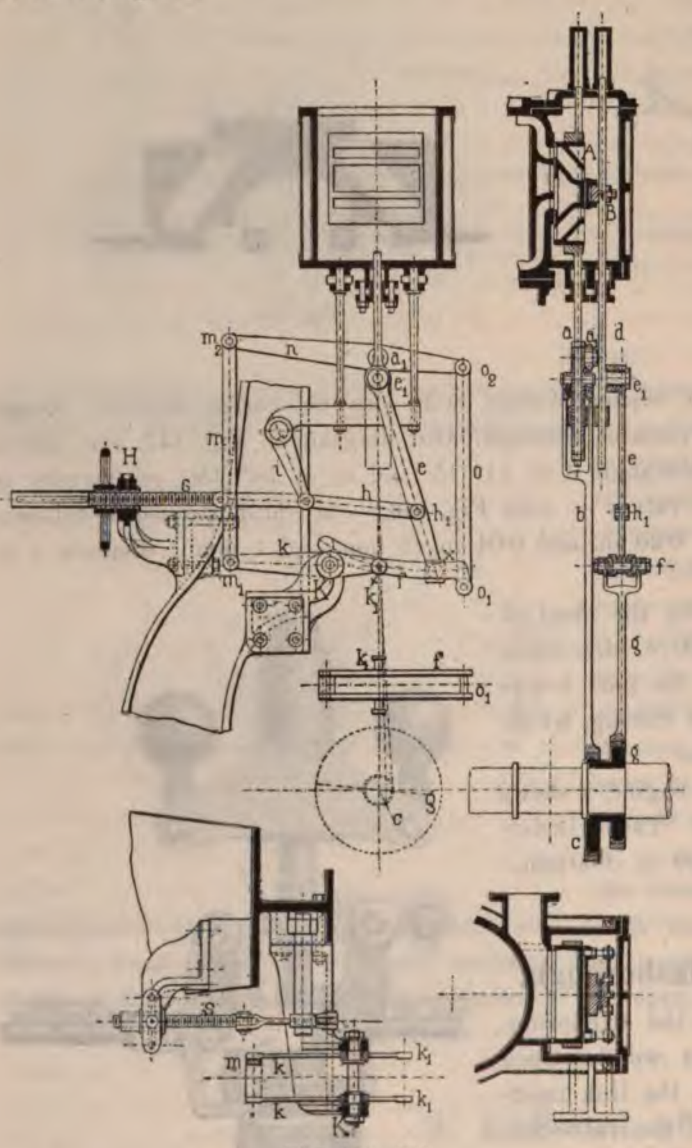


Fig. 149.

*) Corliss-Engines.

11. Lucien Guinotte, of Mariemont (Belgium).

The very ingenious, though somewhat complicated Guinotte's valve-gear, possesses so many advantages, especially in regard to the "reversing mechanism" with which we have still to deal, that it may well be classed amongst the modern expansion-gears. We purpose describing its action, with the aid of Figs. 150—153, which represent this mechanism as applied to a pair of vertical Engines.



Figs. 150—153.

Fig. 154.

The main-slide A is arranged in the usual manner, and the expansion-valve B is made to form a simple plate. The first named is worked off its spindle a and eccentric rod b from the eccentric c. The expansion-eccentric g, keyed under an advance angle of 90^0, carries by means of the rod g_1, the link f; this link oscillates round the centre k_1, which forms the working point of the eccentric-rod. The same swing-pivot is also situated in the eye of the double armed lever k oscillating on the fixed point K. A second double-armed lever n, has its fulcrum mounted on the stud a_1, which is fixed to the main-slide rod a. Through the connecting rods m and o, the motion of the first named lever k is transmitted on to the second lever n, to be again transferred on to the extremity o_1 of the link f, which by the forementioned motion of the two points K and o_1 is moved in a certain rotary oscillating motion; the fulcrum a_1 of the lever n has the same movement imparted to it, as the main-slide.

The one end of the rod e may be pushed into the link f, whilst its other end being fastened to the stud e_1 of the expansion-slide spindle d, transfers the motion of the link on to the expansion-slide. The shifting of the working point x of the rod e on the link, is effected by the rod h suspended on the lever i, being worked off the hand-wheel H and spindle s.

The action of this mechanism is best explained by Guinotte's own graphic method, which presumes, that the link is worked from two eccentrics, without participating in the motion of the slide-valve. In our Fig. 154, we have drawn the slide-circle of the main-slide as well as the outer lap-circle, and so determined the crank-position N_1 corresponding to the main-valve being closed. Moreover, a circle has been described round O, with a diameter $= s =$ to the distance of the valve working edges in their central position. We may now remember, that the commencement of expansion is indicated by the crank-position answering to the point of intersection of the circle s, with the relative slide-circle. We have therefore to determine, the position and the size of the relative slide-circle, as this will give us the extent of the eccentricity as well as the advance-angle.

The centres of these relative slide-circles will lie on the line MM. The centre of the relative slide-circle, cutting the slide-circle s in i_1, is then c_1, and this position answers to a cut-off $= 0$. By way of an example, c_2 would be the centre of the relative slide-circle, were expansion, to begin in crank-position R_2. The latest cut-off is indicated by the crank position R_1. We find, that all the relative valve-circles, in addition to having the point O, in common with each other, intersect each other in a point Q, and that the circle s simultaneously passes through this point Q; hence we perceive, that with all cut-offs, the expansion slide begins to open the port of the main-slide, at the same piston or crank-position. As we already know, this crank-position must not lie *before* the crank-position marked with N_1, but must lie on the contrary, *behind* it, so that the main-slide may have overlapped to the extent of some 0·12—0·16 in (3—4 mm.) as shewn in the diagram.

Fig. 155.

Fig. 156.

The position of the line MM allows itself to be found, when the crank position OQ is determined, by halving this distance OQ, and erecting in the centre, a perpendicular $-MM-$; if we erect in Q a perpendicular on OQ, then this is the line on which the end points oo_1 of the parallelograms lie, and by their delineations we arrive at the determination of the size and position of the expansion slide travels. In this manner, we obtain an inclined line parallel to MM — namely the guide line FF, — which determines the eccentricities as the range from centre O; (i. e. $Of_1 =$ eccentricity for the earliest, and $Of_3 =$ eccentricity for the latest $=$ cut-off).

If these eccentricities are properly transferred in regard to the engine-crank K, we obtain the guide line FF_1 in Fig. 155, on which the centre of the expansion-eccentric must be deemed to slide; in reality however, this variable motion of the expansion-valve is effected by changing the valve-spindle guide in the link. According to our assumption, let the link be moved by the eccentrics OT and OL, so that, even if the line FF_1 be the axis of the link, either the one or the other of the eccentrics must be looked upon as actuating the expansion-slide; in an approximate degree we may look upon the intervening and over T and L located points of FF_1, as the eccentricities of the expansion-slide. Supposing by way of an example, the end of the guide e of the valve-spindle to be in the point X of the link, then the expansion-slide will perform a stroke, just as if it had been worked off one eccentric = of eccentricity = OX. — This arrangement, embodying two eccentrics for the expansion-gear, is not practically carried out; it is supplanted by the mechanism we described by means of the Figs. 147—150. The circle-diagram also holds good for this arrangement, which we will attempt to elucidate still further. The position of the guide-line, is determined as follows: It intersects at X — Fig. 156 — the horizontal-axis; corresponding thereto, the expansion-eccentric g — compare Fig. 151 — is mounted diametrically opposite the crank with an eccentricity OX, and it therefore carries the point k_1 of the link. But as lever k is also motioned from the point k_1, its other extremity m_1 orbits, as if its path were controlled by one eccentric (because $OT:OX = Kk_1:Km_1$); the same occurs with the extremity m_2 of the lever n, on account of the action of the connecting-rod m. The oscillating centre a_1 of this lever n, is however again motioned from the main-slide eccentric = OD; the third point o_2 of the lever n, receives a motion as if it were carried by one eccentric, provided $a_1\ O_2 : a_1\ m_2$ is made equal $LD : DT$. The motion of the point o_2 is then transferred on to the point o_1 of the link.

We perceive, that the motion of the eccentric, must be considered as proceeding from the two eccentrics OX and OL. The link, curved to a radius = the guide-rod e, is not restricted to any length.

The valve-gear of the Coupled Vertical Engines, shewn on Supplement-Plate 11, is similar to the one just described, and we have also retained the same lettering. In Fig. 8, (Supplement-Plate 12) we have drawn the slide-travels in relation to the piston-stroke, the path of the main-slide being represented by the thick-drawn curve. AB is the axis at middle position, and the outer and inner laps are drawn on each side, though the latter are not drawn equal, on account of the uniform compression. The dotted lines indicate the openings of the ports through the expansion-valve, on both sides of the cylinder, during different grades of expansion. The eccentricity of the main-slide = 2·60 in (66 mm.); advance-angle 30°, and the eccentricity of the expansion-valve = 2·50 in (63·5 mm.) The two eccentrics are made in one piece. The distance s = 1·58 in (40 mm.) and the ports are 1·81 in (46 mm.) high.

The cylinders of this carefully constructed Coupled Engine are each 25·59 in. (650 mm.) in bore, and their stroke = 25·59 in (650 mm.).

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12. E. A. Wortmann, of Ruhrort.

(With illustrations on Supplement-Plate 13 Figs. 1—5.)

E. A. Wortmann, exhibited his Valve-gear fitted to a 10·23 in (260 mm.) cylinder engine at the Düsseldorf Exhibition of 1880. This valve-gear, permitting the widest range of cut-off, effects variable expansion by a change in the slide stroke.

The main-slide is worked from an eccentric on the fly-wheel shaft. On the back of the through-ported main-slide, the expansion-slide works, being also driven from an eccentric. The last-named slide-motion is obtained through the intervention of a double link c, which pivots on a stud b. The upper part of this link is provided with a forked bearing, which takes up a beam g. This beam is mounted on the short spindle h, which also carries the lever i. When this lever i is motioned in the direction of the inscribed arrow, the beam g is turned in the same direction and shifts the link-blocks attached to the end of the flat rods kk_1, though the two blocks move in opposite directions to each other. The expansion eccentric-rod a, as well as the connecting-rod

d are forked at their ends, and grasp the link-block. If we presume, the beam g to be turned, whilst the engine is running, then the oscillation of the link will be increased or decreased, according to the declination of the one link-block; moreover by the simultaneous declination of the other link-block, the oscillation of the link is again increased or decreased, prior to its being transferred on to the expansion slide. In this manner, a varying travel is secured to the expansion valve, and as a consequence to the actual doubling motion-effect of the beam g, the change in the cut-offs are rapidly performed. The oscillation of the beam g is effected by a combination of levers automatically controlled from the governor.

In order that the steam may flow equally long on to both sides of the piston, during a certain position of the link, the curves of the link are correspondingly formed. Thus the curve, next to the connecting rod d is an arc, described with the length of the connecting rod d round the centre of the cross-head e; in like manner, the other curve facing the eccentric side, is described to a radius approximately equalling the eccentric rod a.

13. Ransome, Sims & Jefferies, of Ipswich.

The expansion apparatus used by this Firm, was illustrated and described by us in our second volume*) (pg. 141), so that we content ourselves here in referring to their Horizontal-engines

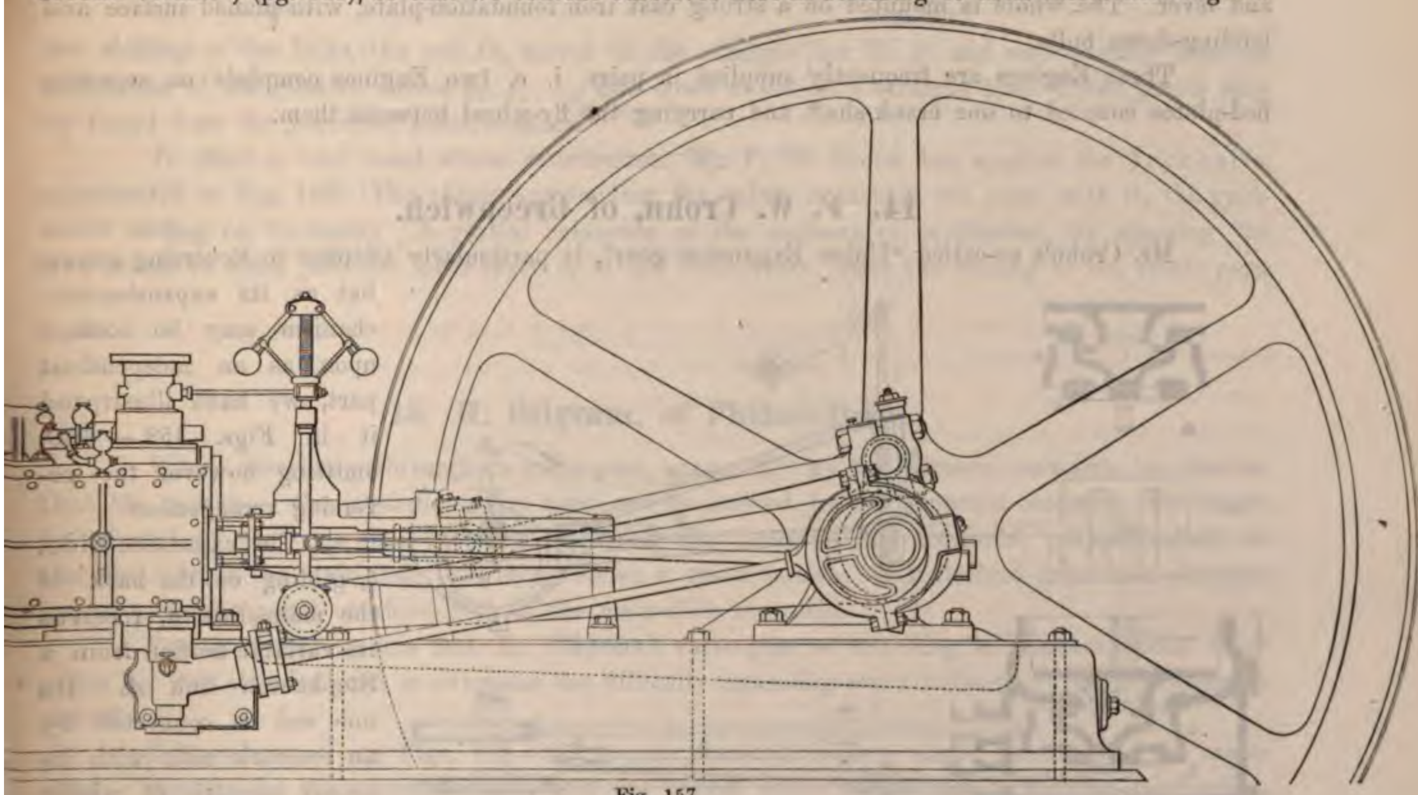


Fig. 157.

fitted with this gear. An engine of this type is represented in the annexed Fig. 157, as built to the following sizes:

*) Corliss-Engines.

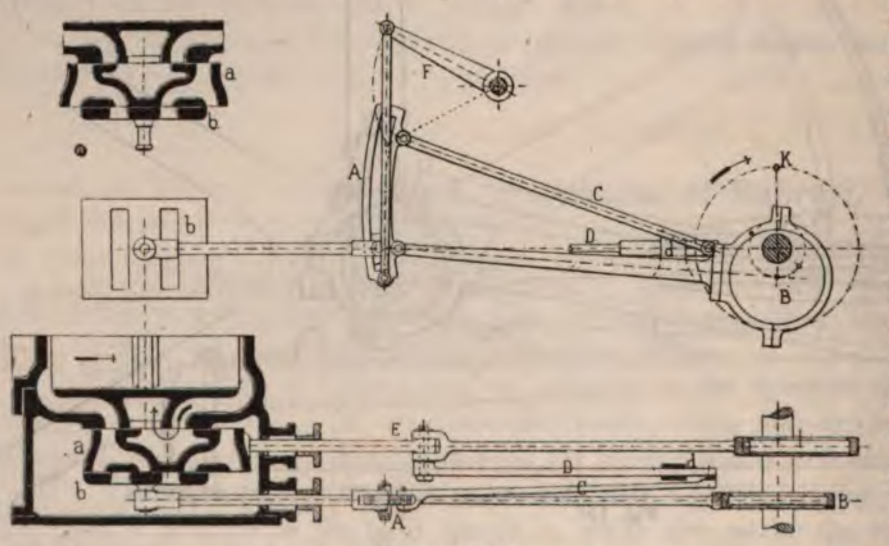
Nominal Horse-power.	Diameter of Cylinder.	Length of Stroke.	Revolutions per Minute.	Diameter of Fly-Wheel.		Approximate space required for Engine-room.	Approximate Net Weight of Engine.
	inches.	inches.		ft.	in.		cwt.
4	6	10	140	4	3	12 ft. × 6 ft.	35
6	7	16	110	6	0	13 ft. × 7 ft.	43
8	8	16	110	6	0	14 ft. × 8 ft.	45
10	10	16	110	6	0	15 ft. × 9 ft.	50
12	11	16	105	8	2½	16 ft. × 10 ft.	60
14	12	20	100	8	2½	17 ft. × 11 ft.	70
16	14	20	100	8	2½	18 ft. × 11 ft.	78
20	14½	24	80	10	0	21 ft. × 12 ft.	130
25	16½	24	80	10	0	22 ft. × 13 ft.	150
30 (2 Cylinders)	13	20	100	8	2½	18 ft. × 16 ft.	165
40	14½	24	80	10	0	22 ft. × 18 ft.	300
50	16½	24	80	10	0	22 ft. × 19 ft.	330

The Engine as here illustrated, is of the Horizontal high pressure Direct-acting type; it is fitted with metallic piston, massive guide bars, best scrap-iron crank-shaft and connecting-rod, massive fly-wheel, bored and turned, efficient governors, feed-pump, starting valve and lever. The whole is mounted on a strong cast iron foundation-plate, with planed surface and holding-down bolts.

These Engines are frequently supplied in pairs, i. e. two Engines complete on separate bed-plates coupled to one crank-shaft and carrying the fly-wheel between them.

14. F. W. Crohn, of Greenwich.

Mr. Crohn's so-called "Union Expansion gear", is particularly adapted to Reversing gears, but as its expansion-mechanism may be looked upon as an independent part, we have illustrated it in Figs. 158 — 160, omitting however the reversing arrangement.



Figs. 158—160.

The expansion-slide, *b*, gliding on the back of the main-slide, *a*, receives its variable motion from a Stephenson link *A*. Its one end is connected by an eccentric rod, with its proper eccentric *B*, whilst the other extremity is connected with the rod *E* of the main-slide, through the unison-rod *C*, and the connecting-rod *D* moving in the guide *d*. According as the link *A* is lowered or raised by the lever *F*, the expansion-valve is permitted to partake more in the motion of its own eccentric B, or to participate in the movement of the main-slide, in which latter case, the two valves may be said to be in unison. The expansion-eccentric B, is keyed diametrically opposite the crank.

In the annexed diagram Fig. 161, OD indicates the main-slide circle, and OD_0 the expansion-slide circle; if we draw the parallelogram $OD_0\ DD$, then OD_x is the relative valve-circle for the earliest cut-off, inasmuch as the expansion-circle only moves in the circle OD_0. We may approximately assume, that with

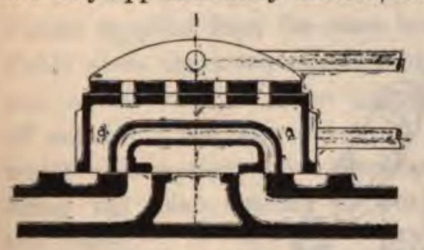


Fig. 162.

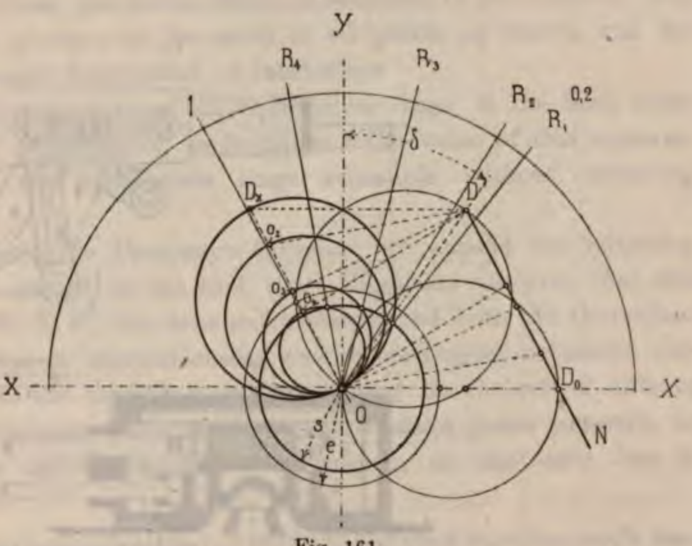


Fig. 161.

the shifting of the links, the end D_0 moves on the straight line $D_0\ D$, and consequently that the end-points of the relative circles o_2, o_3, o_4, also come to lie on a straight line. These points may be found from the inscribed parallelogram.

To effect a very exact steam distribution, Mr. F. W. Crohn has applied the Trick-valve, represented in Fig. 162. The casing surrounding the valve, is cast in one piece with it, the grid-valve sliding on its metal. A partial balancing of the main-valve is effected, by allowing the live steam to enter into the inner-space a, of the Trick-valve, after the closing of the steam-port.

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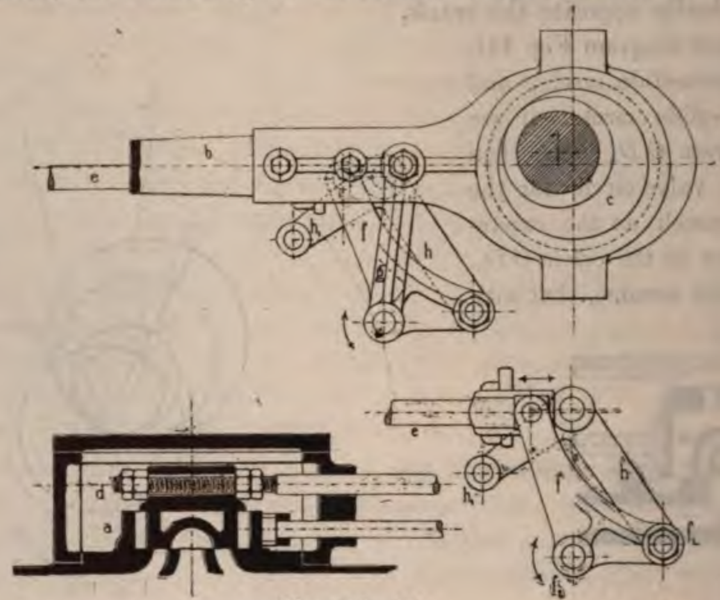
15. H. Bilgram, of Philadelphia.

When describing Duvergier's valve-gear, (page 87) we had already occasion to observe, that the motion of the expansion-valve need not be derived from a separate eccentric, but might be effected off the main-slide eccentric by taking the throw of this eccentric, perpendicularly to the direction of the main-slide; we then receive a crank-motion, as if derived from one eccentric keyed under an angle of about 90°, to the main-slide eccentric.

Paying regard to this fact, Mr. Bilgram's valve-gear — according to Bilgram's Slide valve gears —, was also designed to overcome the difficulty attending many valve-gears in their sluggish cut-off.

Both valves — see Figs. 163—165 — are operated by one single eccentric c: the main-slide a directly by the eccentric-rod b, and the cut-off valve d, through a peculiar mechanism, consisting of four members, viz: the link g, the rocker f, the cut-off rod e, and the adjustment lever $h_1\ h$. The link g jointed by a pin to the eccentric-rod, imparts to the rocker f, a rocking motion on its fulcrum f_1. The rocker is of peculiar form as shewn, but it virtually represents a bell-crank, having an angle of about 50°. To the extreme end of the rocker f, is jointed the cut-off rod e, by which the expansion-valve d is moved. For the purpose of changing the degree of expansion, the fulcrum f_1 of the rocker a, can be moved in a circular arc, being



Figs. 163—165.

attached to the end of the adjustment-lever h_1 h, whose fulcrum is a fixed point. We obtain in this manner a range of expansion lying between 0·0 and 0·9 stroke.

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16. The Buckeye Engine-Company, of Salem (Ohio, U. S. A.).

(With illustrations on Supplement-Plate 6, Figs. 6—16.)

The Engine, made by the Buckeye Engine-Company, has been before the public for about nine years, during which time it has, while retaining its original general plan, undergone several improvements, which are unfortunately not included in our Supplement-Plate 6 (Figs. 6—16). We therefore propose to describe the latest arrangement of engine-details, leaving the reader to infer the so-called improvements brought to bear on the type illustrated.

The live steam after entering, passes through passages and the open pistons, into the interior of the box-valve. From the box-valve the steam is admitted to the cylinder through ports in its face, as these ports are alternately brought to coincide with the cylinder ports.

The cut-off valve, which consists of two light plates connected by rods, works on seats inside of the main valve, and alternately covers the ports leading to the cylinder. The cut-off valve-stem works through the hollow stem of the main valve. The exhaust takes place at the end of the valve, into the valve chest and into the exhaust pipe below.

Among the new features since the first introduction of the Engine, are the relief chambers in the valve seat. To explain the use of these it must be understood that, the steam being inside the slide-valve instead of *around* it (as with the common slide-valve), the tendency of the pressure of the steam in the box-valve ports and in the cylinder is to force the valve from its seat, but this tendency is counteracted by the pressure of the entering steam; this pressure being proportioned to the area of the pistons or equilibrium rings. These pistons are made large enough to hold the valve to its seat at the moment of admission. At other times the pressure on the seat would be greater than necessary; but to prevent such undue pressure, live steam is admitted to the relief chambers through small holes in the face of the valve just after it is exhausted from the cylinder; it is in turn exhausted from them, just before steam is admitted to the cylinder. The result is a moderate and almost uniform pressure on the seats at all points of travel, and the arrangement also greatly assists in the proper distribution of lubrication.

Another recent improvement consists in placing the equilibrium rings in the back cover of the valve chest, instead of in the cover of the valve, as formerly. The value of this improvement consists mainly in its rendering the equilibrium rings accessible without removing the valve.

To these particulars, borrowed from the Company's Circular, we append the following Tables supplied from the same source. In regard to the first, these Engineers observe, that this Table gives the mean effective pressure, (M. E. P.) the terminal pressure, and both the theoretical and actual rate of water consumption due to non-condensing and to condensing automatic cut-off engines. We also devote a column to the throttling engine, giving its theoretical rate of water consumption, when working with the same boiler pressure and average piston pressure, or doing the same amount of work as the non-condensing cut-off engine, on the same line in the Table.

The Table of actual rates of water-consumption (pg. 98) is based upon the Company's own experience in practical cases. They have collated results in as many instances as possible, where the loads were widely variable, but the other conditions reasonably uniform. With data thus obtained, they located points through which were drawn curves representing the pounds of water consumption at different boiler pressures and points of cut-off. The remainder of the Table was filled out by interpolation on these curves.

On the authority of these Engineers this Table, especially the column for non-condensing engines, (marked N. C.) represents very closely the actual performance of their engines of 100 *HP.* and upwards with *dry steam.* The column for condensing engines, (C.) is perhaps less accurate, as they were in possession of fewer data, but for practical purposes it will not mislead. The same result in kind, if not in degree, will be obtained with any other automatic engine.

The Company's calculations of the theoretical economy are based on a mean back pressure (measured from vacuum) of 16 lbs. non-condensing and 6 lbs. condensing, clearance 2 per cent. of the piston displacement, and a compression based on exhaust closure at a point in the stroke that will compress about $4^1/_8$ volumes into one.

The proportionate wastefulness of light loads, being the difference between the actual and theoretical rates, is made very apparent. It will also be noted that the departure from maximum economy is very much more rapid in the direction of light than of heavy loads.

The Table on page 99 shews the load to which each size is best adapted. The rating of these Engines, as given in the third column, is the power actually developed, when running at the speeds named, under a steam pressure of 80 lbs., and cutting off at $^1/_5$ of the stroke, being 35 lbs. M. E. P. The exact figures are departed from only so far as to give the rating in round numbers, easily remembered. When these engines were first rated, it was the Company's belief that 35 lbs. M. E. P. represented the maximum of economy, and hence the medium advantageous load. A longer experience has demonstrated beyond a doubt that better actual results are obtained with a heavier

I. TABLE OF STANDARD ENGINE PERFORMANCE.

1—10 CUT-OFF.

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	3.65	13.65	6.41	72.0	38.0	51.4	16.4	146
45	5.42	15.42	7.00	58.5	35.0	38.5	16.0	120
50	7.19	17.19	7.59	49.0	33.0	31.9	15.6	93
55	8.96	18.96	8.17	43.5	31.5	28.1	15.2	80
60	10.73	20.73	8.76	39.0	30.0	25.3	14.9	70
65	12.50	22.50	9.35	35.7	28.6	23.3	14.6	62
70	14.27	24.27	9.93	33.0	27.7	21.8	14.4	55
75	16.04	26.04	10.52	31.0	26.7	20.6	14.2	50
80	17.81	27.81	11.11	29.0	26.0	19.7	14.0	46
85	19.58	29.58	11.70	27.5	25.3	19.0	13.8	43
90	21.36	31.36	12.28	26.0	24.5	18.4	13.6	40
95	23.13	33.13	12.87	25.0	23.7	17.9	13.5	37
100	24.90	34.90	13.46	24.0	23.0	17.5	13.4	35

15—100 CUT-OFF.

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	9.05	19.05	9.07	54.0	30.0	31.3	16.8	64
45	11.32	21.32	9.87	47.0	28.5	27.7	16.4	56
50	13.59	23.59	10.72	42.0	27.0	25.3	16.1	51
55	15.86	25.86	11.55	38.0	26.0	23.4	15.8	47
60	18.12	28.12	12.38	34.5	25.0	22.1	15.6	43
65	20.39	30.39	13.20	32.0	24.0	21.1	15.4	40
70	22.66	32.66	14.03	30.0	23.0	20.3	15.2	38
75	24.92	34.92	14.86	28.0	22.2	19.5	15.0	36
80	27.19	37.19	15.69	26.0	21.3	18.8	14.8	35
85	29.46	39.46	16.51	24.5	20.4	18.4	14.6	34
90	31.72	41.72	17.34	23.0	19.5	18.0	14.5	33
95	33.93	43.93	18.17	22.0	18.7	17.6	14.4	32
100	36.26	46.26	19.00	21.0	18.0	17.3	14.3	32

1—5 CUT-OFF.

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	13.46	23.46	11.79	45.0	24.0	27.9	17.7	51
45	16.15	26.15	12.87	41.5	23.3	25.7	17.3	45
50	18.85	28.85	13.94	37.0	22.5	24.0	16.9	40
55	21.54	31.54	15.00	33.6	21.7	22.7	16.6	38
60	24.24	34.24	16.08	31.0	21.0	21.7	16.4	36
65	26.93	36.93	17.15	29.0	20.3	20.9	16.2	35
70	29.63	39.63	18.23	27.5	19.6	20.2	16.0	34
75	32.32	42.32	19.31	26.0	19.0	19.6	15.8	33
80	35.02	45.02	20.39	24.5	18.4	19.1	15.7	33
85	37.71	47.71	21 46	23.3	18.0	18.7	15.6	32
90	40 41	50.41	22.54	22.0	17.4	18.4	15.5	32
95	43.10	53.10	23.62	21.0	16.9	18.1	15.4	31
100	45.80	55.80	24.70	20.0	16.4	17.8	15.3	31

25—100 OR 1—4 CUT-OFF.

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	17.34	27.34	14.49	39.0	22.0	27.2	18.5	46
45	20.39	30.39	15.81	36.0	21.5	25.3	18.2	44
50	23.45	33.45	17.13	33.5	21.0	24.0	17.9	42
55	26.50	36.50	18.45	31.2	20.5	22.9	17.6	40
60	29.56	39.56	19.77	29.0	20.0	22.0	17.4	39
65	32.61	42.61	21.09	27.6	19.5	21.3	17.2	38
70	35.67	45 67	22.41	26.4	19.0	20.8	17.0	37
75	38.72	48.72	23.73	25.3	18.5	20.4	16.8	36
80	41.78	51.78	25.05	24.0	18.0	20.0	16.6	35
85	44.83	54.83	26.37	23.0	17.7	19.6	16.5	34
90	47.89	57.89	27.69	22.0	17 4	19.3	16.4	33
95	50.94	60.94	29.01	21.2	17.2	19.0	16.3	32
100	50.04	64.00	30.33	20.4	17.0	18.7	16.2	31

3—10 CUT-OFF.

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	20.75	30.75	17.11	38.0	22.5	27.0	19.4	43
45	24.13	34.13	18.67	35.0	22.0	25.5	19.1	41
50	27.50	37.50	20.24	33.0	21.6	24.3	18.8	40
55	30.87	40.87	21.80	31.2	21.2	23.3	18.5	39
60	34.24	44.24	23.37	29.5	20.7	22.5	18.3	38
65	37.61	47.61	24.94	28.2	20.3	21.9	18.1	37
70	40.98	50.98	26.51	27.0	19.9	21.4	17.9	36
75	44.35	54.35	28.07	26.0	19.5	21.0	17.7	35
80	47.72	57.72	29.64	25.0	19.0	20·6	17.5	34
85	51.09	61.09	31.20	24.0	18.8	20 2	17.3	33
90	54.46	64.46	32.77	23.0	18.5	19.9	17.2	32
95	57.83	67.83	34.33	22.2	18.3	19.6	17.1	31
100	61.20	71.20	35.90	21.5	18.0	19.4	17.0	30

35—100 CUT-OFF

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	23.70	33.70	19.80	37.0	24.0	27.5	20.4	41
45	27.32	37 32	21.61	35.2	23.5	26.3	20.0	40
50	30.94	40.94	23.42	33.7	23.0	25.3	19.7	39
55	34.56	44.56	25.23	32.0	22.5	24.4	19.5	38
60	38.18	48.18	27.04	30.4	22.0	23.6	19.3	37
65	41.80	51.80	28.85	29.3	21.7	22.9	19.1	36
70	45.42	55.42	30.66	28.0	21.2	22.3	18.9	35
75	49.05	59.05	32.47	27.0	20.8	21.8	18.7	34
80	52.68	62.68	34.28	26.0	20.5	21.4	18.5	33
85	56.53	66.31	36.09	25.4	20.2	21.1	18.4	32
90	59.94	69.94	37.90	24.0	20.0	20.8	18.3	31
95	63.57	73.57	39.71	23.2	19.7	20.6	18.2	30
100	67.20	77.20	41.52	22.3	19.4	20.4	18.1	30

4—10 CUT-OFF.

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	26.22	36.22	22.44	38.0	25.0	28.3	21.4	40
45	30.08	40.08	24.49	36.3	24.6	26.9	21.1	39
50	33.95	43 95	26.55	34.5	24.3	25.8	20.8	38
55	37.81	47.81	28.60	33.0	23.8	25.0	20.5	37
60	41.68	51.68	30.66	31.5	23.5	24.4	20.2	36
65	45.54	55.54	32.71	30.0	23.0	23.9	20.0	35
70	49.41	59.41	34.77	29.0	22.7	23.4	19.8	34
75	53.27	63.27	36 82	28.0	22.3	23.0	19.6	33
80	57.14	67.14	38.88	27.0	22.0	22.6	19.4	32
85	61.00	71.00	40.93	26.0	21.7	22.2	19.3	31
90	64.87	74.87	42.99	25.0	21.5	21.9	19.2	30
95	68.73	78.73	45.04	24.2	21.2	21.6	19.1	29
100	72.60	82.60	47.10	23.4	21.0	21.4	19.0	29

1—2 CUT-OFF.

INITIAL PRESSURE.	M. E. P. N. C.	M. E. P. C.	TERMINALS.	RATES. ACT'L. N. C.	RATES. ACT'L. C.	RATES. THEO. N. C.	RATES. THEO. C.	RATES. THROT.
40	30.50	40.50	27.78	41.0	29.5	28.5	23.4	39
45	34.75	44.75	30.33	39.0	28.8	27.6	23.1	38
50	39.00	49.00	32.88	37.0	28.3	26.9	22.8	37
55	43.25	53.25	35 43	35.5	27.9	26.3	22.5	36
60	47.50	57.50	37.98	34.0	27.5	25.8	22.2	35
65	51.75	61.75	40.52	32.5	27.1	25.3	22.0	34
70	56.00	66.00	43.07	31.0	26.7	24.9	21.8	33
75	60.25	70.25	45.61	30.0	26.3	24 5	21.6	32
80	64.50	74.50	48.16	29.0	25.8	24.2	21.5	31
85	68.75	78.75	50.70	28.0	25.4	23.9	21.4	30
90	73.00	83.00	53.25	27.0	24.9	23.7	21.3	30
95	77.25	87.25	55.79	26.0	24.5	23.5	21.2	29
100	81.50	91.50	58.34	25.0	24.0	23.3	21.1	29

M. E. P., N. C., is lbs. of Mean Effective Pressure, Non-Condensing.
" C., " " " " " " Condensing.

Rates, N. C., is lbs. of water per I. H. P. per hour, Non-Condensing.
" C., " " " " " " " " Condensing.

Rates, Throt. is lbs. of water per I. H. P. per hour due Throttling Engines, at same (N. C.) M. E. P. and boiler pressure same as initial pressure on same line.

loading, nearly approaching 40 lbs. M. E. P., or 1/4 cut-off at 80 lbs. In preparing this Table, however, it has not been thought best to change the rating, which has become in a popular sense the commercial *name* of the engine. The fourth column shows, what practical working indicates to be the limits of *good economy* in the direction of light and heavy loads, which are 30 and 44 lbs. M. E. P. respectively.

II. TABLE OF STANDARD AUTOMATIC ENGINES.

SIZES.	SPEEDS.	RATED POWER.	ECONOMICAL RANGE OF POWER.	ULTIMATE CAPACITY.	H. P. CONSTANT.
6" × 14"	215 revs.	15 H. P.	12 H. P. to 18 H. P.	22 H. P.	.0020
7" × 14'	215 "	20 "	17 " to 25 "	30 "	.0027
8" × 14"	215 "	25 "	21 " to 31 "	37 "	.0035
9" × 14"	200 "	30 "	25 " to 37 "	45 "	.0044
10" × 14"	190 "	35 "	30 " to 44 "	50 "	.0055
10" × 18"	165 "	40 "	34 " to 50 "	60 "	.0071
10" × 20"	150 "	40 "	34 " to 50 "	60 "	.0079
11" × 22"	140 "	50 "	43 " to 62 "	75 "	.0105
12" × 20"	150 "	60 "	52 " to 75 "	90 "	.0114
12" × 24"	125 "	60 "	52 " to 75 "	90 "	.0137
13" × 26"	120 "	70 "	60 " to 87 "	100 "	.0174
14" × 24"	125 "	80 "	68 " to 100 "	120 "	.0187
14" × 28"	110 "	80 "	68 " to 100 "	120 "	.0217
15" × 30"	110 "	100 "	85 " to 125 "	150 "	.0267
16" × 32"	105 "	120 "	100 " to 150 "	180 "	.0 24
18" × 36"	100 "	150 "	130 " to 185 "	225 "	.0463
20" × 40"	100 "	200 "	170 " to 250 "	300 "	.0634
22" × 44"	100 "	300 "	240 " to 375 "	450 "	.0844
24" × 48"	95 "	360 "	300 " to 450 "	540 "	.1097
26" × 52"	90 "	440 "	375 " to 550 "	650 "	.1393
28' × 56"	85 "	520 "	450 " to 650 "	775 "	.1741
30" × 60"	80 "	600 "	500 " to 750 "	900 "	.2142

b. Expansion-valve of changeable length.

1. The Original-construction of the Meyer Valve-gear.

(With illustrations on Supplement-Plate 8.)

The Meyer Valve-gear (vide Fig. 166) was patented by Mr. J. J. Meyer, of Mülhausen (Alsatia) in 1842. Amongst the simple expansion-mechanisms, it is probably the best known, as it enjoys the most extensive application. We purpose explaining its construction with the aid of Supplement-Plate 8, as it is there fitted to a twelve horse-power Engine designed by Mr. G. Müller.

Fig. 166.

On the back of the main-slide, through-ported at each end, slides the expansion-valve, composed of two plates. According to the range of expansion desired, these two plates are brought closer to, or further apart from each other, through the screw-gear clearly shewn. The expansion-valve forms as it were, a single plate whose length may be lengthened, or shortened at pleasure, whereby the distance of its working edges from each other, becomes altered. The turning of the expansion-valve spindle, whilst the engine is running, whereby the degree of expansion is altered, allows itself to be effected in the following manner:

The back-side of the valve-chest (Figs. 6 and 7, Supplement-Plate 8), has a guide bracket bolted to it, which forms a sleeve with hand-wheel attached; the valve spindle passes through this sleeve, and is furnished with key and groove, so that by turning the hand-wheel, which does not participate in the alternate spindle-motion, the valve-spindle becomes similarly turned. To indicate the expansion-degree attained by turning the wheel, the forementioned sleeve is furnished with a thread on which a nut works; this nut carried in a frame, is actuated by the turning valve-spindle, and as it is connected with a dial-finger, this finger is made to point on a scale the degree of expansion at which the expansion-valve has been made to work.

The action of this valve-gear may be easily seen by the circle-diagram, which has been drawn to the following dimension in Fig. 167. The port-width = 0·91 in (23 mm.), and its length (eight fold its width) = 7·24 in (184 mm.). Although the exactitude of the steam-distribution is heightened the greater the eccentricities are chosen, in practice these factors are naturally kept as small as consistently can be done, without injury to the steam-action. In this case, where the cut-off must be presumed to be variable between the limits of 0 and $^1/_2$ stroke, the smallest admissible value, may be written as $r = {}^4/_3\ a$ or roughly as = 1·18 in (30 mm.). The outer-lap has been taken at 0·28 in (7 mm.), and the inner at 0·10 in (2·5 mm.). The diagram indicates, that were the main-slide to drive the engine by itself, steam would be cut-off at 0·928 stroke.

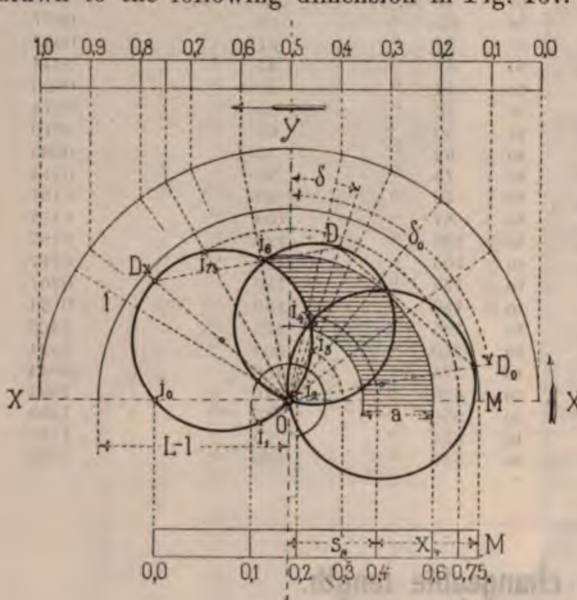


Fig. 167.

The expansion-eccentric has an eccentricity $r_0 = 1·38$ in (35 mm.) and an advance-angle $\delta_0 = 80°$. By inscribing these values in the diagram, — i. e. by transposing the angle δ_0 on OY, and describing a circle on the last side of this angle to a radius equal to half eccentricity r_e, so that this circle shall pass through O, we thereby obtain the expansion-eccentric circle. With the assistance of the parallelogram previously explained, r and r_0 give us the diameter r_x of the relative valve-circle. The chords in this circle indicate the distance of the centre of the expansion-plates from the centre of the main-slide, which values are of extreme importance. If, the distance s of the co-working slide-edges is taken as radius, and a circle described therewith round centre O, then its points of intersection with the relative valve-spindle, give us the crank-positions corresponding to the opening or closing of the through port.

The influence of altering the value s in this valve-gear, may be easily discerned in the diagram; the smaller this value is, the further apart are the plates, and the more the crank-position is shifted to the right, the earlier is the cut-off.

The piston-travel is represented in the upper part of our diagram (Fig. 167); the corresponding position of the expansion-plates, corresponding to any expansion-ratio, may be easily read off. From the piston-positions 0·1 etc., the corresponding crank-positions are determined, and then their points of intersection, with the relative slide circle i are sought; the lengths Oi_1, Oi_2

$O i_3$, $O i_4$, etc., afford us at once the values of s for the various expansion-ratios. Thus, by way of example, for the expansion-ratio 0.6, the corresponding-value of $s = O i_6$. For the expansion-ratio 0.1, the distance $O i_1$ appears negative, (equal to the distance in the negative slide-circle), that is to say, the plates are to be placed so far asunder, that (corresponding with the neutral position of the two slides) they may overlap the through port to the extent stated. In the lower part of our figure, we have transferred the values of s in a straight direction, carrying the positive ones to the right, whilst the negative values are transferred to the left.

For the latest cut-off, the two plates are made to touch each other, in which case $s = L - l$. This distance is represented in our diagram by $O M$. The value x corresponding to the distance of the plates from their central-position are thus at once obtained from the lower part of our diagram. By way of an example, with an expansion-ratio 0·4, the distance of the plate-travel from M, is indicated by x_4, and the remaining piece of $O M$, shewn in the length s_4 is the distance of the working edges from each other.

If we moreover desire to have the successive widths of the through-port disclosed to us, we have only to subtract its length from the determined value s; this has been done in our Figure 167, by shading correspondingly to an expansion degree of 0·6. Care must be taken, that with the maximum expansion-limit, steam may not be given twice, which is prevented by allowing the direction of $O D_x$ to coincide with No. 1 of the crank-position, at which the main-slide cuts off; in this case, $(L - l)$ is advantageously taken $= r_x$. In the constructive example before us, however $(L - l)$ was taken $= r_x + 2·5$, which gives us $L - l = 33·5 + 2·5 = 36$ mm. (1·42 in). Similarly, for the greatest plate-declination, $s_{min.} = O i_0$ for the expansion-ratio zero, the inner-edge must not pass over the through-port; whence it follows, that the plate-length must be calculated after $l > r_x + a_1 + s_{min.}$

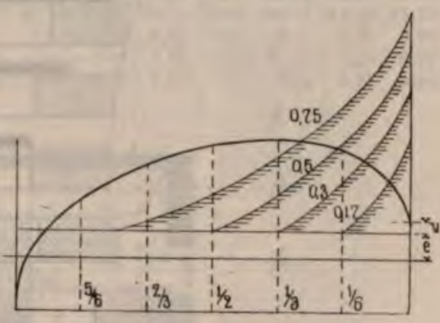


Fig. 168.

In the present case, the earliest cut-off was accepted at 0·167 stroke, whereby the greatest plate-declination $x_{max.} = L - l$. If we presume, that the inner edge of the expansion-plate, during its greatest relative travel, is still 3·5 mm. (0·14 in) distant from the through-port edge, we may write $l = r_x + a_1 + 3·5 = 33·5 + 23 + 3·5 = 60$ mm. (2·36 in) and $L = 96$ mm. (= 3·78 in). The factor L may be determined direct by $L > r_x + x_{max.} + a_1$ therefore $L = 33·5 + 36 + 23 + 3·5 = 96$ mm. (3·78 in.).

In its greatest travel, and greatest relative declination, the external-edge of the expansion-plate will be distant by $x_{max.} + l + r_x = 36 + 60 + 33·5 = 129·5$ mm. (5·09 in) from the central-position. If we therefore choose, the whole length of the slide $= 2 \times 120 = 240$ mm. (9·45 in) — vide Fig. 6, Supplement-Plate 8 —, then in the forementioned case, with the greatest travel of the expansion-plates (corresponding to 0·167 cut-off) these plates would overlap the outer edges of the main-slide by 0·37 in (9·5 mm.). Such would be admissible; for practical reasons alone, it would be detrimental to make that half of the main-slide larger than 129·5 mm. (5·09 in.).

We may at once observe, that the Meyer valve-gear permits an exact regulation of the steam-distribution, which in the majority of cases, it far too little heeded. Namely, in order to effect an exactly equal steam-distribution on both sides of the piston, the distance s of the working edges need only be varied, which can almost be done for all expansion-degrees through the different and opposed screw-pitch. The representation of the valve-travels by the elliptic diagram affords us a clear insight as to the speed with which the ports are closed. The abscissae (Fig. 168) of the curves, — i. e. the parts on the base-line, — are the reduced piston travels, and the ordinates — i. e. the distances of the various curve-points from the base-line — indicate the extent of the valve-travels, as reckoned from the line of the external-lap. We perceive from the size of the ordinates (varying according to cut-off), that the expansion-slide has completely opened the through port in the main-slide, on the dead-centre. The rapid rising of the ellipse, affords a scale for the rapidity with which the port opens, but the cut-off should not be estimated from the falling propensity of the curve, because cut-off is effected by the expansion-valve. To the last named, belong the four falling curves, which refer to cut-offs of 0·167; 0·33; 0·5 and 0·75. The angles, under which the curves cut the base-line, afford a scale for the exact cutting-off; the larger these angles are, that is the more they approach a right angle, the more quickly is the valve closed, and vice versa. We perceive from this fact, how much more advantageously early cut-offs

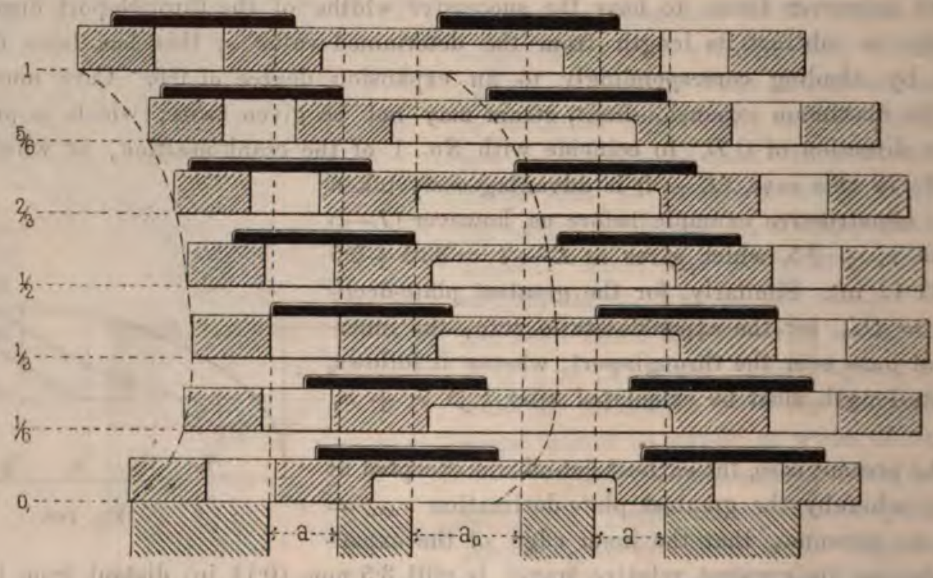


Fig. 169.

shew themselves in this respect, than later cut-offs. In Fig. 169, we have still further elucidated the slide motions. The valves are shewn over each other, corresponding to piston-positions inscribed as at 0, $^1/_6$th, $^1/_3$rd, $^1/_2$ $^2/_3$rds, $^5/_6$ths and full stroke. Expansion begins at $^1/_3$ stroke.

Table of Dimensions of Meyer Valve-gears.

In the annexed Table, we have tabulated the various dimensions of the main-slide, expansion plates, spindles, and the internal space of the valve-chest, used in Meyer Valve gears as ordinarily applied to Engines of from 6·29 in (160 mm.) to 39 in (1000 mm.) — cylinder bore. The earliest admissible cut-off is 0·1, and the latest = 0·95 stroke. In Fig. 170, the expansion-plates are drawn to correspond to a cut-off at $^1/_{10}$th stroke. The dimensions are given in inches and decimals, unless otherwise stated.

Cylinder-diameter	6.29	7.47	8.66	10.23	11.81	16.14	18.51	21.27	24.41	27.56	31.50	35.43	39.4
External-lap e	0.12	0.14	0.16	0.18	0.20	0.26	0.28	0.31	0.39	0.43	0.43	0.51	0.59
Internal-lap i	0.06	0.06	0.06	0.08	0.08	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.12
Advance-angle δ in degrees	15 1/2	15 1/2	16	16	15	15	14 1/2	14 1/2	15 1/2	15	15	14 1/2	15
" " δ_0 " "	68 1/2	68 1/2	68 1/2	68	66	65	64 1/2	64 1/2	64 1/2	64 1/2	63	61	62
Difference $L - l = r_x$	0.71	0.81	0.85	0.94	1.02	1.18	1.42	1.58	1.89	2.01	2.13	2.36	2.76
Eccentricity r	0.67	0.75	0.79	0.91	1.02	1.22	1.46	1.61	1.97	2.13	2.24	2.68	3.03
Eccentricity r_0	0.89	0.98	1.04	1.18	1.30	1 54	1.81	2.05	2.44	2.64	2.78	3.19	3.68
Admission-port width a	0.51	0.59	0.63	0.71	0 79	0.94	1.14	1.26	1.54	1.65	1 73	2.13	2.36
Bridge-width b	0.63	0.79	0.79	0.87	0.91	1.06	1.30	1.42	1.69	1.77	1.85	2.17	2.60
Exhaust-port width a_0	0.79	0.98	1.10	1.18	1.26	1.50	1.58	1.97	2.05	2.21	2.36	3.15	3.94
Through-port width (at its bottom side) a_1	0.53	0.61	0 67	0.75	0.83	0.98	1.18	1.30	1.58	1.69	1.81	2.17	2.44
Metal-width d	0.69	0.79	0.85	0.96	1.06	1.30	1.52	1.67	2.03	2.21	2.28	2.76	3.07
Cavity-width w	1.93	2.44	2.56	2.76	2.91	3.43	3.97	4 60	5.23	5.51	5.82	7.24	8.89
Distance of the inner-edges, g	3.70	3.74	4.05	5.19	5.58	6.76	9.45	8.66	10.15	10.78	11.34	13.46	14.96
Expansion-plate length, l	1.65	1.81	2.05	2.36	2.56	3.23	3.74	4.01	4.72	5.03	5.27	6.49	7.08
Metal-thickness, o	1.06	1.18	1.38	1.38	1.38	1.58	1.58	1.58	1.77	1.97	1.97	1.97	2.76
Distance, p	1.10	1.38	1.38	1.38	1.38	1.58	1.73	1.97	1.97	1.97	1.97	2.76	3.15
Distance, q	1.30	1.58	1.61	1.77	1.77	1.97	2.05	2.36	2.56	3.15	3.15	3.35	3.54
Spindle-thickness at z	0.63	0.63	0.79	0.91	0.91	0.91	1.10	1.10	1.14	1.26	1.02	1.30	1.58
do. " z_1	0.83	0.83	0.98	1.18	1.18	1.26	1.50	1.58	1.58	1.58	1.58	1.77	2.05
do. " z_2	1.02	1.02	1.18	1.42	1.46	1.58	1.89	1.97	2.05	2.05	2.05	2.24	2.60
do. " z_3	0.71	0.79	0.87	1.02	1.02	1.18	1.34	1.42	1.42	1.58	1.58	1.77	2.36
Valve-spindle diameter n	0.71	0.79	0.87	1.02	1.02	1.18	1.34	1.42	1.42	1.58	1.58	1.77	2.36
Length of Thread u	2.48	2.80	3.15	3.54	3.78	4.64	5.51	6.02	7.28	7.67	8.07	9.64	10.82
Length of clearance u_1	0.39	0 39	0.39	0.39	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.59
Valve-chest height H	5.11	6.17	6.73	6.92	7.08	8.07	8.81	10.23	10.43	12.52	12.40	13.98	16.54
" " length J	9.45	11.41	11.81	14.49	15.75	17.52	19.53	22.05	25.79	28.35	28.74	33.86	37.79
Distance f	2.36	2.76	3.07	3.15	3.15	3.54	3.62	3.94	4.32	5.11	5.11	5.31	6.29
Distance h	1.46	1.85	1.97	2.17	2.17	2.56	3.07	3.54	4.13	4.72	4.72	5.31	6.29
Distance k	1.30	1.58	1.69	1.77	1.77	1.97	2.13	2.36	2.36	2.56	2.56	3.35	3.94

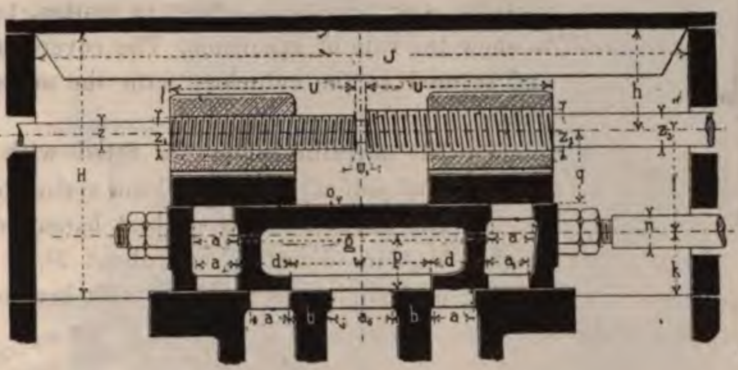


Fig. 170.

2. Engines fitted with the Meyer Valve-gear, adjustable by hand.

In the preceding Chapter, we gave a general discussion on the Meyer Valve-gear, supplementing our remarks, with all the necessary constructive details. We now propose to illustrate and describe a variety of Engines fitted with Meyer valve-gears, rendered adjustable by hand, and to these constructive examples we will then group those Meyer Valve-gears in which the expansion-plates are worked automatically by the governor, instead of by hand.

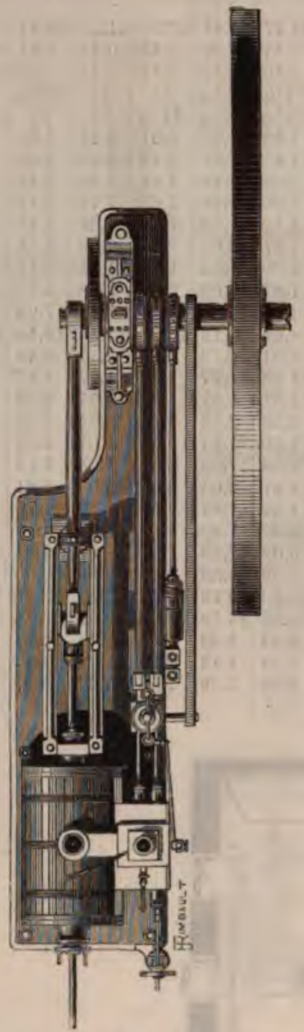


Fig. 172.

a. Whitmore & Binyon, of Wickham Market.

Messrs. Whitmore & Binyon have adopted the Meyer Valve gear, made adjustable by hand, with the governor operating an ordinary throttle valve. In Figs. 171 and 172, we bring elevation and plan of their High-pressure Horizontal Engine, fitted with variable expansion-gear, whereas in Figs. 173 and 174, we bring similar illustrations of their Horizontal Condensing Engine. As both types are similar to each other, excepting that the bed of the last named is lengthened as shewn to take up the Condenser, we will merely describe the last named and our description will apply to a 25 horse-power engine.

The Engine is erected on a cast-iron bed planed to receive the various parts; it is furnished with a governor of the high-speed type, and with steam stop-valve or regulator.

The cylinder is 16" inches diameter, and suits a 20" stroke made of good, hard, close-grained metal, fitted with a steam jacket consisting of a separate liner forced in, and having independent pipes for conducting the steam thereto.

The slide-valve is of the same running of metal as the cylinder to ensure uniformity of wear, and the Meyer expansion-valve working on the top of the main-valve, is provided with variable gear adjustable whilst in motion, together with an index to shew the rate of expansion. The covers are turned and polished and secured to the cylinder, with the necessary bolts and faced nuts.

The metallic piston is fitted with cast-iron rings and with internal self-adjusting steel-coil spring, to compensate for wear.

The crank-shaft is of best hammered scrap-iron, finished bright, $5^1/_2$" in. diameter and about $5^1/_2$" ft. long. The neck-bearing on bed-plate is provided with brasses, in parts adjustable

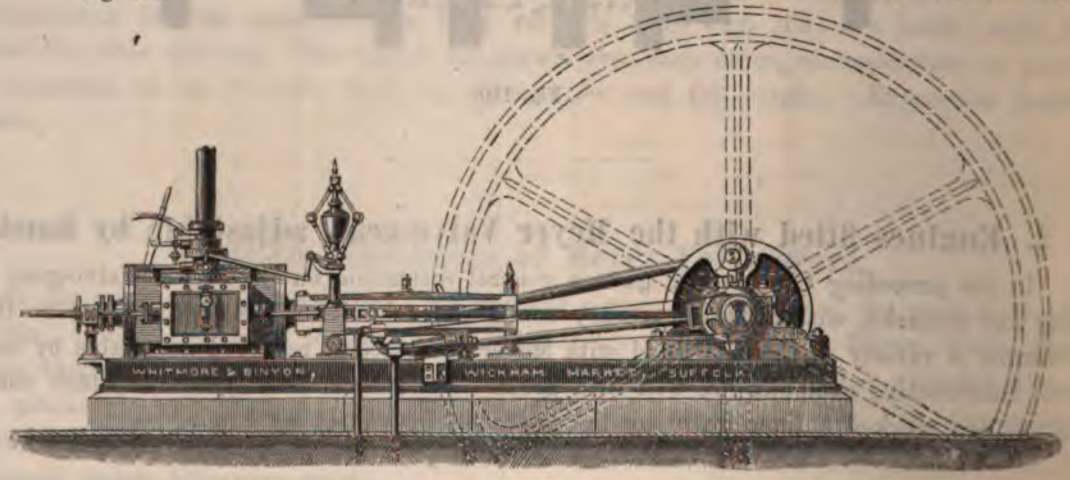


Fig. 171.

ıoth vertically and horizontally. The crank forms a polished, cast-iron, balanced-disc; it is shrunk

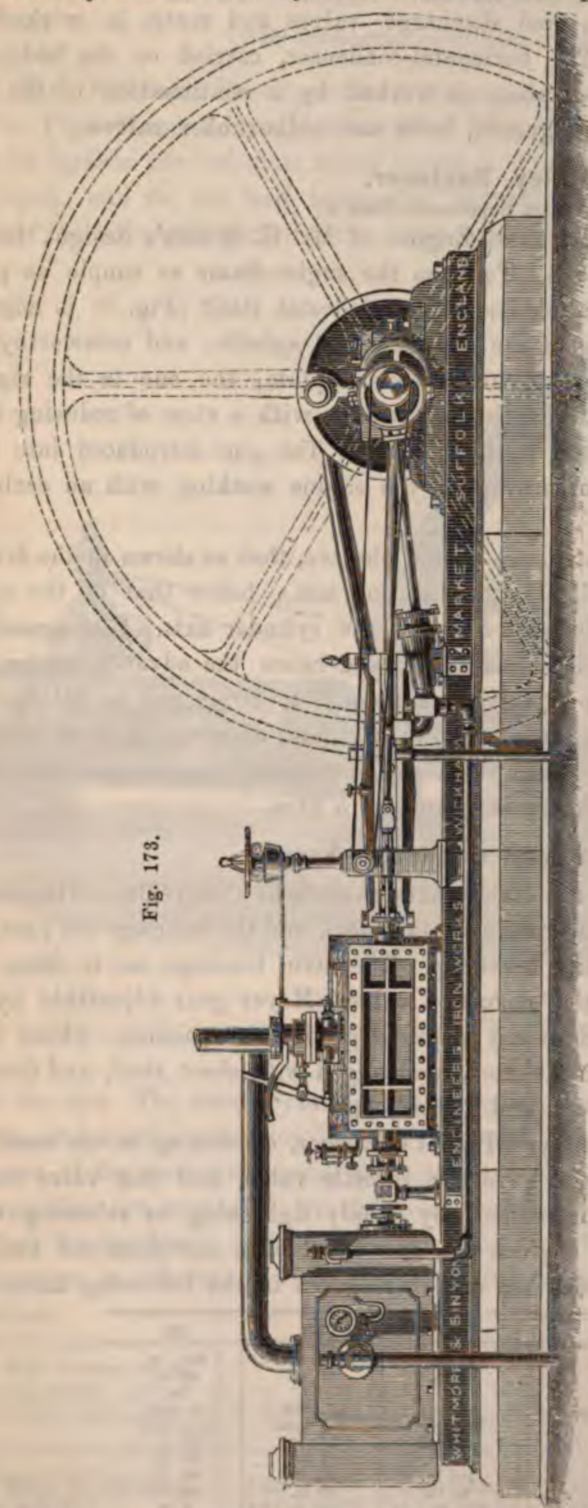
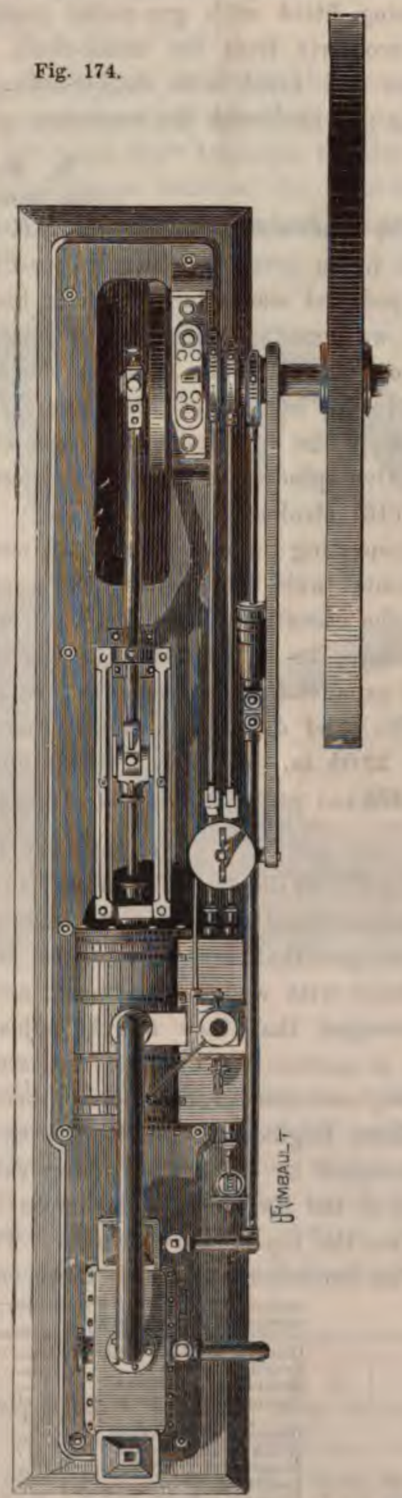


Fig. 173.

Fig. 174.



ıd keyed on to the shaft. The crank-pin is of steel. The connecting-rod is of best hammered iron, with bright wrought-iron straps and gibs, cotters and gun-metal wears at each end. The Feed-pump, being fitted with gun-metal suction and discharge valves and seats, is worked by a separate eccentric from the crank-shaft. The horizontal-condenser, carried on the bed-plate of the engine and fitted with double-acting air-pump is worked by a continuation of the piston-rod and is provided with the necessary grids, guards, bolts and india-rubber valves.

b. G. Müller, Engineer.

(With illustrations on Supplement-Plate 8.)

The construction of the 12 *HP.* Horizontal Engine of Mr. G. Müller's design, is amply illustrated in its details on Supplement-Plate 8. To keep the engine-frame as simple as possible an extra pedestal was attached under the crank end. The pedestal itself (Fig. 9) is adjustable. In Fig. 7 we perceive the necessary jointing of the expansion-rod spindle, and noteworthy is the introduction of guide-bolts fixed on the back of each expansion-plate, the one in the right and the other in the left rib of this valve. Their application is done with a view of reducing the too rapid wear of the spindle-threads, and of the working edges. The pins introduced into the expansion valve spindle, are for the purpose of preventing the engine working with an earlier cut-off than 0·167 stroke.

Respecting the mounting of the eccentric, we should observe, that as shewn in the drawings, the horizontal axis through the slide spindles is 2·21 in. (56 mm.), below that of the cylinder, whereby the eccentric-rod encloses an angle of 2·5° with the cylinder axis. Consequently the eccentrics have to be displaced to this angle in addition, and hence the advance angles of the main and expansion slide eccentrics are respectively chosen equal to $20^1/_2{}^0$ and to $82^1/_2{}^0$.

The chief dimensions of this Engine are as follow: Cylinder diameter 12·60 in. (320 mm.); stroke = 22·05 in. (560 mm.); revolutions 80 per min., and consequently mean piston-speed 4 ft. 11 in. (1.493 m.) per second. The steam-pressure is quoted at 5 atm.

c. Tangye Brothers, of Birmingham.

In Fig. 175 we illustrate the large sized Horizontal Engines, as made by Tangye Bros. of Birmingham. The Engines are fitted with the piston rods and crank shafts of steel, and the bearings are extra large, and so arranged that any wear can be readily taken up. The main bearings are in three pieces, and are fitted with wedge adjustment; and the expansion valves (Meyer gear adjustable by hand) are so arranged that they can be adjusted to any required grade of expansion, whilst the Engines are in motion: the cylinders are steam jacketed, and lagged with sheet steel, and fitted with relief valve, condensed-water cocks, lubricators, and grease cups.

These Engines are all fitted with Tangye's Patent Governor, combining in the small space usually occupied by the ordinary stop valve, a governor, throttle valve, and stop valve complete. The speed of the Engine can be increased or reduced by simply tightening or releasing the cap which forms the top of the Governor. The engines are also fitted with sole-plate for back-chair.

The dimensions to which these engines are made are given in the following table:

NOMINAL HORSE POWER	40	50	60
Diameter of Steam Cylinder	20 in.	22¹/₄ in.	24¹/₂ in.
Length of Stroke	40 in.	40 in.	48 in.
Revolutions per Minute	53	53	44
Approximate weight of Engine, all complete	14 tons	16 tons	19 tons
" " Fly-wheel	5¹/₂ tons	7¹/₂ tons	8¹/₂ tons
Diameter of Fly Wheel	144 in.	168 in.	180 in.
Width of Face, turned	22 in.	24 in.	26 in.
Diameter of Fly Wheel Shaft	7¹/₂ in.	7³/₄ in.	8¹/₂ in.
Length of " "	87 in.	93 in.	102 in.
Diameter of Steam Pipe	5 in.	5¹/₂ in.	6 in.
Diameter of Exhaust Pipe	7 in.	8 in.	9 in.
Approximate over all Dimensions of Engine	276 in. × 111 in.	276 in. × 117 in.	312 in. × 126 in.

d. The Cologne Machine-works Co. Lim., of Cologne.

(With illustrations on Supplement-Plate XIV, Figs. 1 and 2.)

The "Kölnische Maschinenbau-Actiengesellschaft", of Cologne, build the Horizontal Engine, shewn in Figs. 1 and 2, (Supplement-Plate XIV). In place of the usual symmetry being observed, that is as regards the bed-plate being closed in front of the crank-shaft bearings, the flat ⊓-frame is left open, and its one half terminates abruptly immediately in front of the slide-bars. The portion of the bed-plate, carrying the crank-pedestal is cast by itself and is wedged fast to the other

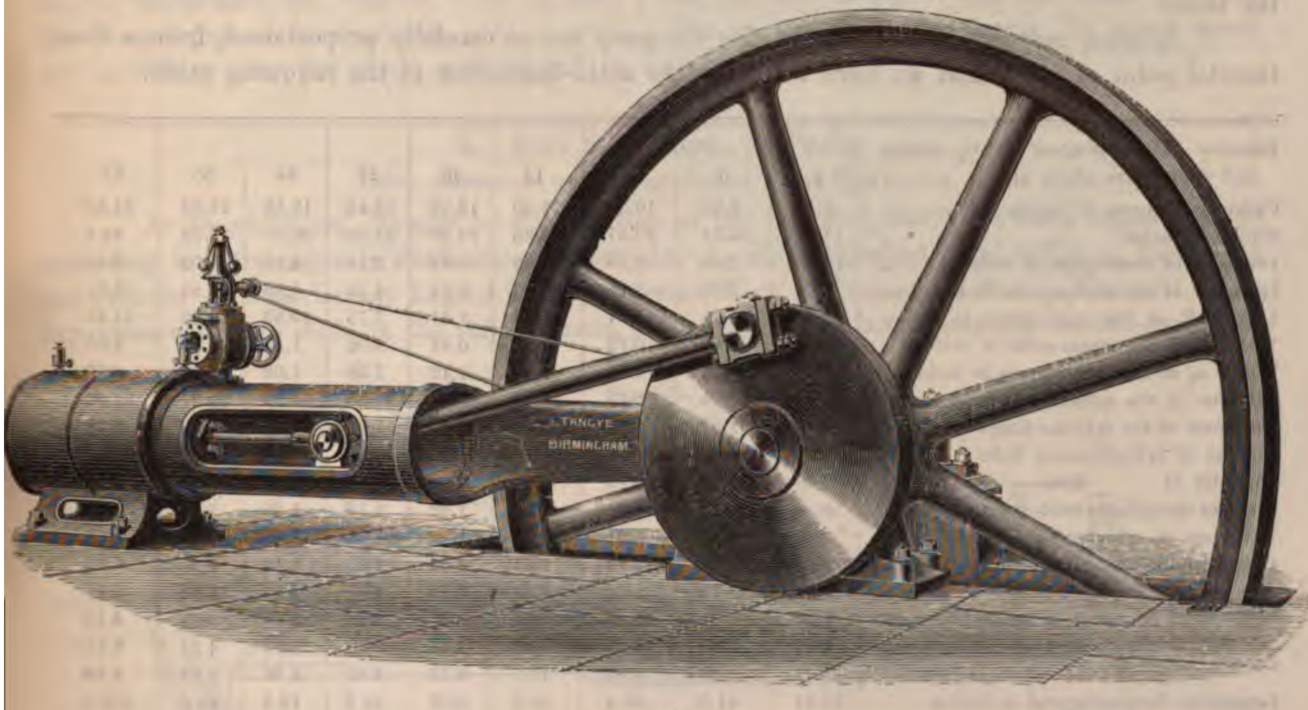


Fig. 175.

part of the bed. The steam-cylinder, the slide-bar, as well as the crank-bearing are bolted to the bed-plate, and special provision is made to resist the horizontal thrusts. Without paying regard to the size of the clearance space, the spindle-rods are placed on the centre-line of the eccentrics. These spindles are supported by the governor-stand and are further held by two braces. The illustrated Engine has a cylinder bore of 18·51 in. (470 mm.) and a stroke of 30·91 in. (785 mm.), and this type is constructed by the forementioned Engineering Firm in the following sizes and dimensions:

Nominal *HP.*: Cutting-off at $^3/_8$th — $^1/_2$ stroke and 4 pressure above atmosphere	8—10	9—12	12—14	16—20	20—25	25—30	28—33	30—35	35—40	40—45	45—50	55—65
Cylinder diam. in inches ..	9.25	10.23	12.40	15.47	18.51	18.51	20.67	20.67	22.64	22.64	22.64	24.80
Stroke in inches	18.51	21.66	24.72	24.72	30.91	37.01	30.91	37.01	30.91	37.01	42.8	49.1
Revolutions per minute ..	75	70	60	60	50	45	50	45	50	45	40	40

e. The Machine Company Humboldt Lim., of Kalk, near Deutz.

(With illustrations on Supplement-Plate XIV, Figs. 3—5.)

We find greater resemblance, with the general practice adopted in the construction of Meyer valve-geared Engines, in the Horizontal Engine type built by the Machinenbau- and Actien-gesellschaft Humboldt, and illustrated on Supplement-Plate XIV, Figs. 3—5, than exists in the last described engine. A defect common to most of these engines, is that the slide-bars are too far distant from the cross-head, although there is no reason, why these should not be brought close up to it. This would certainly necessitate a deviation from the rectangular form adopted in the bed-plate, inasmuch as the bed would have to be narrowed at the slide-bars to carry the latter.

In other respects, the engines of this Company are so carefully proportioned, from a Continental point of view, that we have tabulated the main-dimensions in the following table:

Effective *HP.* cutting-off at $1/2$ stroke and 4 pressures above atm.	2	4	8	14	20	25	38	55	85
Cylinder diameter in inches	6.14	8.26	10.31	12.40	13.98	15.43	18.58	21.66	24.80
Stroke in inches	12.40	16.54	20.67	24.80	24.80	27.80	30.91	37.20	42.8
Diameter of steam-pipe in inches ..	1.58	2.09	2.60	2.83	2.83	3.15	4.13	4.72	5.19
Diameter of exhaust-pipe in inches ..	2.09	2.60	3.15	3.62	3.62	4.13	5.19	6.21	7.24
Length *B* of the steam-ports in inches	3.35	4.36	6.21	7.24	7.47	7.75	10.63	13.39	14.45
Width *a* of the steam-ports in inches ..	0.53	0.63	0.79	0.85	0 91	1.02	1.18	1.30	2.09
Width a_0 of the steam-ports in inches ..	1.02	1.18	1.18	1.30	1.42	1.58	1.69	1.81	2.60
Diameter of the cylinder-cover in inches	10.82	13.94	15.75	18.11	19.85	21.38	24.96	29.37	34.02
Thickness of the cylinder-flange in inches	0.79	1.02	1.02	1.02	1.18	1.30	1.30	1.58	1.58
Number of cylinder-cover bolts	6	6	6	8	6	6	8	10	10
Diameter of ditto in inches	0.63	0.79	0.79	0.79	0.91	0.91	0.91	1.02	1.10
Diam. of the cylinder hold-down bolts in in.	0.79	0.79	0.91	1.02	1.02	1.18	1.30	1.58	1.81
Thickness of cylinder metal in inches ..	0.79	0.79	0.91	0.91	1.02	1.02	1.06	1.30	1.58
Height of the steam-piston in inches ..	3.11	3.35	4.13	4.64	4.64	4.64	5.43	6.17	6.96
Crank-pin { Length in inches	2.09	2.21	2.60	2.83	3.62	4.01	4.13	4.64	5.15
Crank-pin { Diameter in inches	1.58	1.81	2.09	2.32	2.21	3.23	3.07	3.62	4.13
Cross-head pin { Length in inches ..	2.72	2.95	3.35	3.47	3.47	3.62	4.13	4.64	5.15
Cross-head pin { Diameter in inches ..	1.42	1.58	1.81	1.97	2.72	2.83	3.07	3.62	4.13
Length of Connecting-rod in inches ..	30.91	41.3	46.4	50.3	56.7	63.7	73.2	86.6	102.3
Eccentricity of the main-slide in inches	0.91	0.94	0.94	0.94	0.98	1.18	1.42	1.58	1.77
Eccentricity of the expansion-slide in in.	0.98	1.02	1.30	1.30	1.69	1.81	1.81	2.09	2.32
Diameter of the eccentrics in inches ..	6.96	7.67	8.78	9.84	10.43	11.89	13.94	15.95	17.52
Breadth of the eccentrics in inches ..	1.81	2.09	2.09	2.32	2.32	3.15	3.15	3.15	3.15
Crank-bearing { Length in inches ..	4.13	4.13	5.15	5.66	5.66	6.06	8.26	9.29	10.55
Crank-bearing { Diameter in inches ..	2.60	3.15	3.86	4.52	4.52	4.87	6.45	7.47	8.50
Crank-shaft diameter in inches	3.07	3.35	4.40	5.11	5.11	5.70	7.24	8.26	9.29
Piston-rod diameter in inches	1.58	1.73	1.97	2.09	2.09	2.60	2.60	3.11	3.62
Diameter of the valve-spindle	0.79	0.91	1.02	1.02	1.18	1.18	1.30	1.42	1.42

f. Le Brun, of Creil (France).

(With illustrations on Supplement-Plate 19, Figs. 7—11.)

As another example of a similar engine-type resting on a flat bed, which is much liked in France, we illustrate on Supplement-Plate 19, (Figs. 7—11), a Pumping Engine made by Mr. Le Brun, of Creil (Oise). Its cylinder-diameter is 27·56 in (700 mm.), and its stroke = 62·9 in. (1600 mm.), and in other respects the engine is sufficiently detailed in the illustrations here alluded to.

g. Whieldon, Lecky & Lucas, of London.

(With illustrations on Supplement-Plate XV.)

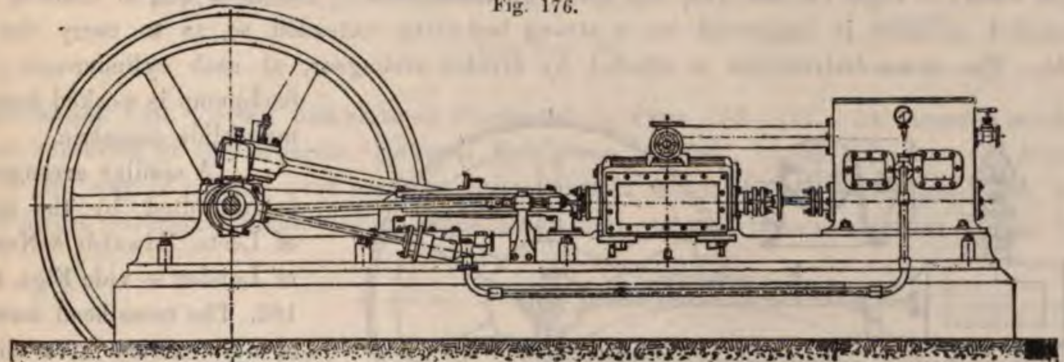
We frequently find the divided slide adopted in large engines, for reducing the clearance spaces. Accordingly, we find this arrangement adopted in the 60 *HP.* Engine, illustrated on Supplement-Plate XV, as made by Messrs. Whieldon, Lecky & Lucas, of London. The valve-mechanism is explained in the longitudinal section of the cylinder (Fig. 4). The cylinder diameter amounts to 24 in. (610 mm.) and its stroke to 4 ft. (1220 mm.) The Porter-governor acting on a throttle-valve, is motioned by bevel-gear off a lay-shaft from the crank-shaft. The bevel-wheels on the crank-shaft are each of 1 in. (25 mm.) pitch, the one having 57 and the other 15 teeth; the second pair of bevel wheels used in driving this governor, also increasing the crank speed, are of 0·79 in. (20 mm.) pitch, with 36 and 18 teeth respectively.

h. Neut & Dumont, of Paris.

(With illustrations on Supplement-Plate XVII, Figs. 1—4.)

As an additional example of the adoption of the "Divided slide", we have represented, — according to "Armengaud's Publication Industrielle" — on Supplement-Plate XVII, in Figs. 1—4, the cylinder of a Horizontal Engine built by Messrs. Neut & Dumont, of Paris. The nuts of the expansion-valve are made in the form of rails, resting on bolts placed vertically to the expansion-

Fig. 176.



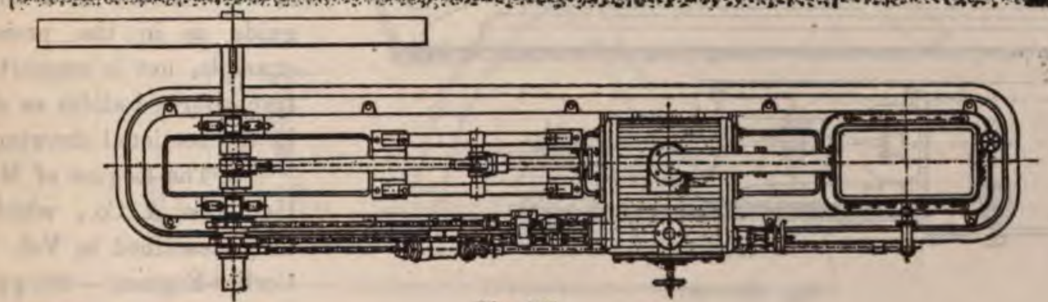
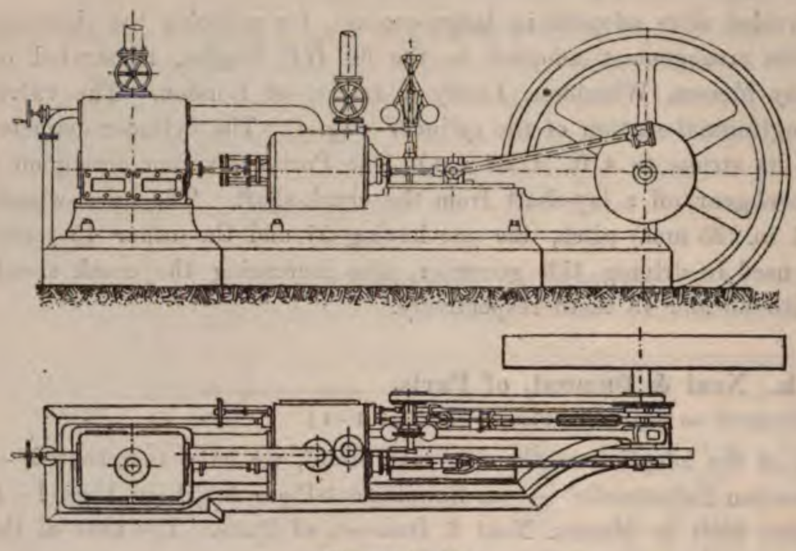


Fig. 177.

plates. As shewn in Fig. 2, the steam is led from the top into the steam-jacket, and passing through the stop-valve chamber enters in the valve-chest. Small pipes lead to the cylinder covers from the first named chamber. The piston-diameter is 27·56 in. (700 mm.), and its stroke = 3 ft. 7 in (1100 mm). Cutting-off at $^1/_5$th stroke, under 5 absolute steam-pressures, and running at 38 revs. per min., this engine developed 100 *HP.*

In continuing to enumerate the various Firms who have adopted the Meyer Valve-gears, we must now confine ourselves, to those few constructions which are specially characteristic.

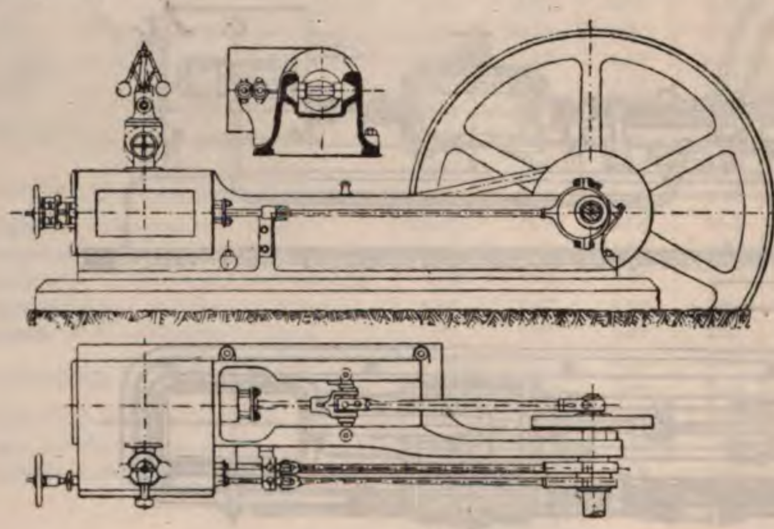
In this respect, a solid arrangement is offered in the Engine, illustrated in Figs. 176 and 177, as made by Messrs. Ruston, Proctor, & Co., of Lincoln. The engine bed is made as narrow as can be consistently done, and the slide-bars are kept close up to the cross-head. The cranked crank-shaft is carried in three journals, two of which are on the engine-bed. The cylinder-bore amounts to 13·46 in. (342 mm.) and its stroke is 2 ft. (609 mm.)



Figs. 178—179.

A compact and solid arrangement is noticed in the Engine shewn in Figs. 178 and 179, and made by Messrs. E. P. Bastin & Co., of London. The steam-jacketed cylinder is supported on a strong bed-plate, extended so as to carry the air-pump, etc. The steam-distribution is effected by divided slide-gear, at each cylinder-end. The feed-pump is worked from the main-slide eccentric.

A similar arrangement is presented by the engine of Leete, Edwards & Norman, of London — vide Figs. 180—182. The cross-head however, is not carried in a slipper-guide as in the preceding example, but is supported in trapez-formed slides as shewn in the sectional drawing.

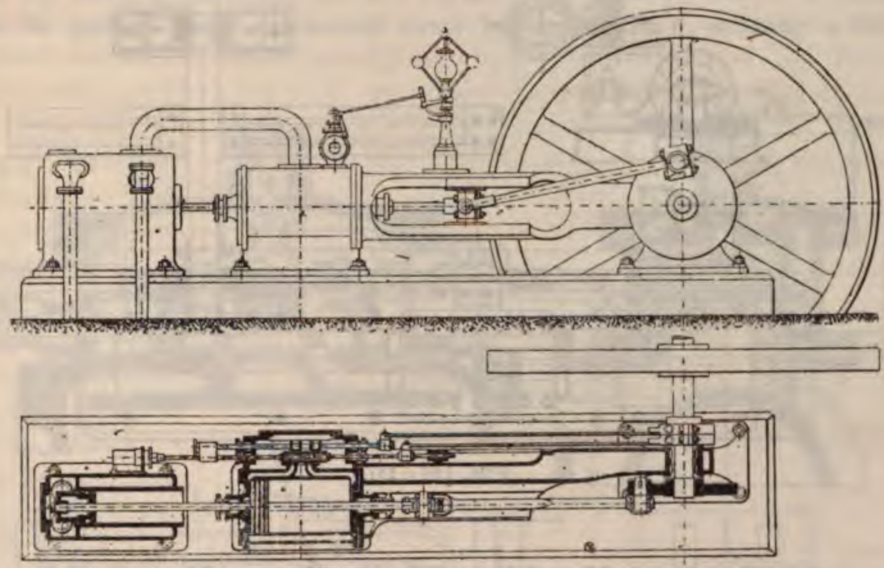


Figs. 180—182.

The Engine of Messrs. Holborow & Co., which we fully described in Vol. II, of Corliss-Engines — see pg. 136 — also belongs to this category, so that we merely reproduce it in Figs. 183—184, to another design.

A larger engine constructed after the designs of Mr. D. N. Morton, by Dick & Stevenson, Engineers of Airdrie, is drawn on Supplement-Plate XVI (Figs. 1—3). The cylinder is 20 in. (507 mm.) bore, and of 30 in. (762 mm.) stroke. As in the last example, the high-speed governor acts on a balanced throttle-valve, being itself driven by belt-gear. The air-pump is arranged vertically; it is of 12 in. (304 mm.) diam. and of equal stroke, and this pump is worked by a cross-shaft and lever from the cross-head. The feed-pump is similarly driven.

An arrangement of Wall-engine fitted with Meyer gear, more or less applied is shewn on Supplement-Plate XVIII. Its construction is simple and solid. Another design, combining the



Figs. 183—184.

slipper-motion with the flat bed-plate is illustrated in Figs. 185—187. As shewn it is of 8 *HP.*; it was exhibited at the Brussels "National Exhibition of 1880", by Mr. Ch. Beer, of Jemeppes.

By way of passing over to those valve-gears in which the expansion-mechanism is placed under direct governor-control, and so made automatic, we may present another Engine built by

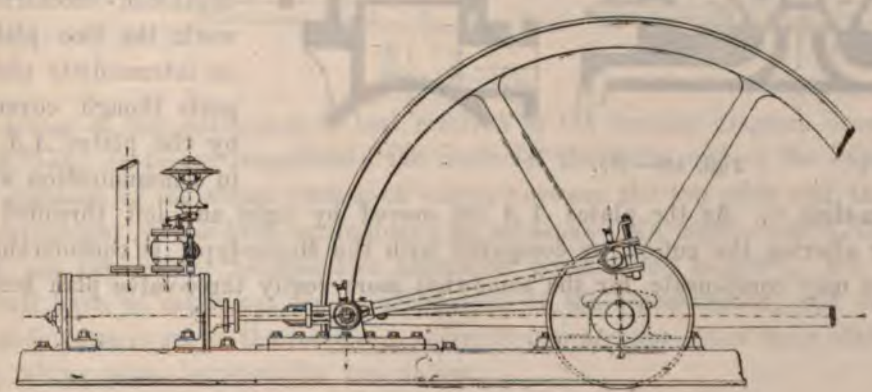
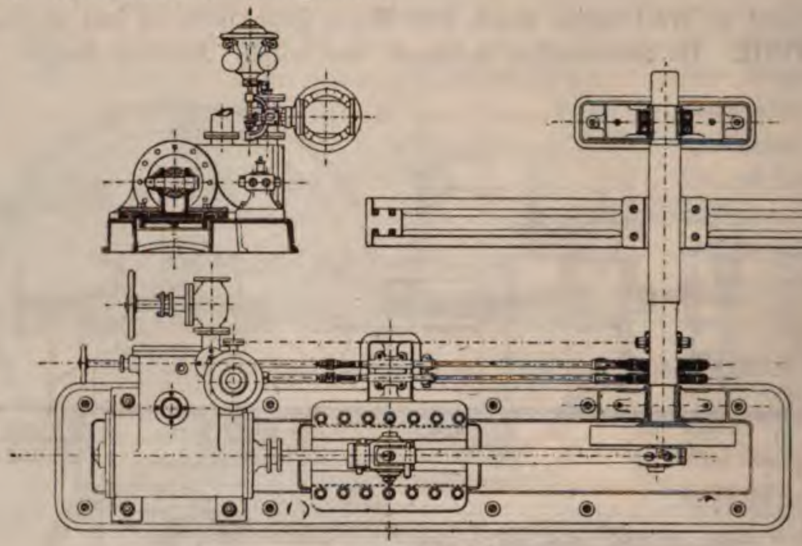


Fig. 185.

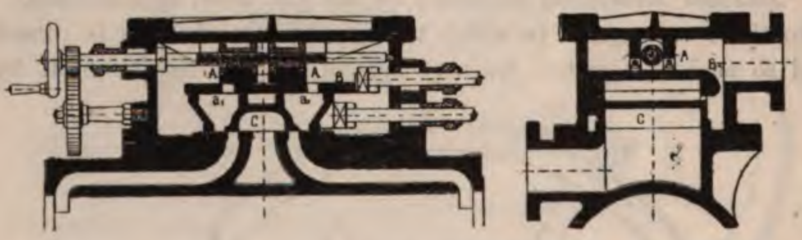
the last named Firm and illustrated by us on Supplement-Plate 10 (Figs. 1—6). The Meyer valve-gear is repeated in the internal valve-arrangement; but a small toothed wheel is fixed at the end of the spindle, which gears into a rack placed over it. This rack is — vide Figure 5 — worked off the governor by a bell-crank, and is thus actuated at the time the expansion-valve changes its travel; as the threaded spindle has little play given to it in the slide-nuts, the governor has only to overcome the friction of the spindle.



Figs. 186—187.

3. The Zorg Maschinenfabrik (Type: Max Eyth).

In 1859, Max Eyth, came before the public with a valve-gear, which like the Meyer type, is based on the variableness given to the working edges of the valve. We illustrate this design in Figs. 188 and 189, as made by the forementioned Engineering Firm. The expansion-eccentric, does not work the two plates *A A*, but an intermediate slide *B*, whose ports though covered at times by the plates *A A*, are always in communication with the ports $a\ a_1$ of the main-slide *C*. As the plates *A A* are moved by right and left threaded screws, the arrangement for altering the cut-off, as compared with the Meyer-type, is considerably simplified, which advantage may compensate for the somewhat more costly three-valve plan here adopted.*)



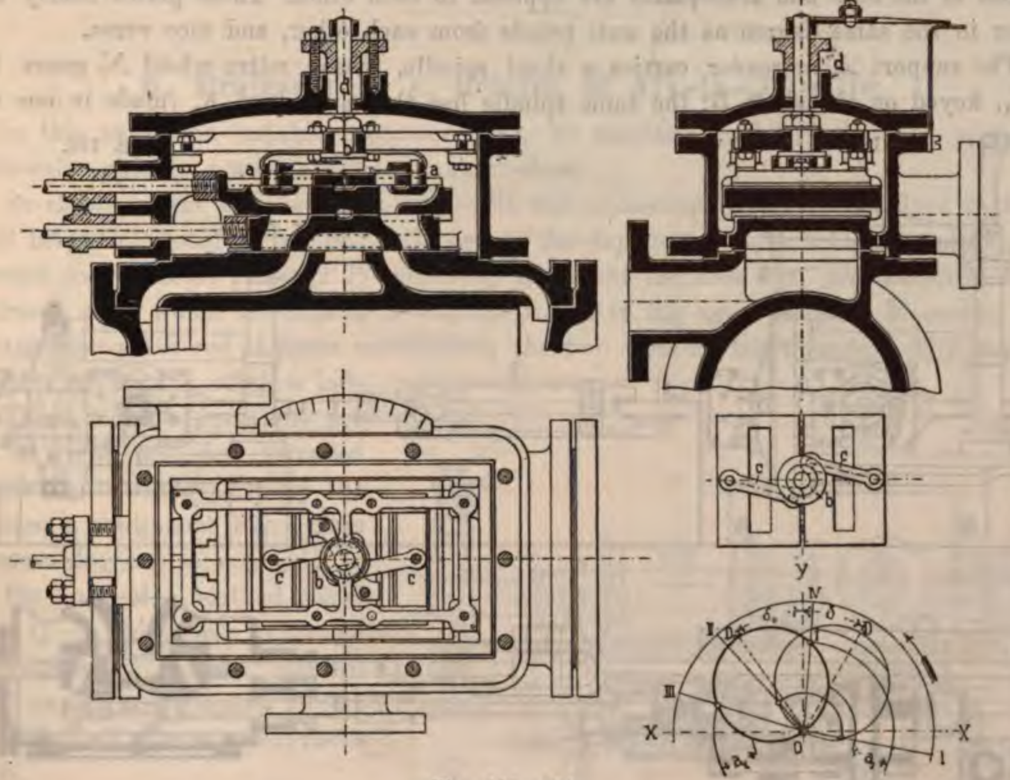
Figs. 188—189.

4. A. Musmann, of Berlin.

Borrowing our illustrations, (Figs. 190—194), from the "Zeitschrift des Vereins Deutscher Ingenieure", the present Valve-gear merely resembles to the Meyer's Expansion-plates, as far as the constructive arrangement is concerned.

*) Vide "Civilingenieur", anno 1877, page 391.

The main-slide carries the two-ported expansion-valve on its back, which expansion-valve is actuated by an eccentric keyed under a negative advance-angle ($-\delta_0$). The relative motion of these two slides takes place according to the laws already laid down, still no cutting off of the steam will take place between them, as the ports of the main-valve present the necessary width. On the top slide, we find two additional plates *a a*, which receive no independent motion, but which can be pushed further or nearer apart by the spindle *d*, working a disc *b*, and two rails *c*.



Figs. 190—194.

The action of this valve-gear is best referred to the circular diagram drawn in Fig. 194; here OD and OD_0, represent respectively the circle of the main- and of the expansion-slide. Oi gives us the distance of the steam cutting-off edges, between the top slide and the plates sliding on it. The port-height a_1 has been again drawn in, as usual. We must observe, that no throttling of the steam can take place, because two admission ports of the height a_1 are offered. In addition, we shall have to mark out the parallelogram of the eccentricities, and make the width of the main-slide ports equal to the relative eccentricity, to prevent a too early cut-off or throttling of the steam taking place between the two valves.

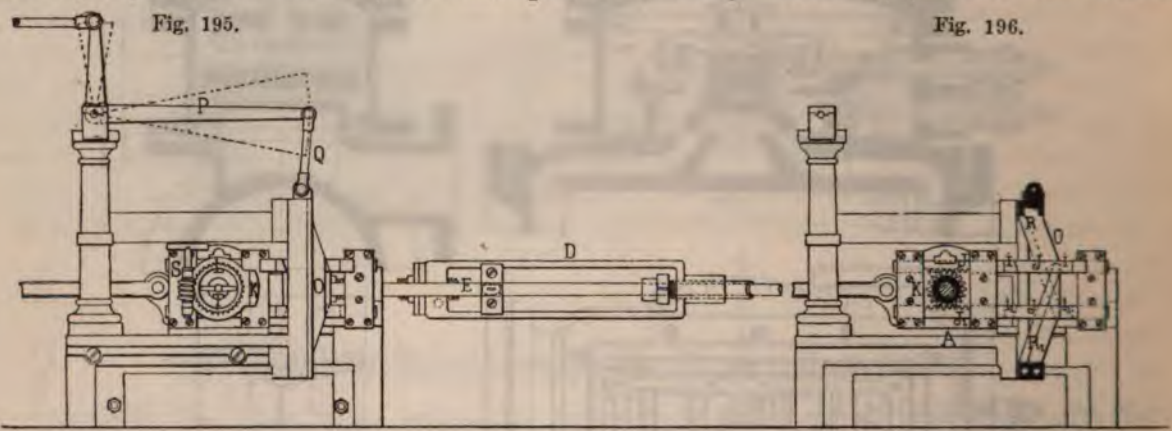
5. The Maschinenfabrik of Graffenstaden.

The chief defect attaching to the Meyer valve-gears consists, as is well known, in the threaded portion of the expansion-valve spindle being much exposed in the steam-space, so impeding the turning of this spindle. For this reason, it is unadvisable to allow the governor to work this spindle direct, but certain mechanisms are interposed to effect this automatically. The present valve-gear is so designed, that the thread, or that part of the mechanism serving for working the plates asunder, is placed *outside* the valve-box; as our Figs. 195—197 shew, this mechanism is arranged on the small rod B, which is supported in the frame A, moved by the expansion-eccentric.

The nut C, of the right threaded screw, is connected to the inner valve-spindle G, and hind plate H, by the bar E; the nut C_1 of the left-threaded screw, on the other hand, is connected to the front-plate H_1, by the frame D, and the hollow spindle F. We must here observe, that the motions of the nuts and slide-plates are opposed to each other. These plates nearly approach each other in the same degree as the nuts recede from each other, and vice versa.

The support A, moreover carries a short spindle, whose mitre wheel N, gears into the wheel N_1, keyed on the shaft B; the same spindle has the spur-wheel K, (made in one with the

Fig. 195. Fig. 196.



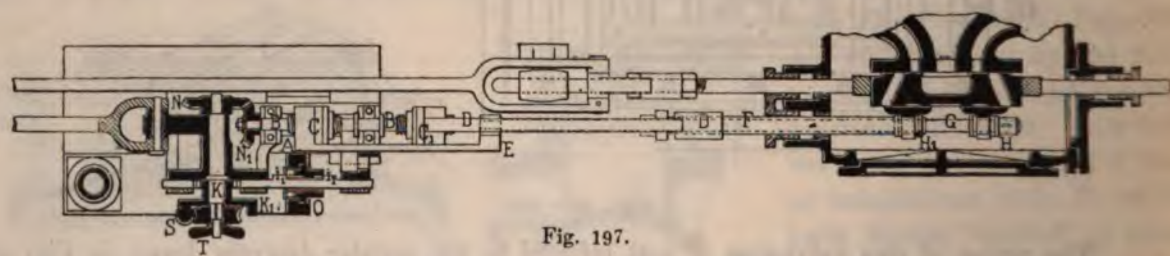


Fig. 197.

disc K_1), loosely fitted to it, and also supports the worm-wheel L, which, by screwing up the thumb-screw T, gears into the disc K_1, and wheel K. The worm S, gearing on to L, is supported by the disc K_1. We find gearing into the wheel K, two horizontal racks J, and J_1 (Fig. 196); the upper rack has a slanting lug i, placed *externally*, whilst the prolongation of the lower rack has similarly an inclined projection i_1, placed *internally*. These racks are guided by the forementioned support A, and take part in its motion; but if they receive additional motion, working in opposite directions to each other, then a rotary movement is thereby imparted to the wheel K, and consequently also to the wheels N, and N_1 as well as to the screw-spindle B; in this manner we obtain a different position of the expansion-plates to each other.

This movement of the racks $J J_1$ is performed by the governor, which acting on the rods P, and Q, pushes a frame O, to and fro. Inclined bars R, and R_1 are fitted to each side of the rectangular opening of this frame O, through which the racks J and J_1 pass, so that when the latter are motioned, according to the position of the frame O, the lugs i and i_1 may come in contact with these inclined bars R and R_1, so causing the racks to be shifted in opposite directions.

Under a normal running speed, the frame O, will be in a central position, and the lugs of the racks $J J_1$ will then permit the bars to pass freely; should the frame be raised or lowered, the lugs come into contact. The governor is however only able to alter the cut-off within certain limits; if these are exceeded, owing to increase or decrease of the engine load, then the thumb-screw T, must be loosened, and the spindle turned by means of the screw S, and the wheel L.

6. Professor H. v. Reiche, of Aix-la-Chapelle.

In this automatic variable expansion-gear, we similarly find the threaded portion of the expansion-valve spindle, placed outside the valve-chest.

As shewn in the annexed Figs. 198—200, the expansion-valve rod, is halved in its centre; each half being connected at one end with one of the expansion plates, whilst its other extremity is connected to the cross pieces $T T$, which by means of the rods $S S$, are combined to form a sliding frame, upon which the expansion-eccentric works in the usual manner. Moreover, each half of the expansion-valve rod is again sub-divided, the two ends having threads, which form on the one a right, and on the other, a left-screw. These threaded portions are encased in right and left threaded nuts, which nuts again piece up the rod to form a continuous bar. This nut is movable, but is not able to turn in the boss of a toothed wheel P — resp. Q —, which boss is carried on a fixed bearing; these toothed wheels P and Q are actuated by the governor through the segment-racks N and O.

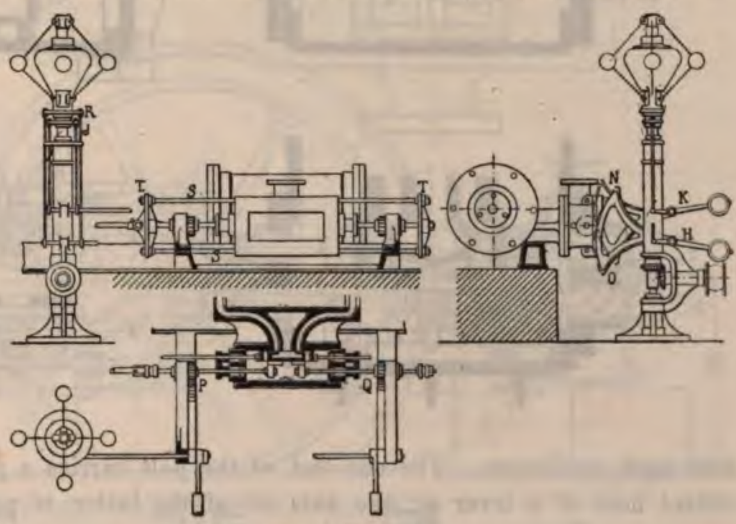


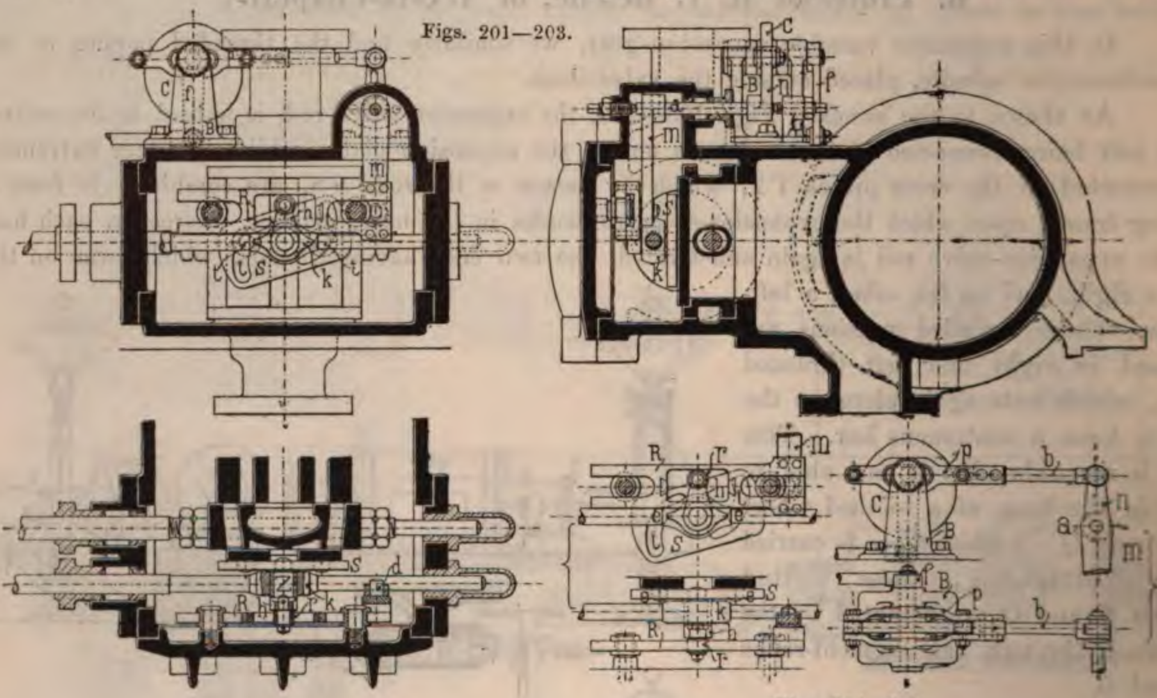
Fig. 198—200.

On account of the expansion-plates always moving in opposite directions to the motion of the frame, and for reason that this movement must take place with a minimum amount of force, the travel of these expansion-plates is made to ensue consecutively, the one receiving its impulse by the forward, whilst the other is moved by the return motion of the frame. Hence each of the metal nuts is arranged to move by itself, and a double governor is used, which acting on two adjustment-rods R and J, reacts through the spindles H and K on to the toothed segments N and O. Thus, inasmuch as rotary motion becomes imparted to one of the nuts of the toothed-wheel bosses, we obtain the travel of the expansion-plate expressed by the summing up of the corresponding screw-pitch; in this manner variable expansion is obtained.

7. A. Pelissier, of Hanau.

In this arrangement, most of the gearing portion is placed inside the valve-box. Our Figs. 201—203 illustrate the cylinder-attachments, whereas details of this arrangement are added in Figs. 204—205. The expansion valve-rod carries in a boxed head *k*, the pin *Z* of a disc *S*, fitted with two spiral-grooves *i*. The latter receive the pins *e* of the expansion-valves, so that when the disc *S* is turned, the position of the two expansion-plates towards each other is changed. The external end of the stud *Z* carries a lever *h*, fitted with a steel roller *r* running in the opening of a bolt *R* which is similarly carried on small rollers; these cause the bolt when motioned, to move in a rectilinear direction; the motion imparted to the roller *r* is done in such a manner, that in oscillating in the forementioned opening of the bolt, it slightly touches its borders

Figs. 201—203.



Figs. 204—205.

with each oscillation. The one end of the bolt carries a pin *d*, which fits in the longitudinally slotted hole of a lever *m*; the axis (*a*) of the latter is passed out of the valve-box through a suitable stuffing-box and is lightly carried on two pointed studs. The lever *n* is mounted on the same axis *a* in the manner shewn.

For transmitting the governor-motion, the frame *B* carries a spindle having at its middle a cam-disc *C*; this non-circular disc, as soon as turned by the governor, imparts a to and fro motion to its encircling frame *p*, which alternate rectilineal motion is transferred on to the lever *n*. In our illustrations, all the parts are shewn in their central-position; correspondingly the lever *h* assumes a vertical position, and the roller *r* moves unmolested in the bolt. As soon as the last named becomes shifted, the roller *r* strikes against the side of the bolt-opening prior to the valve-rod completing its stroke, whereby the lever is forced to change its position. Simultaneously the disc *S* becomes turned, so that the pins of the expansion-plates, which before this occurrence were in the middle of the spiral-slots, are shifted more towards one of the groove-ends, whereby the expansion-plates are brought to the variable distance *s* apart from each other.

8. W. N. Dack, of Patricroft. (Bertram, of Edinburgh.)

(With illustrations on Supplement-Plate XVI, Figs. 4—6.)

Practice has shewn that the valve-gear of Mr. Dack, as illustrated by us on page 139, of "Corliss-engines", was in a certain sense defective and required improvement. We are not in a position of illustrating the nature of the improvements brought to bear on this valve-gear since the publication of our "Corliss-engine" work, so that we here confine ourselves to illustrating the Dack valve-gear as modified by Mr. Bertram, of the Leith Walk Foundry, Edinburgh. The details shewn on Supplement-Plate XVI, Figs. 4—8, at once explain the modification here adopted. The cylinder of the engine illustrated has a diameter of 2 ft. 6 in (762 mm.) and a stroke of 3 ft. 6 in (1066 mm.); the engine is speeded to 52 revolutions per minute. The vertical air-pump has a diameter of 1 ft. 8 in (508 mm.).

9. Louis Soest, of Düsseldorf. Hy. Berchtold, of Thalweil (near Zürich).

(With illustrations on Supplement-Plate XVII, Figs. 5—10.)

The principle adopted in the last named valve-gear, is repeated in the valve-gears of Louis Soest of Düsseldorf and of H. Berchtold of Zürich. The difference between the three designs,

Fig. 206. Fig. 208.

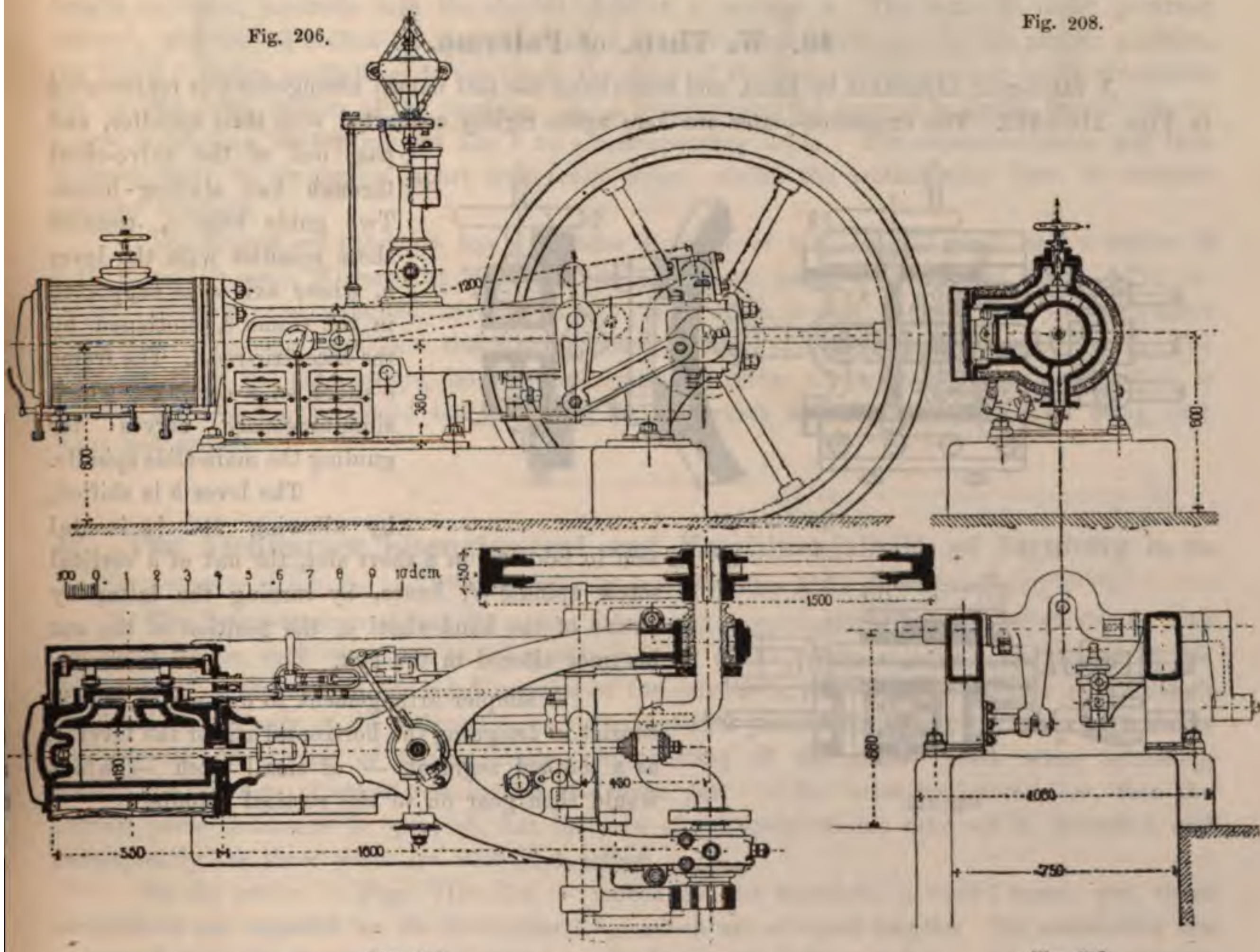


Fig. 207. Fig. 209.

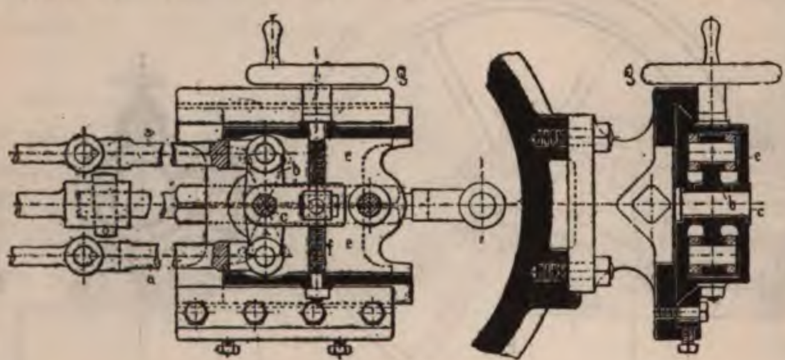
consists in the expansion-valve rods not passing separately out of the valve-box, inasmuch as by making the one hollow, the other rod is inserted inside it. The expansion-plates may thus be grasped centrally, and the whole arrangement displays greater symmetry, than Dack's design. A second stuffing-box has of course to be introduced on the extremity of the one valve-rod, so as to pack the internal rod steam-tight.

The cylinder shewn on Supplement-Plate XVII, Figs. 5—7, belongs to a pair of Engines, constructed by Mr. Louis Soest, of Düsseldorf; owing to the engines being coupled together, the governor, arranged between the two, works the transverse shaft on the valve-box, acting through a balanced lever on to a three-armed lever. The cylinder-bore = $17^{3}/_{4}$ in (450 mm.); stroke = $27^{1}/_{2}$ in (700 mm.).

The engine-design of Mr. Berchtold, of Thalweil (Switzerland), is represented in the annexed Figs. 206—209. An additional peculiarity of this valve-gear, is the form of the engine-bed, and of the cross-shaft which works the air and feed-pumps and the main-slide.

10. W. Theis, of Palermo.

A valve-gear adjustable by hand, and resembling the last named arrangement is represented in Figs. 210—212. The expansion-plates are here again rigidly connected with their spindles, and pass out of the valve-chest through two stuffing-boxes. Two guide bars *a*, connect these spindles with the lever *b*, whose axis *c* is supported in the frame *e*, motioned by the eccentric-rod *d*. The frame *e* slides on a carriage, which simultaneously serves for guiding the main-slide spindle.



Figs. 210—211.

The lever *b* is shifted, by allowing its horizontal arm to take up in a short slot, the nut of a vertical screw spindle *f*; hence, by turning the latter by means of the hand-wheel *g*, the position of the nut becomes altered in the slot.

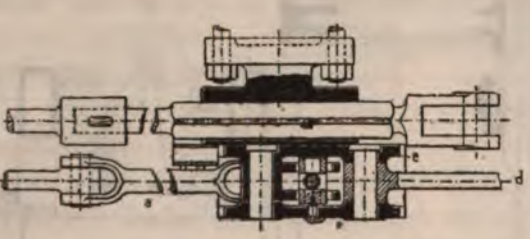


Fig. 212.

A simpler arrangement to our minds, would consist in designing the horizontal arm of the lever *b* as a toothed segment — of small pitch — which would then gear on to the vertical spindle.

11. Berlin Union Co. Lim., of Berlin.

(With illustrations on Supplement-Plate 9, Figs. 1—8.)

The valve-gear of the Engine, exhibited at the Vienna Exhibition by the Berlin Union Co. Lim., is drawn on an enlarged scale in Figs. 4—8 (Supplement-Plate 9). The internal arrangement of the valve-gear with the main-valve, and the two expansion-plates, approaching and receding from each other, are as in the Meyer valve-gear; but the characteristic feature consists in the manner in which the slide action is obtained.

No screw-spindles are used, but each plate is rigidly connected with a separate rod *c*, which slide in stuffing boxes arranged close to and over each other. These rods have small links with pins, which connect them to a circular disc *b*, which is caused to oscillate by the expansion eccentric. As long as the whole gear-mechanism is in its middle position, the disc receives no other motion than the one due to the expansion eccentric, cut-off taking place always at the same time. The cut-off is changed in the following manner:

Two levers *d* oscillating on rigid pins *e*, are furnished with longitudinal slots at their inner ends, which eyes receive the forementioned pins of the rods *a*; the steel studs *f* placed midlength on them, protrude into the slanted slots of a carriage *g*. The latter is under governor control, and can be shifted by the bell-crank *h*, in a vertical direction. In the middle position, the studs *f f* when oscillating, do not touch the sides of the slots, which however takes place with the up and down motion of the carriage. As a consequence, the lever *d* is forced to oscillate on a new centre-line, so turning the disc *b* to a corresponding angle. The expansion-plates are thus brought close to or further apart from each other, whilst the motion they have in common remains constant.

The Engine we illustrate has a cylinder diameter of $14^1/_2$ in (370 mm.) and a stroke of 2 ft. 4 in (710 mm.); it works at 55 revolutions per minute under a pressure of 5 atm. The cylinder overhangs and is bolted to the massive bed, which is cast in one with the main-shaft pedestals. We may point out the large exposed surface of the valve-chest as a defect. The slide-bar is of the slipper-type, bored cylindrically, whereby a new and unusual connection is effected between the cross-head and its sliding surface, which must be characterised as being very light and simple.

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12. The Nienburger Eisengiesserei and Maschinenfabrik, of Nienburg o. S.

(With illustrations on Supplement-Plate XIX.)

The Steam-engines of this Firm, are fitted with a valve-gear, patented by C. Cario. The expansion-plates, each connected to a separate rod, cut off $2^1/_2$ ports at once. The reason of this arrangement is due to the one-sided impulse of the valve-rods, which in this manner pass through the centre of gravity of the valve-surfaces. The external port-openings are $2^1/_2$ times as wide as the internal, on account of the expansion-valve shutting off the narrow ports when returning, whilst the full flow of steam remains for the broad port. If the latter begins to close, then the narrow ports commence to open, so that the area of surface-admission may not be curtailed, and subsequently the three ports are shut off together.

In the rod *e* — Figs. 213—216 — moved by the eccentric, a stud *i* turns, and these oscillations are repeated on the lever-arms $h\ h_1$, which are of equal lengths. Its extremities are connected with the expansion-valve rods $s\ s_1$, by two guide links r and r_1. Any undue turning of the lever is counteracted by a brake-arrangement, the lever-arm h being of a disc-form, whilst the wooden cone k is fastened to it. The brake-piece m is prevented from turning, and may be passed against the wooden-cone by a set-screw a; thereby the lever hh_1 is hindered from turning by frictional resistance.

Fig. 213.

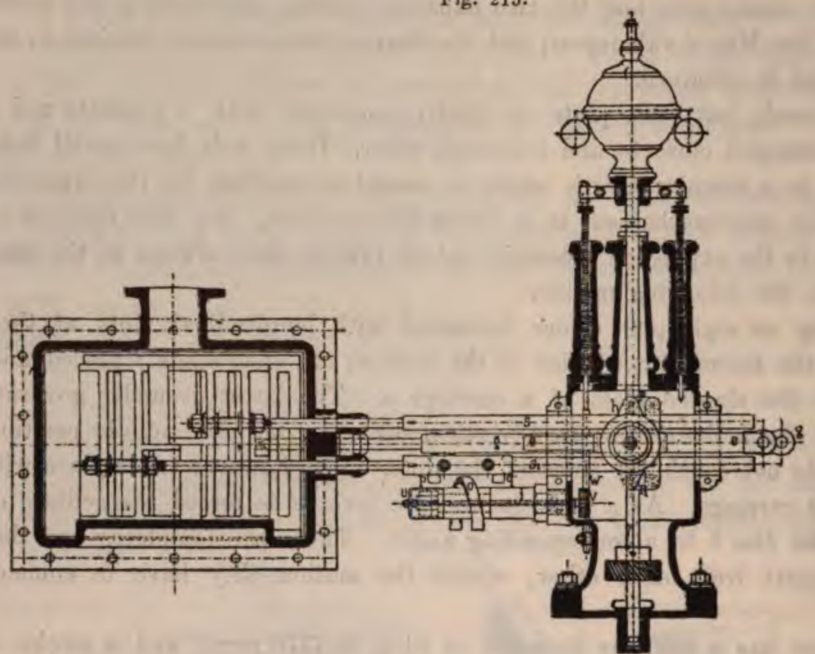
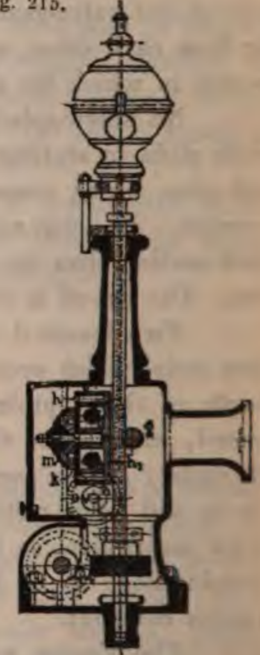


Fig. 215.



Underneath the expansion valve rod s, we have, a worm o mounted on a steel-pin t fixed to the governor-stand; this worm can be easily motioned off the governor by the rack w, and the toothed wheel v. Now when the lugs p and q on the expansion-rod s_1, strike again the worm, a stoppage ensues — i. e. the expansion rod s_1 — assumes a different position; this however commands an altered position of the rod e through the lever hh_1. If the governor has shut

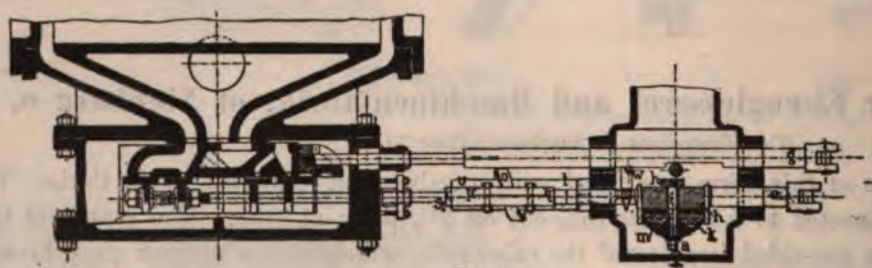


Fig. 214.

Fig. 216.

steam off, the lugs p and q no longer come in contact with the worm o. The governor is fitted with two additional spiral springs, whereby the normal engine speed, may be varied.

Noteworthy is the engine girder-frame illustrated on Supplement-Plate XIX, which not merely gives a pleasing effect to the machine, but also contributes to the solid bedding of the cross-head.

13. Erie City Iron-Works, Erie, (Penn. U. S. A.)

The general-arrangement of the engines mades by this Firm, was already illustrated on page 24. The large sized engines are however supplied with an expansion-gear, which we represent in the annexed Figs. 217—219. We meet here the novel feature, that the two ports, 1 and 2, of the main-slide, are no longer parallel to each other, but converge towards one another. We note that the wedges introduced in the Shank expansion-gear, as illustrated and described by us on page 130—131, of our second Volume, are transferred to the port-openings and to the expansion-valve. The latter is no longer composed of two pieces, but of one single casting, and may therefore be termed a trapez-valve. The distance of the working valve-edges, which must naturally be measured in the valve-travel direction, is altered by the rising or falling of the trapez-slide, — i. e. in normal direction to the valve-motion, which movement is depending on the longitudinal motion of the slide. The lateral edges include the same angle (65°) with the port-edges of the main-slide.

Fig. 217.

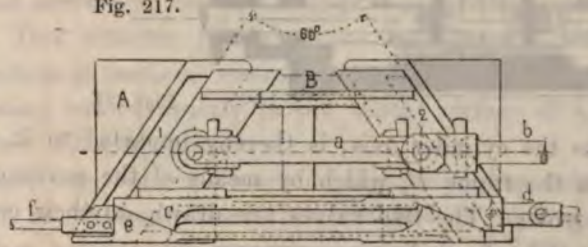
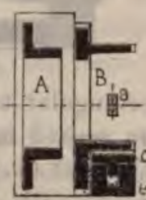


Fig. 219.



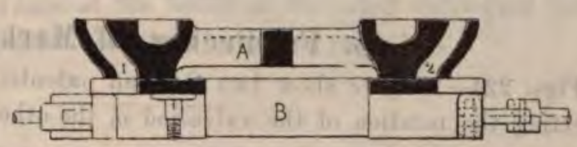
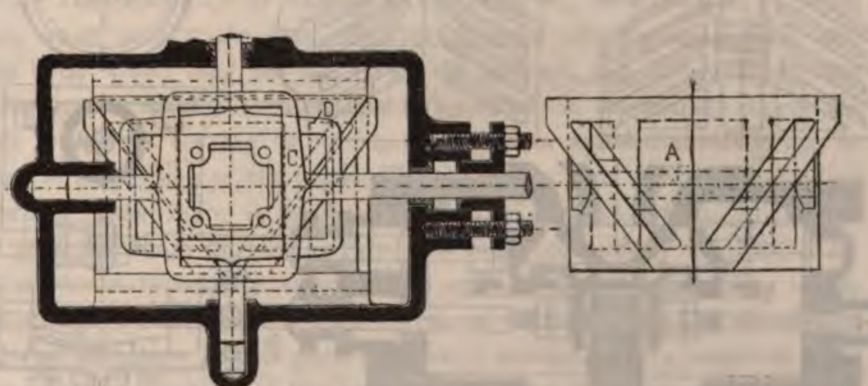


Fig. 218.

In the annexed wood-cuts, the divided *D*-slide has been utilised. The expansion-slide, with its link *a*, is connected to its valve spindle *b*, in order to impart vertical motion to the valve. The latter slides on an inferior wedge-formed piece *c*, which is hung by the link *d*, to the metal of the valve-box. Below, we have the wedge *e*, to which a rod *f*, passing out through a stuffing-box, is fixed; this rod can be drawn in and out by an external handle, whereby the forementioned rising or falling of the valve is obtained. The governor works on a throttle-valve, in these engines.

14. J. Ewerhard of Gevelsberg, Westphalia.

The expansion-valve in this valve-gear is also a trapez-valve. The annexed Figs. 220—223, illustrate the arrangement inside the valve-chest, as well as the face of the main-slide *A*, and of the trapez-valve *B*. These two are arranged on the same principle as the preceding example; towards the cylinder, the main-valve ports are parallel to each other, but converge at an angle of 75° on the expansion-slide face.



Figs. 220—221.

The double motion of the trapez-valve, (patented in Germany), is obtained in the following manner: The frame C, is motioned to and fro by the eccentric; it is made to include with its two parallel sides the four cornered shoulder of the expansion-valve, so that a motion

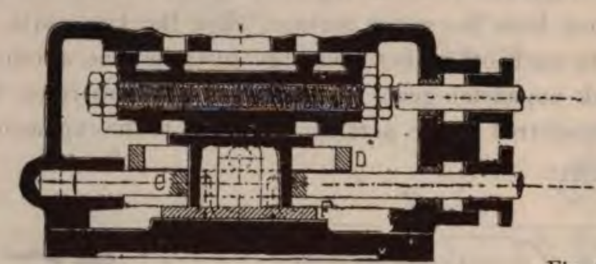


Fig. 222.

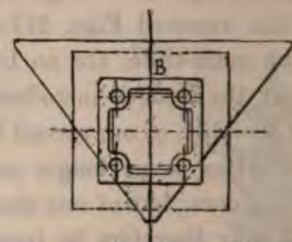
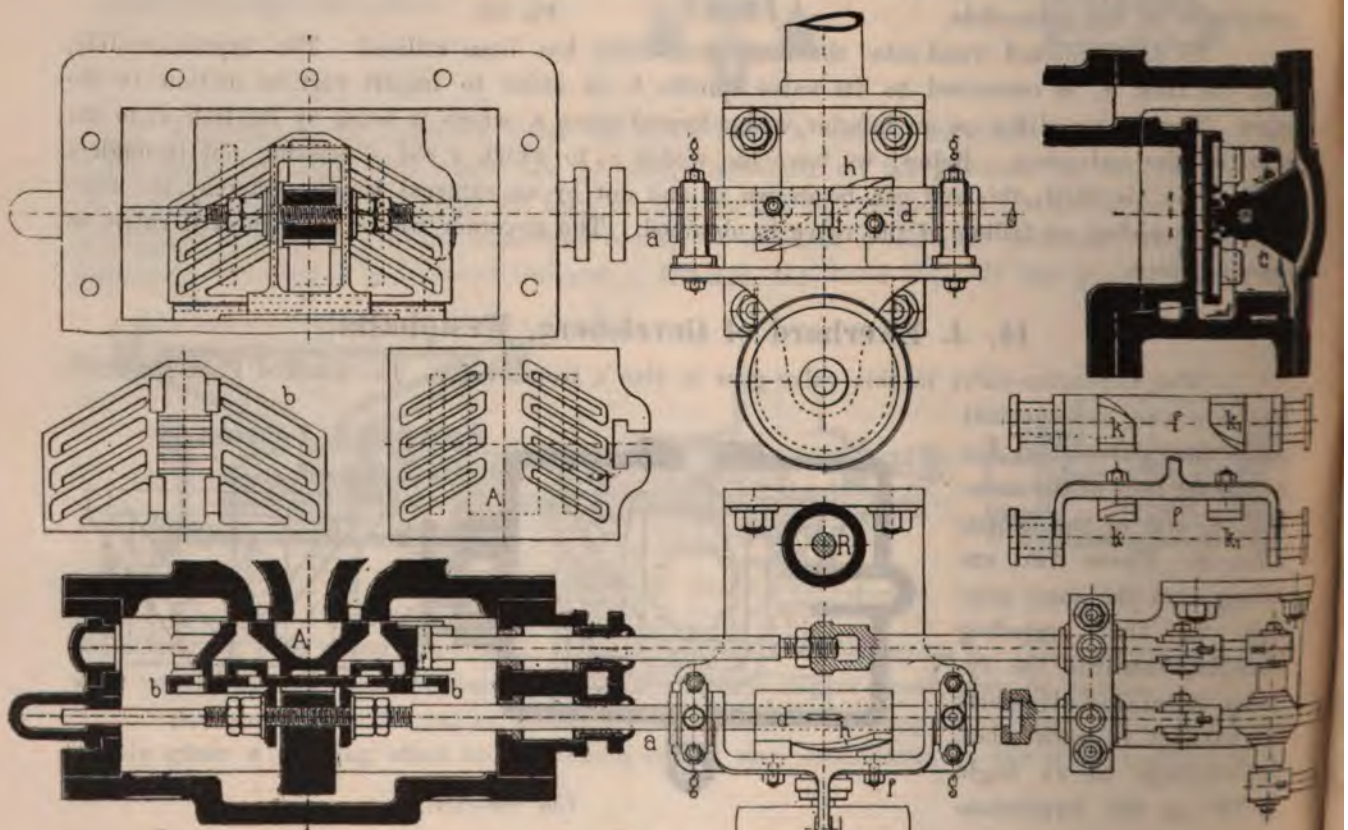


Fig. 223.

rectangular to the cylinder axis, is thereby imparted to it. The two other sides of this shoulder, are carried in the frame D, which by means of the governor or a lever, can be shifted vertically to the slide-stroke. The two valves are drawn in their central-position. A plate F, is fitted to the expansion-slide, for balancing purposes.

15. Fr. Becker, of Mark-Gladbach.

In Figs. 224—230, we show two German patented valve-gears, the one for a certain mechanism effecting the rotation of the valve-rod a, the other referring to the arrangement of a grid-


Figs. 224—230.

formed expansion valve *b*, which is made also in one piece only. A toothed rack is cast on its back, into which a small segment (balancing the valve and furnished with counter weight *c*,) gears. In connection with the external mechanism, the valve-spindle *a*, carries a rigid collar *d*, on to which a helical shoulder *h*, is cast. In front of the latter, we find supported in bearings *g g*, a saddle *f*, which at *i*, is grasped by the governor rod. This saddle is furnished with two lugs $k\,k_1$, which respectively play over and under the shoulder *h*. Their horizontal distance is determined to allow the shoulder to move over the whole slide travel, without coming in contact with the forementioned lugs. We may now observe, that on the saddle *f*, turning, the threaded surface *h*, also comes in contact with the inclined surface of one of the lugs, and gliding over this surface, is simultaneously forced to rotate. This rotation effects as we have seen a shifting of the expansion-plates vertically to the direction of motion, whereby the distance of the working-edges is altered. On account of the lugs being formed exactly to the helical surface of *h*, the force of contact is deadened, and rotation ensues without noise.

The governor in this valve-gear, also does not work continuously, but only during one valve-stroke. As long as no alteration in the engine loads is manifested, or so long as the speed is not changed, no connection takes place between the expansion mechanism and the governor-rods, whereby the latter experiences no annoyance at the hands of the other valve-gear portions. The same remark applies to Pelissier's valve-gear described by us on page 116.

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16. D. Longworth, of London.

We may supplement this chapter, with Longworth's automatic valve-gear and governor. Similar to the last described example, the expansion-valve is free to move at right angles to the direction of travel of the main-slide. As the governor adopted shows some novelty, we will describe the same, utilising for this purpose the description published by "Iron", whence our Fig. 231 is also borrowed.

The new features in the governor itself consist first, in the introduction of a cast-iron bell or hollow cone, suspended on the vertical governor-spindle, rotating with it, and capable likewise of an up-and-down movement on the spindle by means of a slot in the latter. This hollow cone acts as the counterpoise to the centrifugal force of the balls, replacing the weight in the well-known Porter governor. Within the cone revolve the governor-arms, suspended from the spindle in the usual manner. The specialty of the governor-balls is, that instead of being rigidly connected to the arms, as is usually the case, they are free to revolve upon pins, and the surface of the hollow cone upon which they act can be varied in form, and the governor thus rendered as isochronous as required. As the counterpoise is mounted on the spindle above the point of suspension of the ball arms, the bearing in which the governor spindle revolves can be brought quite close to the point of suspension of the arms. The spindle is thus effectually steadied without the aid of a top bearing; thus there is much less vibration and wear than in the old methods, and the governor is therefore more durable. The balls being completely covered in by the counterpoise, all risk of accidents is entirely avoided. It will be seen by reference to the illustration, that the governor, although running at a high speed, is driven by gearing instead of by belt. We would direct special attention to this point, as many accidents have occurred, both to engines and machinery, through the breaking of the belts which drive the governor.

The main slide-valve is actuated by an eccentric and a slide-rod in the usual manner, and

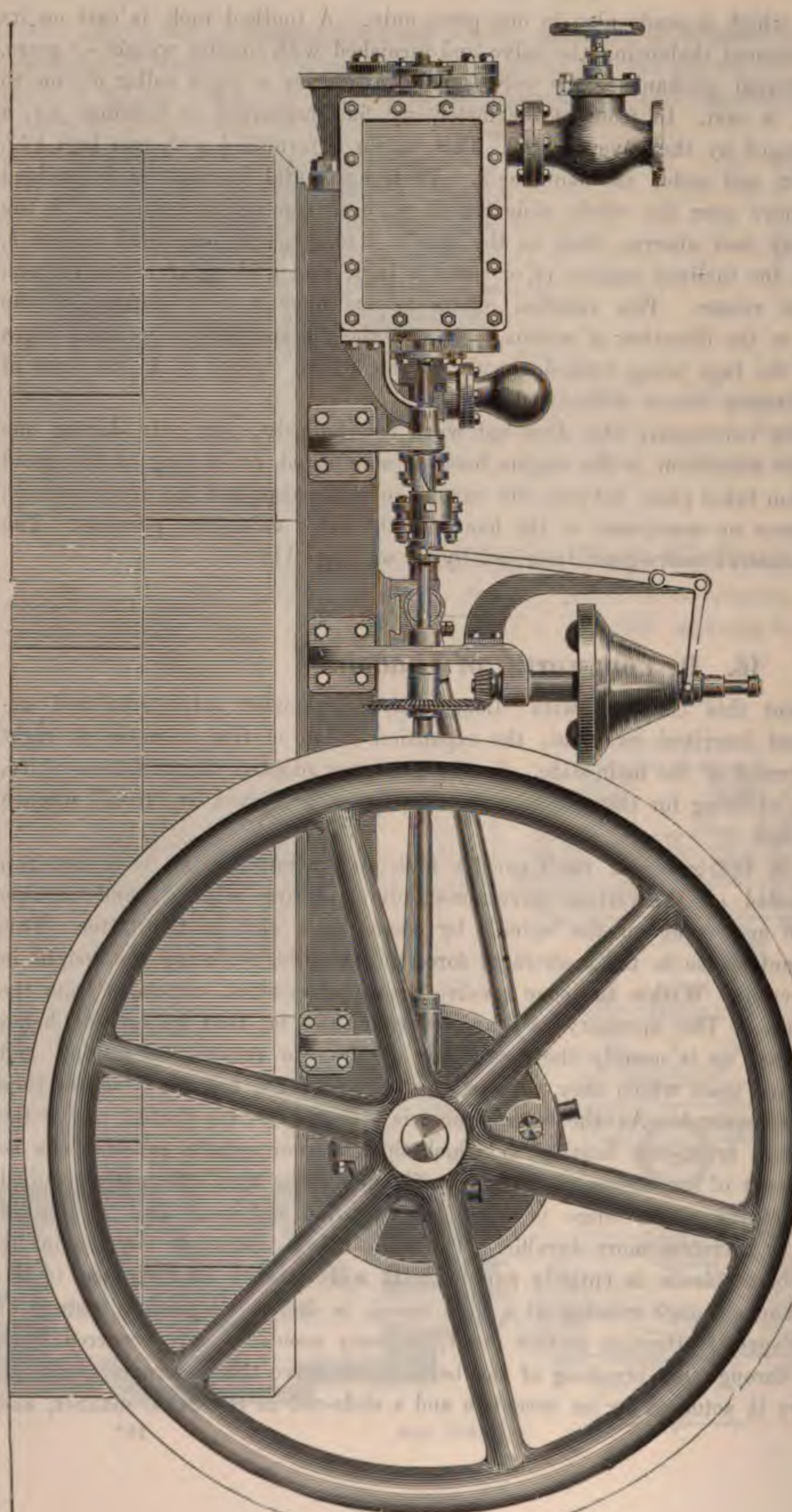

Fig. 231.

is of the ordinary construction as regards the ports which communicate with the steam-cylinder. On the back of the main slide-valve is mounted the expansion valve. This is of the plate or flat type, though other kinds may be employed. By means of guides on the back of the main slide-valve, the expansion valve is made to partake of the longitudinal motions of the former. The expansion valve is free however, also to move at right angles to the direction of travel of the main slide-valve. There are two sets of horizontal grid-iron ports in the back of the main slide-valve, one set communicating with one end of the steam-cylinder, the other set with the other end. Corresponding ports are formed in the expansion valve, but they are so arranged that when the steam has admission through one set of ports, it is cut off from passing through the other set, and *vice versa*. As the expansion valve is moved up and down by the spiral cam, to be afterwards described, the steam is thus alternately cut off from either end of the cylinder. When the valve remains in mid-stroke, steam can be admitted to either end of the cylinder. This point is obviously of importance on many occasions. In the case of Rolling Mills for example, when a bar gets jammed in the rollers, the expansion valve can be rendered inoperative by a slight modification in the spiral cam, and the engine can then be reversed by the usual hand gear. As the total travel of the expansion valve is only $^1/_2$ inch in a 20 horse-power engine, it will be readily seen that the wear, as well as the power required to move the valve, is reduced to a minimum. The expansion valve remains in whatever position it is moved into, whilst, as its travel is at right angles to that of the main valve, the cut-off can take place as early or as late as is required.

The connection between the governor and the valves is formed as follows: — On the back of the expansion valve are cast two horizontal ribs, the space between them forming a groove in which is freely fitted the end of a toothed lever attached to a rocking shaft, which is placed parallel with the main slide-valve rod, and passes out of the steam-chest through ordinary stuffing boxes and glands. On this rocking shaft, and outside the steam-chest, is keyed a forked lever having a weight attached to counterbalance the expansion valve. This lever carries two rollers. Between the rollers, and mounted on the horizontal shaft shown for driving the governor, is placed the before-mentioned spiral cam. This revolves at the same speed as the crank-shaft of the engine, while it is capable of being moved along the shaft by the bell crank lever connecting it with the governor. As the spiral cam revolves, it acts alternately on the rollers, and through them on the expansion valve. Since the cam acts upon the rollers during only one-third of its revolutions, it is quite free to assume any new position consequent on a change of speed in the engine during the remaining two-thirds, and there being thus no resistance of any kind, the maximum of sensitiveness is obtained.

The working of the automatic mechanism can now be readily understood. When, owing to a lightening of the load on the engine, the speed of the governor is increased above its normal rate, the augmented centrifugal force of the balls forces the hollow counterpoise to move up the spindle. Coming into contact with the bell crank lever, it acts through this upon the spiral cam, causing the latter to move to the right hand, and thus bringing a more advanced section of its spiral into the same place as that of the rollers on the forked lever. The steam is thus cut-off earlier in the stroke. When, owing to an increased load on the engine, the speed is diminished, and the counterpoise moves down the spindle, an effect takes place opposite to that just described, and the cut-off is later. The peculiarity of the spiral cam consists in this: — Its eccentricity is so slight that the angle with which it acts on the rollers is within the angle of repose of the acting surfaces, so that there is no tendency in the cam to resist the action of the governor. Experience has shown that in point of durability the cam will outlast the engine itself. It also gives a quick cut-off, and the gear is said to work quietly at 200 revolutions per minute.

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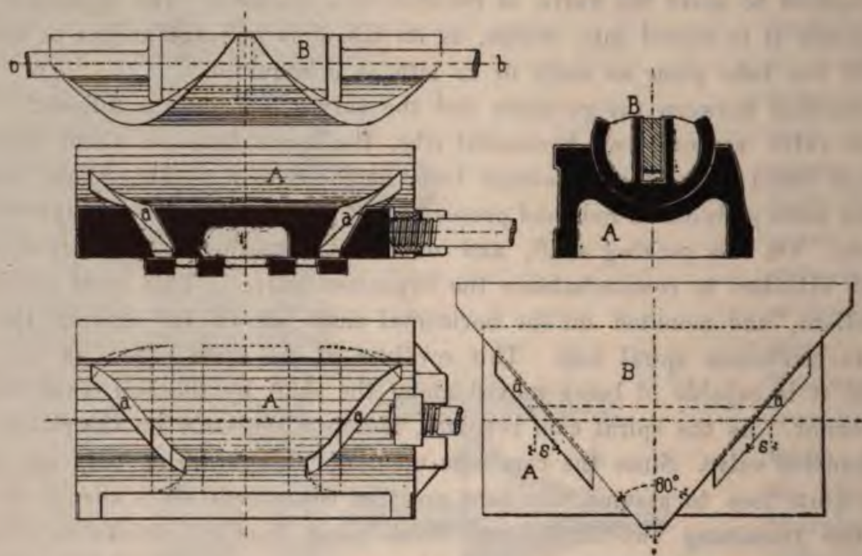
17. The Original Rider Valve-gear.

The preceding valve-gears form as it were the stepping-stone to the Rider-gear, so called after its inventor A. K. Rider, of New-York. The only difference between the two types consists in the abandonment of the *flat* trapez-valve face *B*, for a *cylindrical* face, whose axis coincides with the axis of the expansion-valve rod *bb*; this new expansion-valve is similarly motioned vertically to the main-slide direction, which is done by causing its spindle to turn, whereby the distance of the working edges is altered.

The longitudinal section and plan shewn in Figs. 233 and 234 at once explain the course of the ports *a a*, in relation to the main-slide *A*, which now appear of helical form. The expansion valve *B*, is drawn over the main-slide *A*; the sides of the former, form an angle of 80°, as is best seen from the development of the slide surface represented in Fig. 236.



Figs. 232—236.

To motion the expansion-valve, its rod *b*, is flat, and is provided with necks which fit exactly in the socket of the former. The rotary motion of the expansion-valve rod, which extends to 90° for all available cut-offs, can easily be effected by the governor, whose rod works a lever placed over this valve-rod. To admit of the to and fro motion of the valve-spindle taking place the last named lever is square, or is loosely mounted on a key-way, which permits the longitudinal motion of the valve-spindle.

Owing to the simplicity of the Rider valve-gear, it has been extensively used, and we now propose to describe some of its applications by certain Engineers:

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18. Engines fitted with the Rider valve-gear.

a. G. Sigl, of Vienna.

(With illustrations on Supplement-Plate 16, Figs. 1—10.)

The Vienna International Exhibition brought the Rider valve-gear into greater prominence, and to G. Sigl the merit is due of having introduced considerable improvements on the original design. On Plate 16, we illustrate several Rider valve-gear modifications of this Engineering Firm. In Figs. 1—4 of the same Plate, we shew an engine of 12·40 in. (315 mm.) cylinder-bore, and of 24·80 in. (630 mm.) stroke, designed with short steam-ports, on the face of which a channeled valve slides; the expansion valve appears therefore correspondingly long. Noteworthy is the construction of the valve-chest, the cover-joint of which passes through the centre of the expansion-valve spindle. A feed-water-heater is arranged inside the cylinder-support; the former consists of two short wrought-iron pipes, closed at their ends, which are surrounded by the exhaust-steam, and are connected together by a top-piece. The circulation in these pipes, ensues longitudinally by inserting two smaller pipes, which conduct the feed-water to one end, and take it away again at their other extremity. The engine is fitted with all the necessary fittings to enable indicator-diagrams to be taken off each cylinder-end.

The pair of Engines represented in Figs. 5—9, of the same Supplement-Plate, was one of the Steam-Motors of the Vienna International Exhibition. It shews a sensibility in the regulation of its balanced Rider-valve-gear, which leaves nothing more to be desired. The details of Figs. 8 and 9, shew how the main-valve is furnished with a cover, inside whose slotted surface similarly inclined passages are arranged. As the expansion-valve is arranged with diametrically opposed ledges, a perfect balancing of this valve is obtained. The engine has a cylinder diameter of 23·71 in. (526 mm.) and a stroke of 41·50 in. (1054 mm.). The range of automatic cut-off lies between 0·08 and 0·6 stroke. The number of revolutions per min. = 42. The cylinder cast in one with the valve-chest, is bolted to the bed-plate, the crank-shaft pedestal being also bolted thereto. The bed is scooped out to receive a crank-race, and forms also the slipper-guide for the cross-head. To shorten the length of the ports, the expansion eccentric is brought close up to the crank-shaft pedestal, and its rod is in a straight line with the expansion-valve spindle; on the other hand the outer eccentric has to act on an intermediate lateral lever-spindle, so as to get clear of the expansion-rod on to its own main-slide spindle.

An arrangement where no regard is paid to shortening the steam-ports is illustrated in our Fig. 10, of the same Supplement-Plate. It is shewn as applied to a 20 *HP.* Engine of 12·40 in. (315 mm.) cylinder-bore, and 24·80 in. (630 mm.) stroke, which Engine was also exhibited at the Vienna International Exhibition.

b. Gebrüder Sulzer, of Winterthur.

(With illustrations on Supplement-Plate 15, Figs. 5—6.)

c. Maschinenfabrik Augsburg, of Augsburg.

(With illustrations on Supplement-Plate 15, Figs. 1—4.)

The Engine-cylinder constructed by Messrs. Sulzer Bros., illustrated in longitudinal and transverse sections on Supplement-Plate 15, Figs. 5—6, is built in an improved form by the Maschinenfabrik Augsburg, who as licensees have acquired the right, off the first mentioned Firm. We shew the improved arrangement in Figs. 1—4 (Supplement-Plate 15). A comparison of these two valve-gears, shews that in the last named design, the expansion-valve is balanced. The cylinders are cast with double linings, the admission taking place from below, so that the steam passes through the jacket, and through a superior hand-valve in to the valve chest, arranged at the cylinder-side. We note a new arrangement of engine-girder frame, furnished with legs, fore and aft. The front cylinder-cover is cast with the bed, and the overhanging cylinder is bolted thereto by eight bolts. The eccentric rods are supported in a characteristic method. The Sulzer Engine drawn on Supplement-Plate 15, to a smaller size than the one alluded to in our Table under No. 27, is of 7·08 in (180 mm.) cylinder-bore, and 17·72 in (450 mm.) stroke, running at 90 revs. per min. The Augsburg Engine-type has a cylinder of 6·69 in. (170 mm.) diam. and of 15·75 in. (400 mm.) stroke, and works at 120 revs. per minute. Running under 5 atm. pressure, and cutting off at $^1/_4$ stroke, it gives off 10 *HP.* In conclusion the designs of these two engines, must be admitted to be exceedingly elegant.

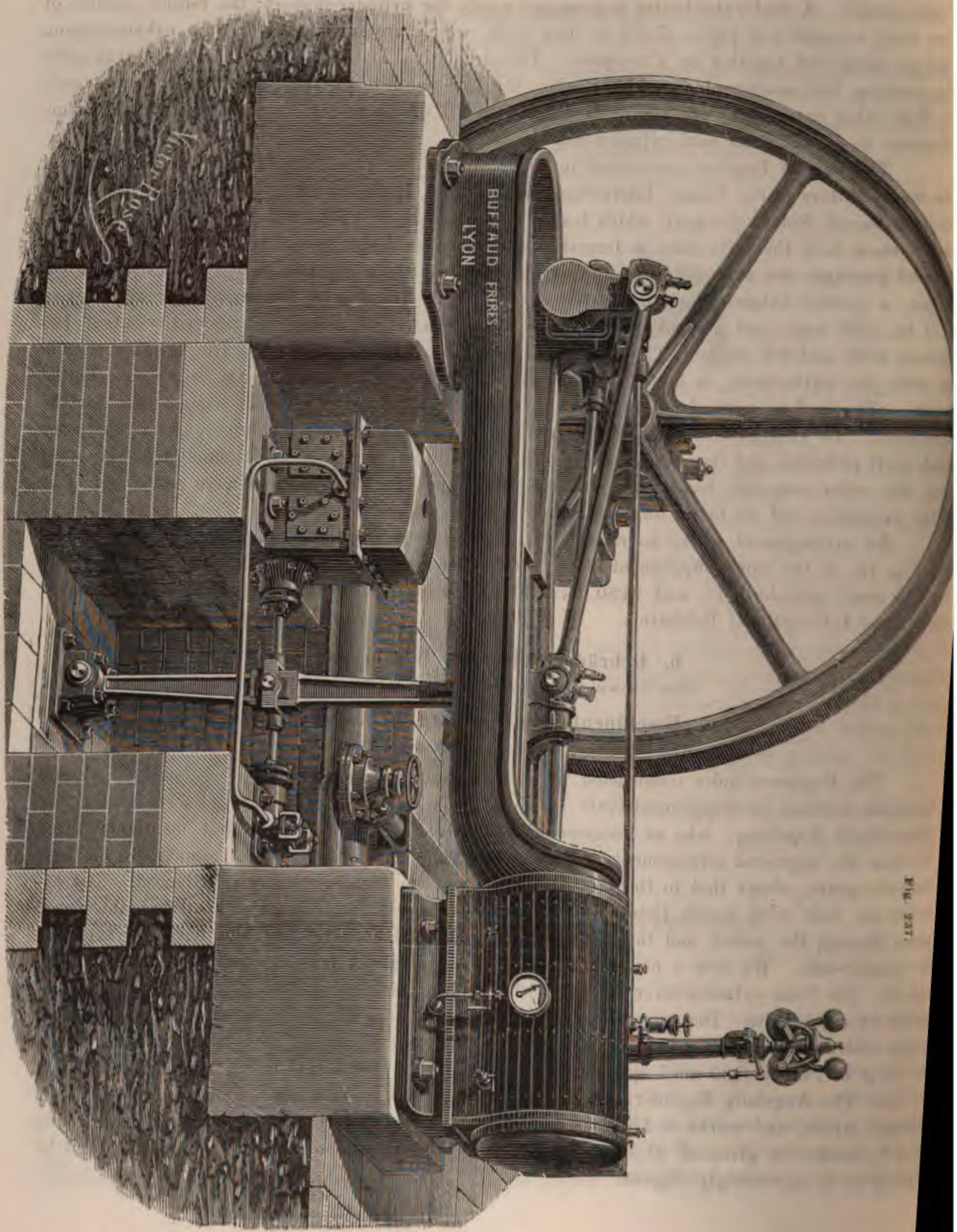


Fig. 237.

d. Buffaud Frères, of Lyons.

In addition to the Engine-type illustrated by us on page 184 of our second volume, Messrs. Buffaud Frères, of Lyons, construct a Rider Valve-geared Engine which we illustrate in Fig. 237, with condenser attached. The general design of the machine will be seen from our woodcut, and as the valve-gear mechanism is repeated in its original form, we will merely append a Table of the chief dimensions relating to these Engines:

Horse-Power	4	6	8	10	12	15	20	25	30	40	50	60
Cylinder diam. in inches	6.69	7.87	9.45	11.02	11.81	11.81	13.78	14.96	16.14	17.72	19.69	21.66
Stroke in in.	16.73	16.73	20.48	20.48	20.48	23.62	25.98	29.92	29.92	35.43	39.37	39.37
Revolutions per minute ..	75	75	70	70	70	65	65	50	50	45	45	45

e. Gebrüder Sachsenberg, of Rosslau, o/Elbe.

(With illustrations on Supplement-Plate 14, Figs. 1—7.)

The Rider Valve-gear has also been adopted in its original form by these Engineers, as shewn on our Supplement-Plate 14, Figs. 1—7. That this valve-gear works well, is proved by the annexed diagrams Figs. 238—239. The first of these was taken with the Engine running idle, steam much throttled, and cut-off at 0·4 stroke, whereby mean pressure = 0·340 atm. The revolutions per min. = 58, and as the stroke = 26·77 in. (680 mm.), an indicated *HP.* of 54·5 results. The cylinder diam. = 13·39 in. (340 mm.). The second diagram (Fig. 239) corresponds to cut-off at $^1/_6$ stroke, 82 revs. and 6 ft. (1·85 m.) mean piston-speed. The average pressure = 1·86 atm. and the indicated *HP.* = 42·05. The general engine-design has some characteristic features. In the first place, we note the semi-Corliss and semi-box frame. The connecting rod has received the double T-section, as at times applied to locomotives. Access is gained to the interior of the bolted valve-chest, by the top cover, for reason that the steam supply-pipe is cast at the side of the valve-box.

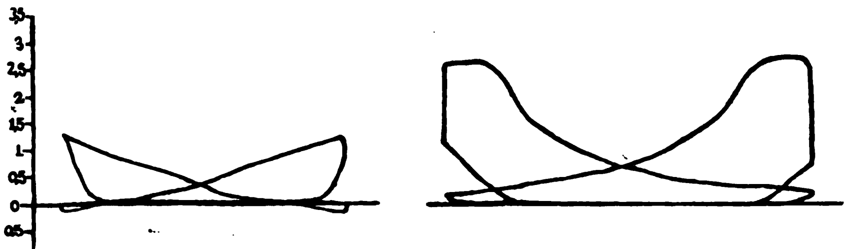


Fig. 238—239.

f. The Swiss Locomotive- and Machine-Works, of Winterthur.

(With illustrations on Supplement-Plate 14, Figs. 8—13.)

The Manager of this Company (Mr. Ch. Brown) has adopted the Rider Valve-gear in a somewhat modified form, and it is this modified design we represent on Supplement-Plate 14, Figs. 8—13. For balancing purposes, the main-slide has a cylindrical-casting cast on it, taking up the cylindrical expansion-valve. The motion of the main-slide is obtained direct from the eccentric; on the other hand the expansion-valve is driven off the same eccentric disc by an intermediary mechanism. To this end, a pin is screwed into the upper part of the eccentric ring, for the purpose of taking up two links, which form as it were a knee-leverage. The motion ensuing off the latter, is identical to the one obtained by a second eccentric. The cylinder-diam. is 9·84 in. (250 mm.); its stroke = 19·69 in. (500 mm.). The cylinder is jacketed, and is provided with extra lining. The fork-shaped bed is opened out, to give access to the cylinder stuffing box and to the cross-head. The latter is provided with screw attachment. The two engine-bed prongs, each form a bearing for the main-shaft, and as shewn in Figure 11, they are carried on legs, so that the engine-frame is supported on three points. In place of a cranked main-shaft, two crank-discs are used, which carry between them the crank-pin; the latter is 4·72 in. (120 mm.) in diam. and 7·87 in. (200 mm.) long. The feed-pump is driven off the free end of the main-shaft by a small crank. We may also draw attention to the support given to the valve-rods, which by the screw arrangement adopted, enables their lengths to be altered, simultaneously allowing each valve-spindle to turn by itself, though the Proell governor only works on the one expansion-valve rod.

g. The "Rheinische Maschinenfabrik", of Kalk, near Deutz.

(With illustrations on Supplement-Plate 17, Figs. 1—5.)

The expansion-valve is here balanced, and to effect this, the main-slide has received a cover screwed on. Noteworthy is the manner in which the valve-spindles are supported in their straight motion. The expansion-eccentric is fitted close up to the bearing and the respective valve-rod is supported in two bearings of a bracket; between the two bearings this rod simultaneously serves as a guide to the cross-head of the main-slide spindle, in the manner shewn in Fig. 2. The cylinder-diameter of the engine illustrated = 7·87 in. (200 mm.) its stroke = 15·75 in. (400 mm.). The cylinder ports are somewhat long, still the exhaust pipe does not touch the actual cylinder. Generally, the feed-pump is fixed to the expansion-eccentric, although we have omitted it in our drawings.

h. Gebrüder Pfeiffer, of Kaiserslautern.

(With illustrations on Supplement-Plate 17, Figs. 6—13.)

To reduce the clearance spaces, — amounting in this example to only 2—3 per cent — Gebrüder Pfeiffer, use the divided slide-arrangement, illustrated on Supplement-Plate 17, in Figs. 6—13. Respecting the proper distribution of steam, the circular diagram (Fig. 240) may be advantageously consulted; it was drawn under the following constructive-data:

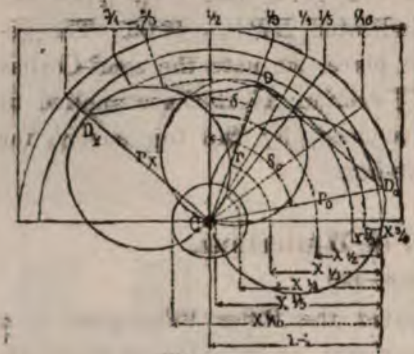


Fig. 240.

Advance-angle $\delta = 20^0$; Port-width $a = 1{\cdot}42$ in. (36 m.) Advance-angle $\delta_0 = 80^0$; main-slide eccentric $r = \frac{4}{3} a = 1{\cdot}89$ in. (48 mm.); external-lap $e = {}^1/_4\, a = 0{\cdot}47$ in. (12 mm.); internal-lap $i = 0{\cdot}08$ in. (2 mm.), external-lead $v = 0{\cdot}16$ in. (4 mm.); bridge-width $= \frac{a}{2} + 10 = 1{\cdot}10$ in. (28 mm.); $L\!-\!l = 2{\cdot}21$ in. (56 mm.); expansion-eccentric $r_0 = 2{\cdot}28$ in. (58 mm.); relative eccentricity $r_x = 2{\cdot}11$ in. (53·5 mm.). The cylinder is steam-jacketed, and our Fig. 10, explains the steam-supply regulation through a hand-wheel. This engine, with a cylinder diameter of 19·69 in. (500 mm.) and a stroke of 37·01 in. (940 mm.), gave off when working at 6 atm. over-pressure in the boiler, 55 effective *HP.*

i. Hayward, Tyler & Co., of London.

(With illustrations on Supplement-Plate XX.)

In the engine represented on our Supplement-Plate XX, the governor works on the valve-spindle by rack and segment gear. The segment is left open, to allow the main-slide spindle to pass through it. The bottom end of the governor rod, carries a weight, which may be altered according to the speed at which the engine is desired to run. The connection of the expansion-valve with its spindle, is effected by a pin screwed on the latter, with a spiral-spring. The cylinder diameter = 12 in. (304·5 mm.) and its stroke = 24 in. (609 mm.). The engine exhibited at the "Paris Exhibition" of 1878, was furnished with a brake, for the purpose of shewing the sensitiveness of the action of the governor on to the valve-gear. In the annexed Table, we publish the chief dimensions of these Engines (made with cranked main-shaft up to 6 *HP.*, but constructed after the design shewn on our Supplement-Plate XX in larger sizes):

Nominal Horse-power	1.5	2	3	4	6	8	10	12	16	20	25	30
Cylinder-diameter in in.	3 1/2	4 1/2	5 1/4	6 1/2	8	9	10	12	14	16	18	20
Stroke in in.	8	8	8	10	16	18	20	24	28	32	36	36
Flywheel-diameter in in.	24	24 1/2	42	42	60	72	72	84	84	102	102	120
Width of Fly-wheel rim in in.	2 1/2	4	4	4	6	8	8	9	9	10	10	12
Diameter of steam supply pipe in in.	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4	4 1/2	5
Diameter of steam exhaust pipe in in.	1	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4	5	5 1/2	6	7

k. Rikkers, of St. Denis (France).

The peculiar way in which the crank-pin is motioned in the engines made by Mr. Rikkers, of St. Denis, gives a characteristic appearance to this engine-type, as will be seen on examining

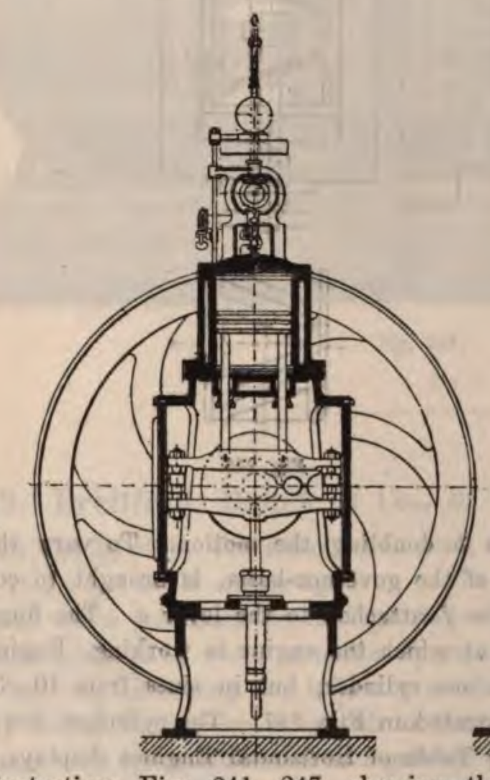


Fig. 241.

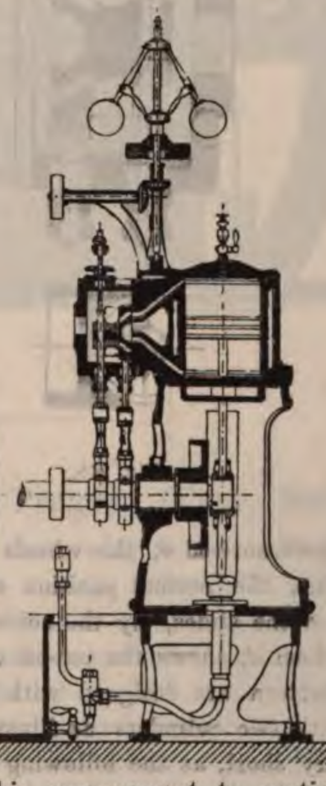
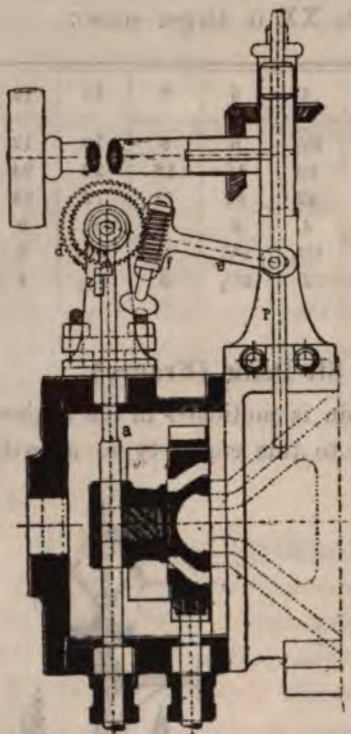


Fig. 242.

the annexed illustrations Figs. 241—247, shewing this arrangement to vertical and horizontal designs. Two piston rods are used, as may be seen in Figs. 241—242. Constructed in this manner, the whole machine is very strong and compact, and it shares the additional advantage of taking up little standing room and of being easily moved from place to place. The arrangement of the Rider valve-gear, (Figs. 243—246), adopted in all these engines, is only in the one respect remarkable, namely in the method applied in the transmission of the governor-motion on to the valve-spindle *a*. This spindle is worked by the wheels $b\,b_1$, the rod *c*, the wheel *d*, and the

Fig. 243.



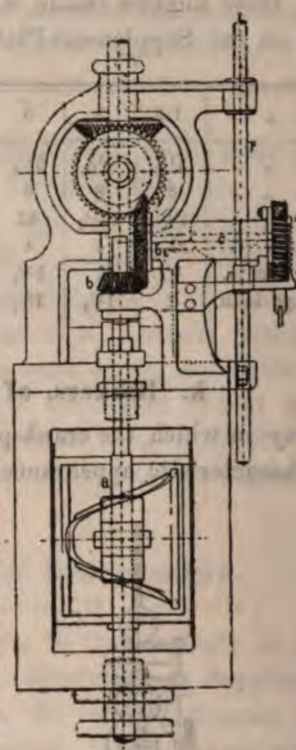


Fig. 244.

Fig. 245.

Fig. 246.

lever *e*, off the governor-rod *r*, the wheels *b* doubling the motion. To vary the speed or the power of the engine, the normal position of the governor-balls, is brought to coincide with the desired positions of the slides, by the screw *f* attached to the lever *e*. The finger *z* of a scale attached to the wheel *d*, shews the cut-off at which the engine is working. Engines of 4—8 *HP.* made after this pattern are designed with one cylinder, but in sizes from 10—50 horse-powers, they are made with two cylinders as illustrated in Fig. 247. The cylinders are steam-jacketed; they are made very short, as the following Table of Horizontal Engines displays, and we should observe that the first named size, works with fixed expansion.

Horse-power	4	6	8	10	12	16	20	25	30	40	50
Cylinder-diameter in in. ..	6.69	8.85	11.81	7.87	9.84	11.81	12.99	14.57	15.75	17.72	19.69
Stroke in in.	7.87	9.95	11.81	7.87	9.84	11.81	12.99	14.57	15.75	17.72	19.69
Revolutions per minute	100	100	100	90	90	80	70	70	65	60	55
Weight	14 cwts.	18 cwts.	22 cwts.	26 cwts.	35½cwts.	57 cwts.	77 cwts.	89 cwts.	116cwts.	148cwts.	177cwts.
Length of engine in ft. and in.	3ft. 7 in.	3ft. 11in.	4 ft. 3in.	4 ft. 7 in.	5 ft. 3 in.	5ft. 10in.	6 ft. 6 in.	7 ft. 2 in.	7 ft. 6 in.	8 ft.	8 ft. 6 in.
Width of engine in ft. and in.	3ft. 7 in.	3ft. 11in.	4 ft. 3in.	4 ft. 7 in.	5 ft. 3 in.	5 ft. 7 in.	5ft. 10in.	6 ft. 6 in.	6ft. 10in.	7 ft. 3 in.	7 ft. 3 in.

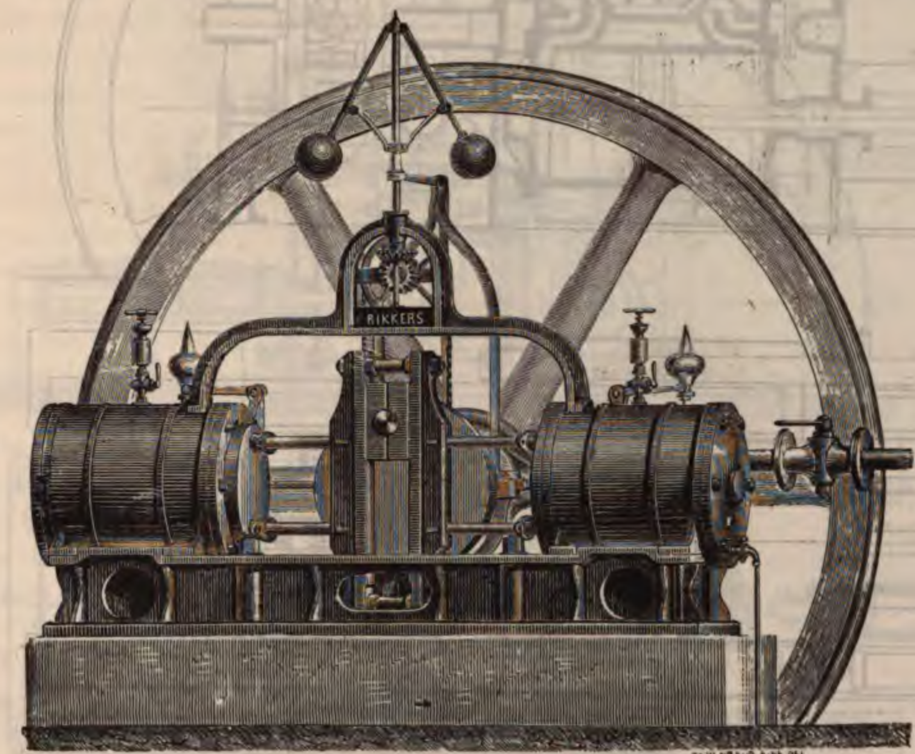


Fig. 247.

19. Breitfeld, Daněk & Co., of Prague. (Type: Staněk.)

The fact displayed by the Rider valve-gear, that owing to the oscillations given to it by the governor, it ground itself steam-tight on to its seating, induced Mr. Staněk to introduce a novel valve-gear, which we illustrate in Figs. 248—251. In this design, the main-slide has also a cylindrical form given to it, whilst a uniformly repeating oscillatory motion is likewise imparted to it, without however exercising any influence on the cut-off. The expansion-plates work similarly to the ordinary Meyer Valve-gear, inasmuch as they are merely motioned in the direction of the cylinder-axis, and their distance asunder is regulated by an external hand-wheel. We may observe, that the lateral oscillations of the main-slide, cause the sliding surface of the cylinder and of the expansion-valve to grind steam-tight.

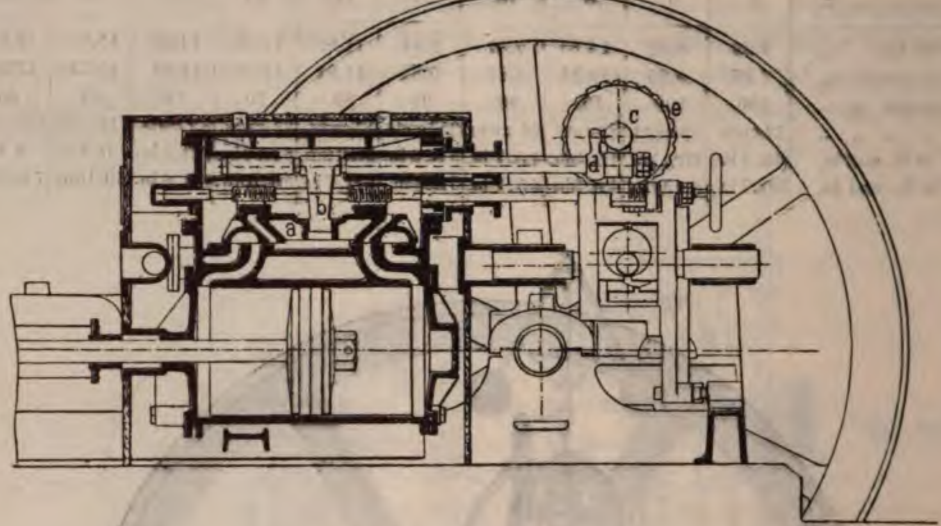


Fig. 248.

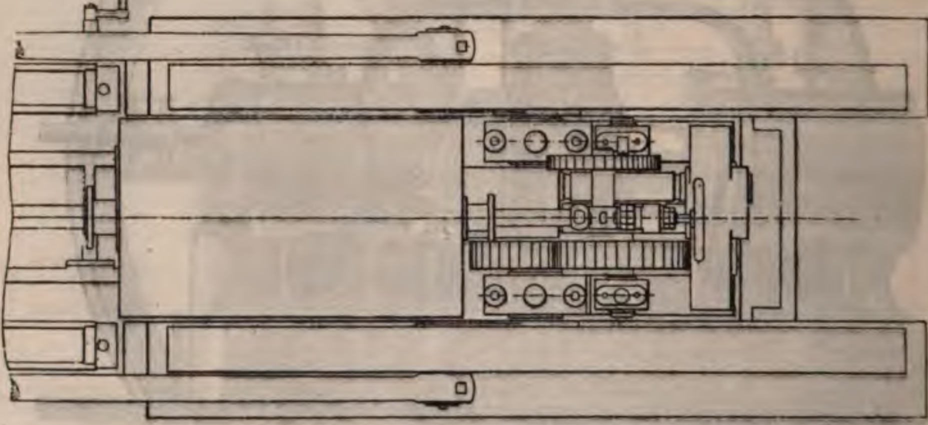


Fig. 249.

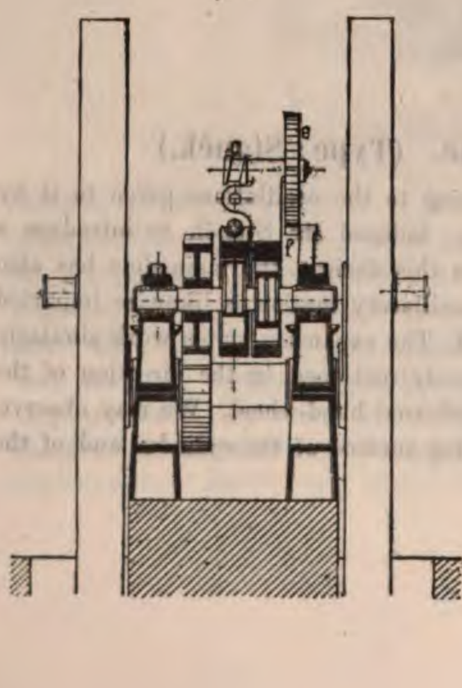


Fig. 250.

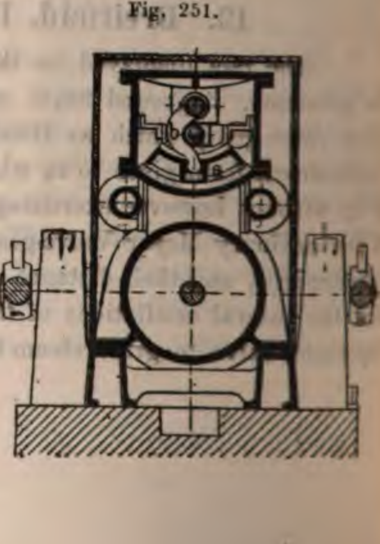
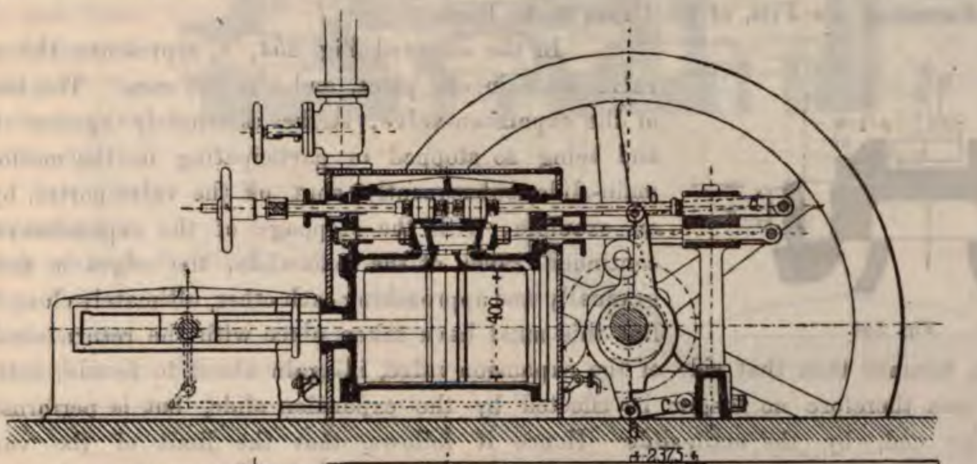


Fig. 251.

Our woodcuts (Figs. 248—251) shew this arrangement applied to a Pumping-Engine, in which the crank-shaft is placed immediately behind the steam-cylinder, while two crank-rods connect the piston-rod cross-head with the two fly-wheels. The two valves are worked by eccentric and crank-loop from a lay-shaft, the main-slide *a* receiving its two motions by the arm *b*. The lateral oscillations are effected by the lever *d*, keyed on the valve-rod; this lever gears into a slow revolving inclined groove *c*. The revolving motion is effected, by a ratchet-wheel *e*, mounted

Fig. 252.



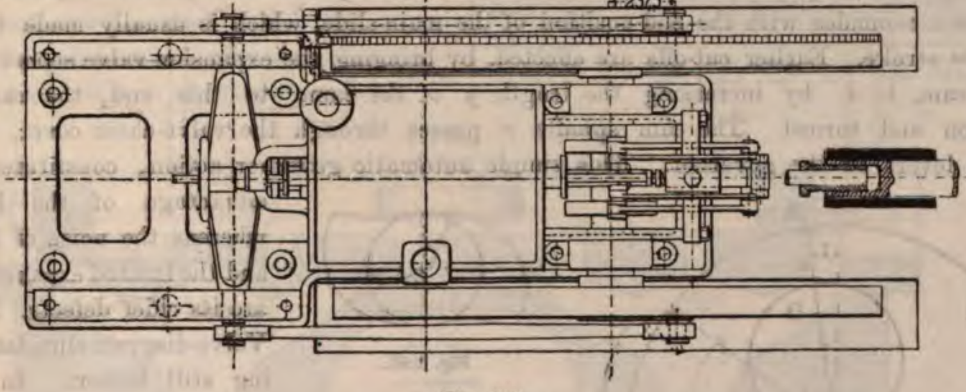


Fig. 253.

on the axis of the groove *c*, inasmuch as this wheel following the motion of the eccentric, is moved forward by a tooth each stroke, through a pawl fitted to the engine-bed. Hence, each oscillation of the slide depends on the number of teeth in the ratchet wheel.

Another arrangement of the Breitfeld-Daněk Valve-gear type, in which the ordinary Meyer Valve-gear is applied, is illustrated in Figs. 252—253. In this constructive example, the crank-shaft is also placed close up to the cylinder, and the valves are worked with great exactitude, by driving them off eccentrics keyed on this shaft, and furnished for this purpose with two arms *a* and *b*. The vertical motion is taken up by a link *d*, which is connected with the valve-rod. The position of the valves is altered in the usual manner.

C. Drag Valve-gears.

1. The Original Farcot Valve-gear.

As a last type of double valve-gears, we may class those, in which the expansion-valve lies loosely on the back of the through-ported main-slide, the expansion-valve being consequently dragged by the main-slide motion, until some external mechanism stops it from following the main-slide any longer; valve-gears embodying this principle were first introduced in 1858 by Messieurs Farcot et ses Fils, of St. Ouen, (near Paris).

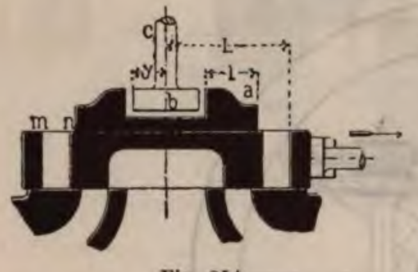


Fig. 254.

In the annexed Fig. 254, *a*, represents the expansion valve made in one piece, and *b* is the cam. The inner edges of the expansion-valve, strike alternately against this cam, and being so stopped in participating in the motion of the main-slide, subsequently shut off the valve-ports; by way of an example, with the stoppage of the expansion-valve, and continued travel of the main-slide, the edges *m* and *n* work gradually and approaching each other, ultimately close their port. But this must have taken place with the return stroke of the main-valve, because then that side of the expansion valve, is again about to recede; cutting-off of the steam can therefore no longer be effected by the expansion slide, but is performed at the piston-stroke end, by the main-slide. Hence it follows, that the limit of the variableness of expansion coincides with the end-position of the main-slide, which is usually made to occur at about $^2/_3$ths stroke. Earlier cut-offs are effected, by bringing the expansion-valve sooner in contact with the cam, i. e. by increasing the length *y* of the cam; to this end, the cam is made cam-fashion and turned. The cam spindle *c* passes through the valve-chest cover, and is motioned by levers off the governor. This simple automatic governor action, constitutes the main advantage of the Farcot-gear, whereas the noise of its working and the limited expansion it allows, are its chief defects. The Zeuner Valve-diagram elucidates its working still better. In Fig. 255, *O D*, is supposed to represent the main-slide circle with the comparatively small advance angle δ. The position of the two valves for that certain crank-position where admission-port is just closed, corresponding to a given cut-off, may (according to Fig. 255), be expressed by the equation,

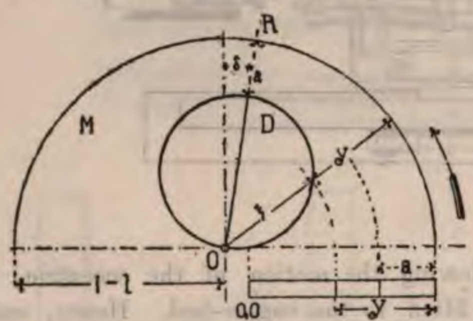


Fig. 255.

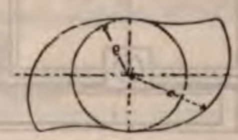


Fig. 256.

$$L - l = y + (\text{Valve-travel})\ (L - l) - \xi = y.$$

The circle *M* has been described to the constant radius $(L - l)$, consequently the distance between this circle and the valve-circle *D*, represents the cam-width *y* for every crank-position. The crank-position *O R*, answers to the latest cut-off through the expansion-valve; it is usual to select corresponding hereto, the smallest size of the cam $= a$, which has then to be augmented to the distances that the circles are apart from each other, in order to effect earliest cut-of through this expansion-valve. According as the angle is chosen, so the shape of the tappet will result. (Vide Fig. 256.)

Fig. 257.

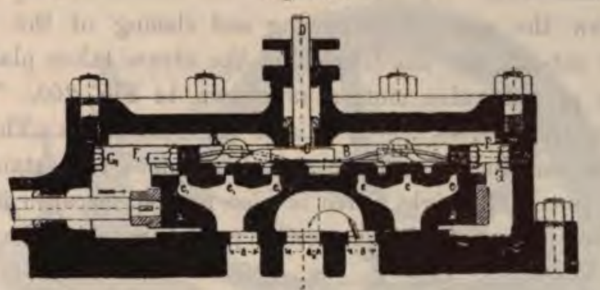
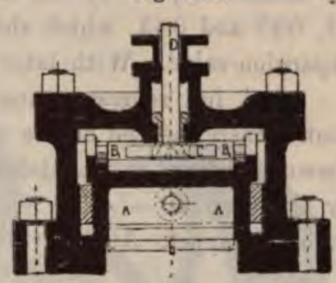


Fig. 258.



With large sized Engines, divided slides are usually used as shewn in Figs. 257 and 258, and these are then grid-formed. The closing of the valve-ports is also here effected by the tappet, but for prompt opening purposes, each plate is furnished with a stud F — resp. F_1 — which, with each stroke-end strikes against a fixed bolt G — resp. G — screwed in the valve-chest. The last named in no wise controls the rate of cut-off; it is only necessary to choose the distances between the studs and bolts, so that the through-port is quite opened out when the main-slide is at its stroke-end.

Fig. 259.

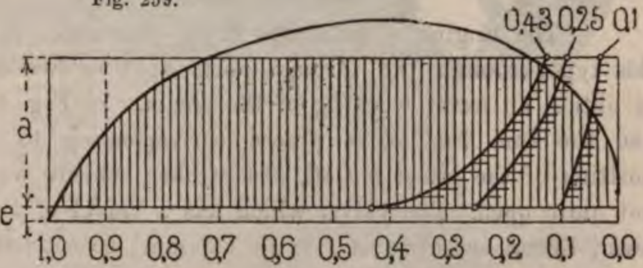
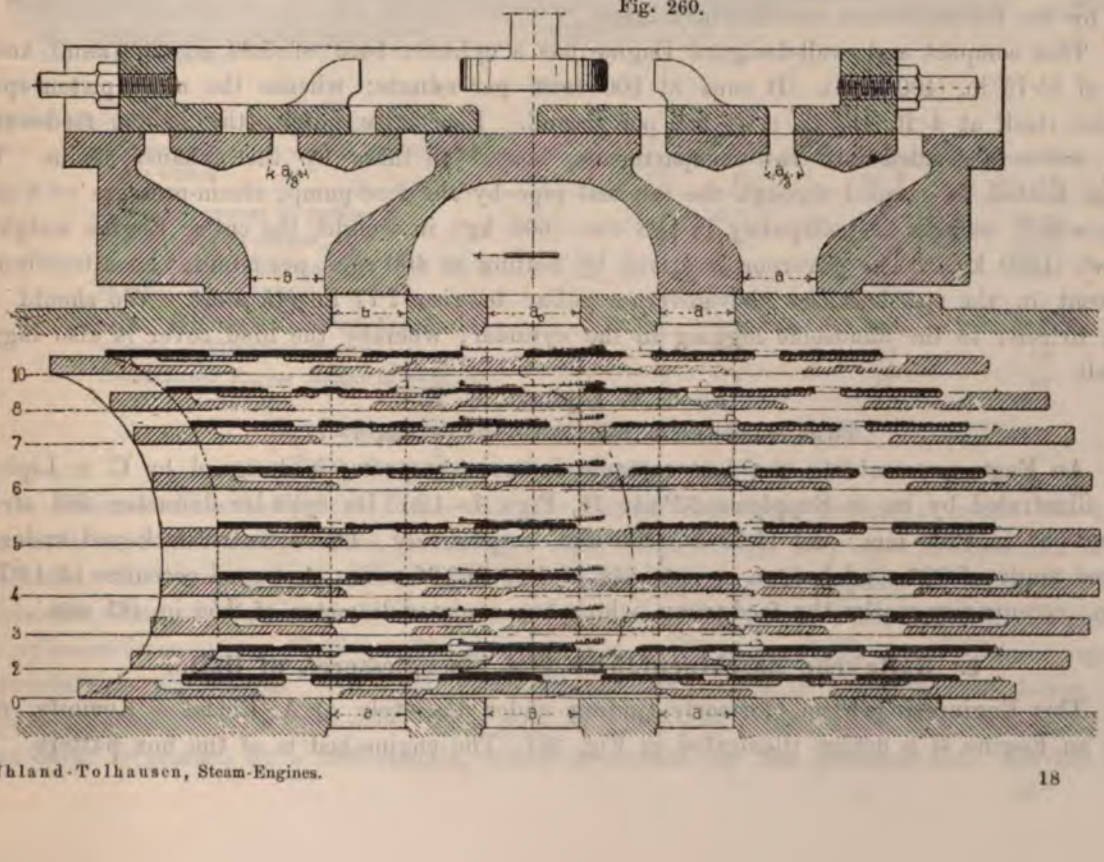


Fig. 260.



In Fig. 259, we have represented the piston stroke by the elliptic diagram; e, is the external-lap, and a, the port-width. Accordingly, the vertical shaded area indicates the opening of the admission-port by the main-slide. We have drawn the curves corresponding to cut-offs, of 0·1, 0·25 and 0·43, which show the gradual narrowing and closing of the through port by the expansion-valve. With later cut-offs, the shutting-off of the steam takes place slowly.

A full representation of the valve motion is shewn in Fig. 260. The main-slide moves continuously, as the course of the — . — . — . elliptic curve indicates. The left expansion-valve shewn in black, at first takes part in the motion; and then comes to a stand-still, as represented by the vertical — — — — line. The right valve is also at rest, because it has come in contact with the tappet. All the valves move to the left, somewhat prior to reaching the position indicated by 5.

2. Engines working with the Farcot-Valve Gear.

a. Gebr. Schmaltz, of Offenbach-on-Maine.

(With illustrations on Supplement-Plate 18, Figs. 1—6.)

The Engine of Schmaltz Bros., illustrated in Supplement-Plate 18, Figs. 1—6, belongs to this type, though the through ports abut in two openings in the upper valve-surface, in order to obtain an exact working of the steam. In Fig. 4, the valve is shewn in the central position; and the cam Fig. 5, is placed corresponding to earliest cut-off. Fig. 6 is drawn under supposition of the latest cut-off, (0·4 stroke), whence we perceive that the ports on the other side are not quite open. The valve, which has a travel of 1·46 in. (37 mm.) is worked by an intermediary lever, by an eccentric of 1·38 in. (35 mm.) eccentricity; keyed under an advanced angle of 5°, the feed-pump, which is 1·38 in. (35 mm.) in diameter, and of 3·15 in. (80 mm.) stroke, is simultaneously driven by the forementioned intermediary lever.

This compact and well-designed Engine has a cylinder bore of 7·87 in. (200 mm.) and a stroke of 15·75 in. (400 mm.). It runs at 100 revs. per minute; whence the mean piston speed calculates itself at 4 ft. 4½ in. (1·31 m.) per second. Especially noteworthy is the feed-water-heater, which is divided into two compartments, heated in turns by the exhaust steam. The water so heated, is pumped through the internal pipe by the feed-pump; steam-pressure = 6 atm. The fly-wheel, serving as belt-pulley is 11·8 cwt. (600 kg.) in weight, the entire Engine weighing 35·4 cwt. (1800 kg.). The governor is driven by belting at 400 revs. per minute; an alteration of 6 per cent in the speed causes the governor collar to rise 1·77 in. (45 mm.). We should not neglect to refer to the handsome lagging in the cylinder, whereby the hind cover is also lagged with felt.

b. C. v. Liphart, C. E.

(With illustrations on Supplement-Plate 18, Figs. 7—12.)

An Engine resembling the last example in many respects, is designed by C. v. Liphart, and is illustrated by us, in Supplement-Plate 18, Figs. 7—12. Its cylinder diameter and stroke are also 7·87 in. (200 mm.) and 15·75 in. (400 mm.) respectively. The eccentric is keyed under an advanced angle of 20°, and has an eccentricity of 1·02 in. (26 mm.). A second eccentric of 1·97 in. (50 mm.) eccentricity works the feed-pump, which has a piston-diameter of 2·56 in. (65 mm.).

c. Halle'sche Maschinenfabrik und Eisengiesserei, of Halle.

This Engineering Firm, formerly trading under the style of A. Riedel & Kemnitz, constructs an Engine of a design illustrated in Fig. 261. The engine-bed is of the box pattern. The guide-bars are supported at one end by the cylinder stuffing-box, and at the other end by a small bracket, through whose centre, the piston-rod works. The dimensions and sizes to which these

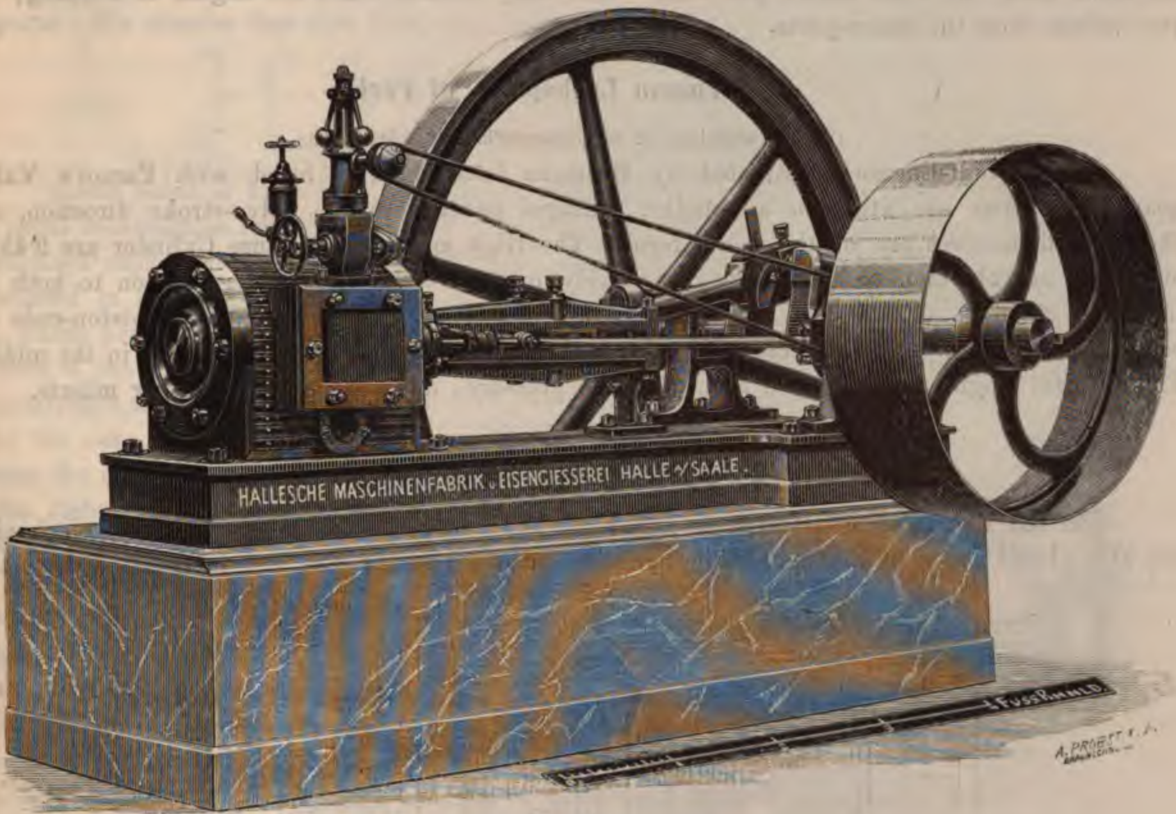


Fig. 261.

engines are built, are as follows:

Horse-Power	3	6—8	10—12
Cylinder-diameter in inches	5.11	8.26	10.23
Piston-stroke in inches	8.26	14.37	14.37
Revolutions per minute	175	100	100
Diameter of Fly-wheel	39.37	61.7	74
Width of Planed Fly-wheel Face	4.91	6.17	6.17
Weight of Fly-wheel in cwts.	4	10	12
Approximate Engine weight in cwts.	13	27	34

d. Compagnie de Fives-Lille, of Fives-Lille.

(With illustrations on Supplement-Plate 19, Figs. 1—6.)

Whereas French Engines fitted with the Farcot Valve-gear generally retain the original type with its ornamental columns, mouldings, etc. which design may now be pronounced to be antiquated, the Compagnie de Fives-Lille has modernised the old design. The 14 *HP.* Engine which this Company exhibited in Paris in 1878, is drawn in Supplement-Plate 19, Figs. 1—6. The cylinder-diameter = 19·69 in. (500 mm.); stroke = 39·38 in. (1000 mm.); Engine speed = 40 revolutions per minute. We meet here with divided valves in separate valve-boxes, which merely communicate with each other by a pipe, in which the valve-spindle is placed. Each valve chest cover is pierced by a cam-spindle, which is worked by the governor-rod. On the top of the cylinder, two small valves are placed, which facilitate the stoppage and starting of the Engine. The two are hung on a rod, so that by a hand-lever, steam may be given either to the one or the other side. In their middle position, which they assume when the engine is working, the two valves close the steam-ports.

e. Hermann Lachapelle, of Paris.

(With illustrations on Supplement-Plate 22, Figs. 5—8.)

The Woolf-Engine constructed by Hermann Lachapelle, is fitted with Farcot's Valve-gear. The cams are fitted to a spindle, arranged parallel to the valve-stroke direction, and the cams themselves are of the roller form. The High and Low Pressure Cylinder are 9·45 in. and 19·72 in. (240 mm. and 450 mm.) respectively in diameter. The stroke common to both cylinders is 27·56 in. (700 mm.). The cylinders are placed side by side, and their piston-rods are coupled with the ends of the cross-head valves; the connecting-rod is made to work in the middle. This 30 *HP.* Engine works at 6·5 atm. (absolute pressure), and runs at 60 revs. per minute.

3. E. Bourdon, of Paris.

In the Valve-gear illustrated in our Figs. 262—263, the moving parts of the mechanism are also placed away from the valve-chest, being arranged at the side and in front of the latter.

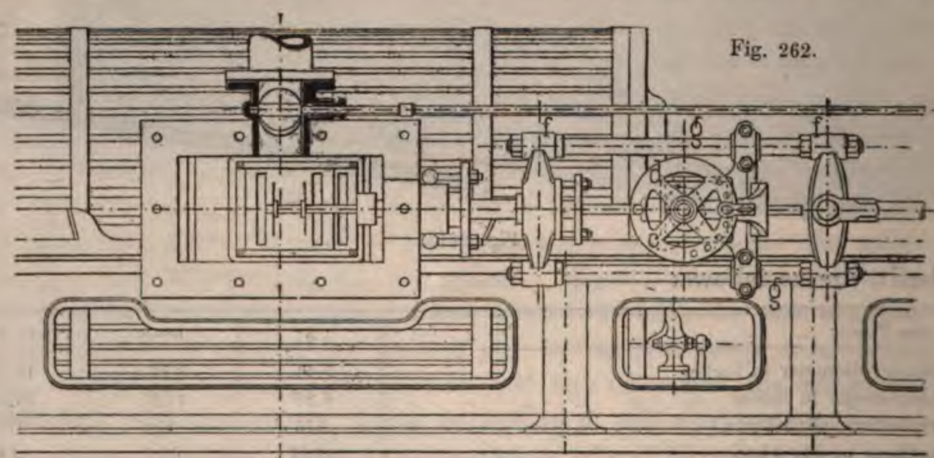


Fig. 262.

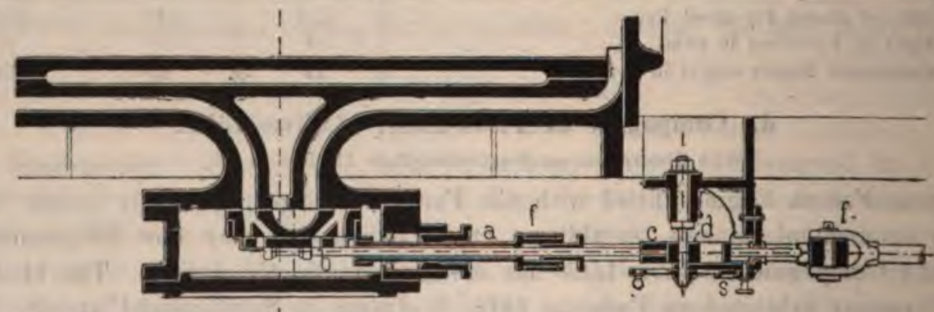


Fig. 263.

This somewhat complicates the design, which can only be justified by the very small valve-chest it admits. The rod *a*, of the main-slide is hollow, so as to take up the rod *b*, of the expansion-plates. This rod *b*, carries externally a small frame *c*, which surrounds the cam *d*, mounted on a spindle motioned by a hand-wheel. Whilst the engine is working, this hand-wheel is held fast by the tightening-up screw *s*. The rod *a*, of the main-slide, is connected to the eccentric-rod by two rails *f f*, and two rods $g\ g_1$; in this manner, a frame is formed, which is guided in two supports. We observe that this Valve-gear must work exactly like the simple Farcot gear.

4. Louis Soest, of Düsseldorf.

Louis Soest of Düsseldorf, has adopted the Farcot Valve-gear in various modifications. In the usual construction embodying the non-divided expansion-plate, we note the special feature of an inclined expansion-valve surface, which dispenses with the use of springs, etc. This design is illustrated in Figs. 264—267, and for the cam is substituted a roller, fitted with spiral lugs $a\ a_1$ which perform the same function as the cam. Attention must be paid, that the knocking surfaces of the drag-valve form the external edges, and that consequently, if for the sake of an example, we assume the main-slide to be moving to the right, whereby the steam-admission ensues on the left, then the right knocking-surface *a* comes into play. In drawing the circular diagram, the length *L*, must not be measured from the valve-middle, but from the cutting-off edge to the end of the corresponding roller-lug. The length *l*, must be reckoned as from the cutting-off edge of the expansion-valve, to the other side of the corresponding impact-surface. The value $L - l$ then again is a constant magnitude, whence may be deduced the positions of the valve, and the various expansion-ratios. The development of the lugs is shewn in Fig. 267, the curve *A A*, belonging to the lug nearest the crank, and the curve *BB*, answering to the opposite lug. The eccentricity, under an advance-angle of 15°, amounts to 1·38 in. (35 mm.); the opening corresponding to dead-centre = 0·12 in. (3 mm.); the external lap = 0·24 in. (6 mm.). Analogous to a compression of 0·95, the inner lap on the crank-side equals 0·31 in. (8 mm.), whilst that on the external side = 0·20 in. (5 mm.). The limit of expansion in the forward stroke is 0·42 and in the return-stroke 0·32 of the stroke. The highest and lowest positions of the lever are indicated in Fig. 266.

Fig. 264. Fig. 265.

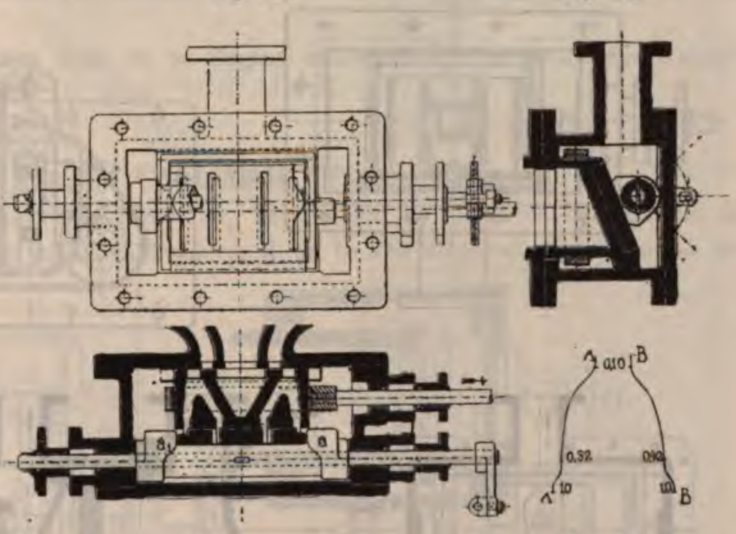
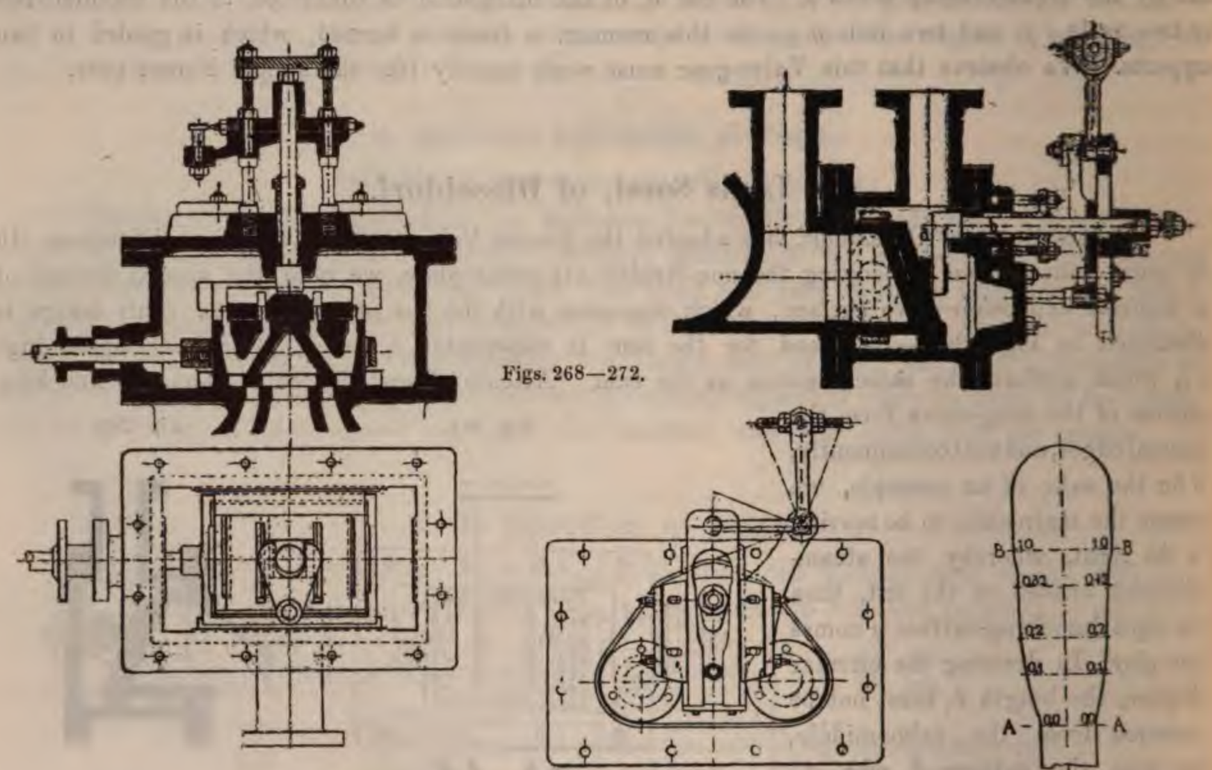
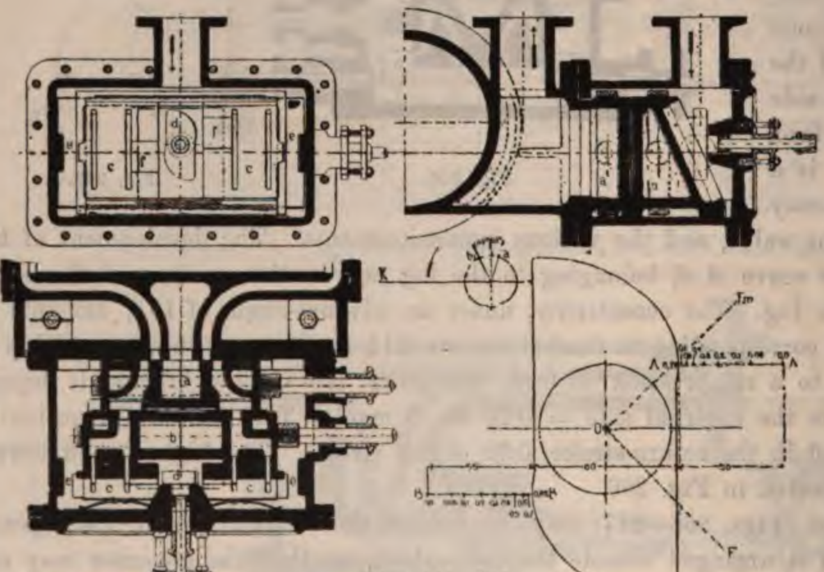


Fig. 266. Fig. 267.

The second modification (Figs. 268—277) may be termed the "forked Farcot valve-gear". In this design, the mechanism is arranged outside the valve-chest, so that the governor may not have to overcome the friction of the stuffing-box. The expansion-plate made in one, has a pin, which works in the forked-lever *a*, of the axis *b*; hence this axis moves with the oscillations of the main-slide. The other end, has a small crank *c*, which extends into the fork, which is vertically motioned by the governor. With the oscillations of this fork, the crank *c*, is stopped by the fork-sides used in place of the cam, and steam is thereby cut-off. The curve of the fork is drawn to an enlarged scale in Fig. 272, the rates of cut-off being also inscribed thereon. The



Figs. 268—272.



Figs. 273—277.

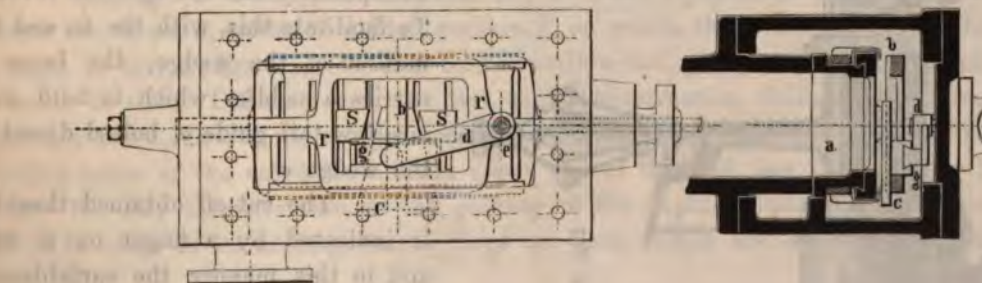
defect of the Farcot valve-gear, which as already stated, consists in the limited degree of expansion, is said to be remedied in a number of modifications, embodying the application of a second eccentric, and which thus permits all grades of expansive-working.

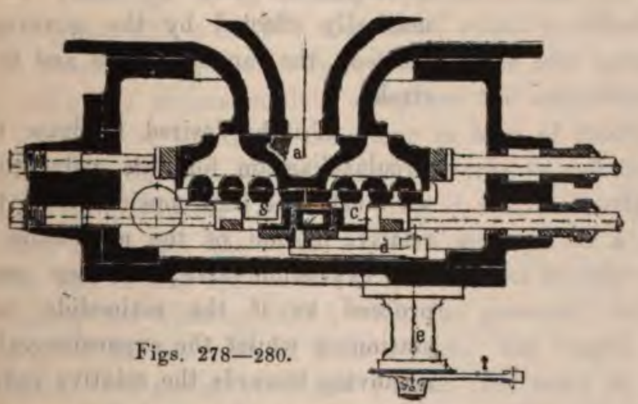
Louis Soest, constructs the valve-gear illustrated in Figs. 273—277, with three valves. The lowest valve is the main-slide a_1 which works in the usual style; the middle slide b, is driven in such a manner by an eccentric b_1, keyed under a drag-angle, that its course is changed at about 70 per cent. of the piston-stroke. The through-ports of these two valves are made sufficiently wide on their contact-surfaces as to remain always open. The expansion is only determined by the drag-valve c, whose divided form is fitted with cam d; placed under governor-adjustment, similarly to the Farcot valve-gear. We may thus perceive, that the drag-valve by knocking at e, towards the piston stroke end, has already fully opened the through ports; moreover, we note that during the greater part of its travel with the middle valve, the lugs f, may come in contact with the cam d, whereby the limit of expansion again coincides with the change of motion of the middle valve; hence the limit of expansion, may vary between 0 and 80 per cent. The exact form of the cam is drawn in Fig. 277, where the lines AA and BB, represent the lines of impact of the lugs f, with the ranges of cut-off inscribed. OF is the position of the lever cutting-off at 0·0 stroke, and OF_m coincides with the latest cut-off. The eccentrics of the two valves are mounted to an eccentricity of 1·38 in. (35 mm.). The main-slide a has an external lap of 0·28 in. (7 mm.). For an equal compression of 0·95, the inner lap on the crank-side = 0·30 in. (7·5 mm.) that externally = 0·18 in. (4·5 mm.). The grades of expansion with the forward and return strokes are respectively 0·82 and 0·75. The lead-angle $\delta = 16^{\circ}$ and the drag-angle δ_0 of the expansion-eccentric = 34°. In drawing the diagram, as was shewn in Fig. 277, the last valve-circle indicates the cut-offs corresponding to the cam dimensions.

An exactly similar valve-gear was fitted to an Engine exhibited by the Sächsische Dampfschiffs-Maschinenbau-Anstalt of Dresden.

5. Gebr. Decker & Co., of Cannstadt (Type: Krause).

In the valve-gear illustrated in Figs. 278—280, the motion of the second eccentric is utilised in another manner, inasmuch as it is not transferred on to the drag-valve, but on to its





Figs. 278—280.

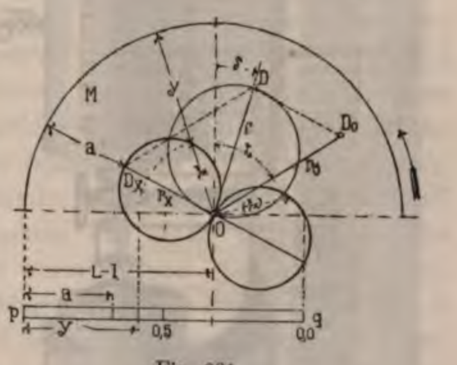


Fig. 281.

lugs. The middle valve is here dispensed with, and the grid plates of the drag-valve move again on the main-slide a; the remainder of the mechanism is somewhat complicated. This mechanism must be so arranged, as to be able to impart two motions: namely the to and fro motion of the

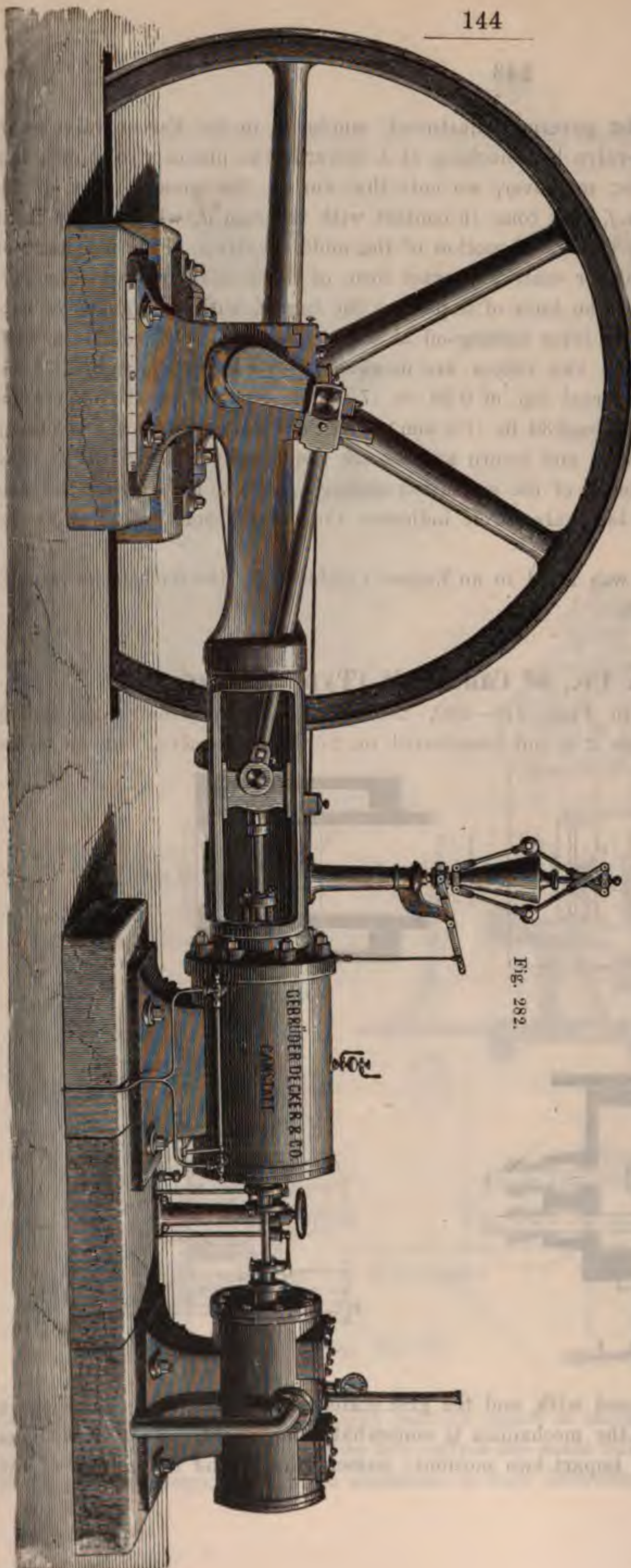


Fig. 282.

eccentric, and the movement from the governor.*)

In this example, the valve-rod connected with the second eccentric, is completed to form a frame *r*, in which the double wedge *c*, slides longitudinally across the cross-piece *b* (in place of the Farcot cam); this wedge can overtake the main-slide in its return-stroke, and is able to push the latter by the lugs *s*, cast on its cover. These lugs, the inner side of which must be inclined as the wedge is, serve for opening the through-ports. They accomplish this, inasmuch as their opposite side comes in regular contact with the frame *r*. The governor action, shewn by the rising or falling motion of the wedge *c*, is effected by the lever *d*, which is connected to the governor-rod through the spindle *e* and the external lever *f*. To facilitate this, with the to and fro motion of the wedge, the lever *d* carries a saddle, which is held in a swallow-tail guide *g*, bolted direct to the wedge *c*.

The cut-off obtained thereby, is indicated by a finger on a dial, and in this manner the variableness of expansion may be easily automatically effected by the governor, between the range of 0·05 and 0·07 stroke.

If it be desired to draw the circular-diagram for this valve-gear, we must take into consideration, the relative motion of the main-slide to the expansion-valve, for we must proceed as if the main-slide was stationary whilst the expansion-valve is moving towards the relative valve-

*) We shall shew, that this condition is fulfilled in a remarkably sim manner in Guhrauer's Valve-gear.

circle; $O D_x$ — (Fig. 281) — is the relative valve-circle. If we also here designate, (as we did on page 101), L as the distance of the internal edge of the external port on the top surface of the main slide, from its centre; l as the distance of the external cutting-off edge of the plate from the middle of the inclined portion of the lug; then with the difference $(L-l)$ as radius, we have described the circle M. The distances between this circle and the relative valve circle, indicate the variable widths y, of the wedge, as taken from the middle of the inclined portion of the lug to the centre of the wedge. As almost the entire eccentric stroke for motioning the wedge during one piston-stroke, comes into play, the earliest cut-offs refer to the lower negative relative valve circle, inasmuch as subtracting its negative secant from the value $L-l$, gives* the sum of the two, as the diagram shows.

A Condensing Engine fitted with this valve gear is represented in our Fig. 282. Designed with a cylinder diameter of $15^3/_4$ in. (400 mm.) and a stroke of $31^1/_2$ in. (800 mm.) and working at 5 atm. over-pressure, this engine running at 60 revs. per min., and cutting off at $^1/_4$ stroke, gave off 55 *HP*.

6. Chemnitzer Werkzeugmaschinenfabrik (lately: Joh. Zimmermann), of Chemnitz.

(With illustrations on Supplement-Plate 20.)

The valve-gear constructed by these Engineers is also of the Kraus' type, being only slightly modified.

In Figs. 4—7 (Supplement-Plate 20), we have represented the valve-gear by itself. Fig. 4 shews the frame h, with its welded portion k, on which the double-wedge f, slides. The cheek l, is fixed to this wedge (Fig. 6), and in its swallow-tail groove, the saddle m, of the valve-motion, is made to slide. Differing from the last named construction, this saddle is arranged direct to the governor rod n, in a more simple manner — by a screw-pin; the governor-rod is guided in two stuffing-boxes of the valve-chest. The upper end of this rod, has the governor link-work fastened to it. We may call attention to the guiding of the expansion-plates on the main-slide. To press the slide more on its seating, four springs are used, which are screwed in the frame work of the main-slide.

In Figs. 8—13 of our Supplement-Plate 20, we illustrate an Engine fitted with similar valve-gear, with a divided main-slide, which exercises however no influence on the expansion-valve. The frame is represented by a, and has the four springs f, screwed to it, of which two are always pressing one expansion-plate e, against the main-slide; in addition, we note four prismatic pieces g, which serve to steady the frame in case of shocks. The saddle d, consists of two pieces; the one part being fast to the wedge c, works to and fro with the frame, whilst the other portion d_1, slides in d, working the lower piece d, and the wedge c, vertically, through the rack h. A small pinion gears into this rack, which is mounted on a spindle passing out of the valve-chest. The other end of this spindle has a worm-wheel k, into which the worm l, gears. A spherical joint, connects the worm-spindle l, with the governor, and so working in the direction of its axis, it reacts on the worm-wheel k, as a rack. The length of the rod is regulated by turning the worm-spindle. The steam-cylinder is 9·45 in. (240 mm.) in bore, and has a stroke of 19·69 in. 500 mm.). In order to keep the ports small, it has its valve-chest cast on, as close to the cylinder as possible.

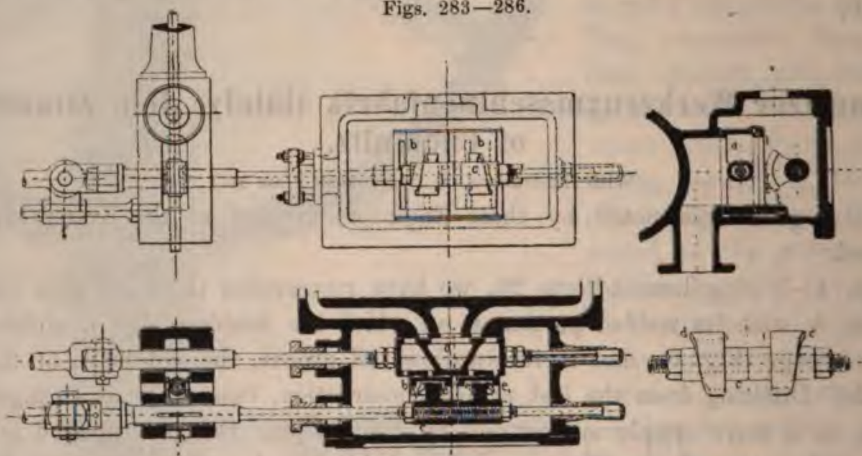
* $(L-l) - (-\xi x) = (L-l) + \xi x = y$.

The two valve-chest covers are divided by a bridge plate, which serves for taking up the external mechanism of the governor. In this manner, the internal valve-gear is easily controlled without requiring pulling to pieces.

7. Ph. Swiderski, of Leipzig.

Philipp Swiderski fits an expansion-valve-gear to those Engines he constructs in sizes of 6 — 120 *HP.*, which owes its origin to Mr. Alfred Guhrauer. We represent this design in Figs. 283—286, and there can be no doubt that as far as simplicity is concerned, it excels the preceding example. It is termed a "Farcot-gear admitting of all expansion-grades", and it similarly uses a second eccentric for working the lugs which are here arranged spiral-fashion on the valve-rod. By turning the valve-rod, the different widths of the lugs come into play. This design resembles the Meyer valve-gear in many respects, inasmuch as with early cut-offs, the expansion-plates are rather worked off the expansion-eccentric, than dragged. On the top of the main-slide *a*, (whose through ports divide into two openings on its back), we find the expansion-plates *b*, which are guided in a ledge shewn in our drawing; these expansion-plates do not slide in the valve-box, but on a plate fixed over the main-slide.

Figs. 283—286.



The expansion-valve rod carries a sleeve *c*, which has a cam for each expansion-plate; the internal slanting sides *i* of these cams, are rectilinear and perpendicular to the direction of motion, whereas the external sides *d* are of a spiral-form. Corresponding to these sides of the cams, each expansion-plate has two lugs *e* and e_1, and accordingly, their inner sides *e* are arranged parallel, whilst the external surfaces e_1 are spirals to augment the contact-surface with the lugs. The distance of the lug-surfaces *e* and e_1, facing each other on each expansion-plate are constant, whereas those surfaces of the sleeve which come in contact with each other, and which therefore also serve for working the expansion-plates, may be varied in their distances apart by turning the sleeve.

From this description, we perceive, that the valve-rod allows itself to be easily turned, on account of its running idle twice during each piston-position, whereby the governor reaction on the valve-rod is facilitated. The opening of the through-ports, through contact of the expansion-plates is also easily done, because whilst opening, the plates are not heavily pressed. The governor is placed before the valve-chest, and is mounted on a support, which helps to guide the two valve-rods. The expansion valve-rod has a slot inside this support, over which a lever *k* is pushed loosely, so that its wedge passes through this slot. In this manner, the lever h, though not participating in the to and fro motion of the valve-rod, is able to turn the latter, when the rod leading from the governor demands such action.

8. A. von der Becke, of the Sundwiger Eisenhütte, near Iserlohn. (Type: Guhrauer).

(With illustrations on Supplement-Plate 13, Figs. 6—11.)

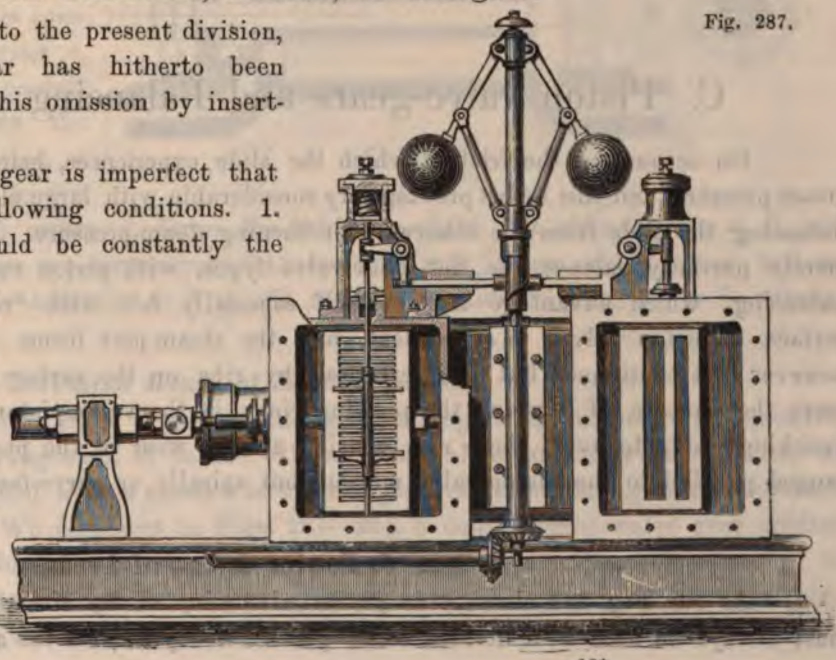
At the Düsseldorf Exhibition of 1880, an Engine was shewn in motion, constructed by A. von der Becke, of Iserlohn; it is this example we illustrate on Supplement-Plate 13, Figs. 6—11. The valve-gear is based on the same principle as the preceding, but separate main-slides are arranged for each cylinder-side, whose through-ports diverge into four narrow openings. The expansion-plates are here also independent of the main-slides, and are guided in ledges. The expansion-rod carries a sleeve, which is supplied at its ends with two straight lugs, whilst its middle is provided with two inclined lugs, corresponding to which the lugs on the expansion-plates are formed. The valve-rod, and consequently also the sleeve, is controlled by the governor by an external lever. The maximum declination of the governor balls corresponds to a turn of the valve-rod of about 60°, and to an alteration in the cut-off of from 5 to 70 per cent.

The engine exhibited had a cylinder-bore of 11·81 in. (300 mm.) and a stroke of 23·62 in. (600 mm.) and worked at 65 revolutions per minute. The slide bars are bored out of the girder-frame, cast in one with the crank-shaft pedestal. The cylinder and valve chest are also cast in one piece and the inferior side of the steam-ports is arranged sufficiently low, to let the condensed water flow off.

The condenser and steam-cylinder rest on one bed-plate; the pipe leading from the cylinder to the condenser is furnished with two valves, allowing the condenser to be cut off, when off duty whilst the engine is running.

9. John Turnbull, Junior, of Glasgow.

Fig. 287.



Though not belonging to the present division, still as Turnbull's Valve-gear has hitherto been omitted, we may make good this omission by inserting it here.

Any system of Cut-off gear is imperfect that does not comply with the following conditions. 1. The travel of the valve should be constantly the same. 2. The area opened up for admission should also be constantly the same. 3. The capability of prolonging the admission to any part of the stroke, and 4. Simplicity of detail with the fewest number of parts.

The Cut-off gear designed by Mr. John Turnbull Junior, of Glasgow, seeks to comply with the whole of these conditions. From Fig. 287, it will be seen that short slide valves are employed, one at each end of the cylinder to ensure short steam ports, whilst a cut-off plate is used to work on the back of each valve, at right angles with it. The travel given to the cut-off plates never exceeds $^3/_4''$; the area opened up is nearly twice that of the steam-ports, with a view of obtaining the full boiler pressure on the piston. The cut-off plates are actuated by a single scroll cam

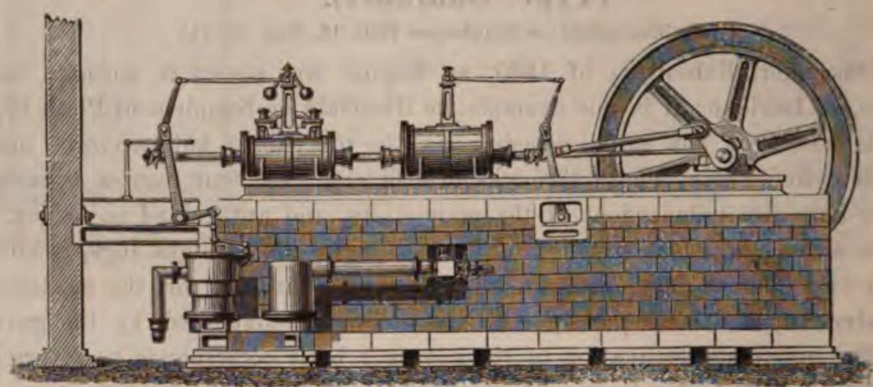


Fig. 288.

which works on a spindle driven by wheel gear at the same number of revolutions as the crank shaft. By prolonging this spindle it may also be used for driving the governor. The cam is raised or lowered by the action of the governor, and thus cuts off the admission sooner or later as the load necessitates.

Our other wood-cut Fig. 288, is Mr. Turnbull's patent Tandem Compound Engine without slides. It is fitted with his Cut-off gear; it has his patent double parallel motion which reduces the friction and works the air pump, as well as prevents the weight of the pistons from bearing on the cylinders.

C. Piston valve-gears and Balancing Arrangements.

On account of the friction which the slide experiences, being augmented with increase of steam-pressure, and this defect proving very considerable with large slides, it has to be remedied by balancing the slide from the otherwise burthening steam-pressure. Whereas, certain arrangements merely partially balance the flat slide-valve types, with piston valve-gears we obtain a perfect balancing, which advantage makes itself especially felt with "reversing-gears". The sliding surface of piston valves is cylindrical, and the steam-port forms an annular opening, which is however not continuous but is interrupted by ribs on the surface of the metal-contact. These serve the purpose of carrying the packing rings of the valve-piston over the port edges without knocking; but, to avoid these ribs causing a local wear of the packing rings, they are not arranged parallel to the piston-valve motion, but spirally or curve-fashion.

a. J. Fowler & Co., of Leeds.

As our Fig. 289 shews, the piston-valve adopted by Messrs. J. Fowler & Co., of Leeds, must always be used in a divided form, which thereby secures the additional advantage of obtaining narrow steam-ports. The three cavities A, A_1 and B, are partitioned off, steam-tight, by the two pistons, so that the same pressure always exists in the cavities A, A_1, so differing from the space B. It matters not, whether the live-steam enters at A, A_1, whilst B is the exhaust, or vice-versa. This last named case, takes place in our wood-cut; for in the position of the steam-piston D, live steam passes out of A, through the port a_1, behind the piston, and the exhaust takes place through the port a, into the cavity A. The piston valves slide in cast-iron cylinders, which contain the inclined slots. In order to balance the weight of the two piston-valves, the diameter of the upper valve was made $^1/_4$ inch (6 mm.) larger than that of the under one; thus the greater pressure in B counteracts the piston-valve weight.

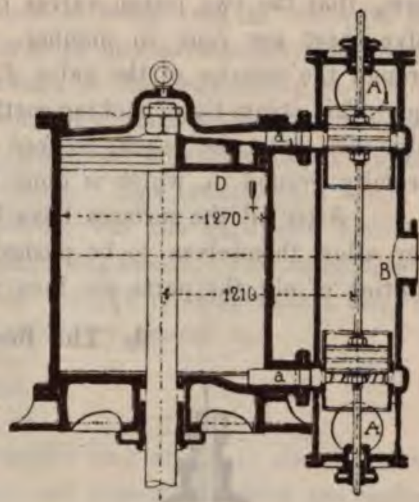


Fig. 289.

b. J. C. Hoadley Company, of Lawrence, Mass. (U. S. A.)

In these piston valve-gears, special care must be taken in the steam-tight packing of the piston-valves; and the side walls of the piston body should recede more than occurs with the ordinary steam-piston, so as to prevent throttling the steam when opened. In this respect the piston valve, illustrated in Fig. 290, of the J. C. Hoadley & Co. is commendable. It has a lap-width of $2^1/_2$ in. (64 mm.), which is formed by two rings, that are feather-tongued into each other. They are kept together by the two side-discs of the piston, which slightly protruding, are rounded off. The wear of the packing-rings is compensated for, by the inner ring a, which by the pressure of the conical disc b, is opened out. To fix the distance between the piston-valve, a cast-iron sleeve c, is inserted. In this constructive example, the inner cavity A, forms the exhaust, whilst live steam enters at B, and B_1. The inner and external laps are respectively 0·12 and 1·54 inch (3 mm. and 39 mm.); and as the eccentricity of the eccentric amounts to 2 in. (51 mm.) expansion only begins at $^3/_8$ stroke.

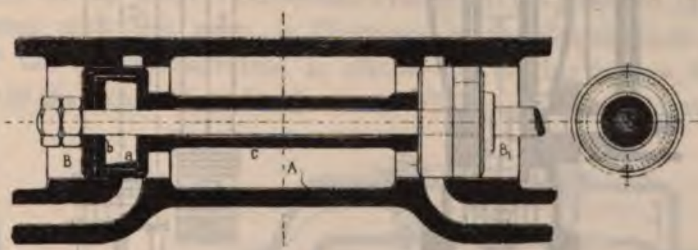


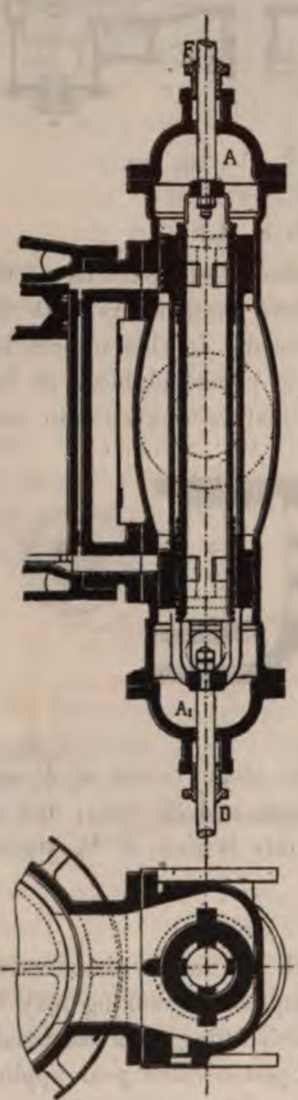
Fig. 290.

c. Jeremiah Head, of Middlesborough.

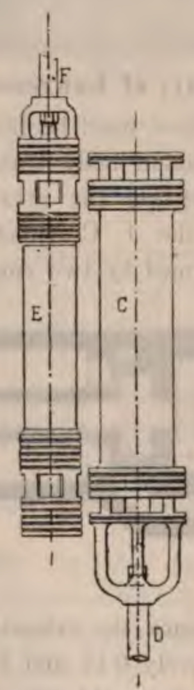
If it is already difficult to make a good steam-tight packing, with the simple piston-valve, it is much more so, in the arrangement of double valves. Still, all complicated packing may be obviated, if the piston is provided with a number of narrow grooves, which filling with condensed water, so form a tight joint. We represent in Figs. 291—294, a double piston-valve gear applied to a vertical engine, as introduced by Mr. J. Head, of Middlesborough. The main-slide C, is worked from a vertical falling rod D, from one eccentric, whereas the expansion-valve E, is also worked centrally from a rising rod F, from an eccentric, off an intermediate link. The woodcuts shew, that the two piston valves C and E, are through-ported, and that the steam ports of the valve-chest are four in number. The two cavities A, A_1, communicate with each other, through the interior of the valve E, whereas the middle cavity communicates with the exhaust-pipe. This steam-tight packing method has proved itself to be well adapted to high-speed engines, only care must be taken, to feed the boiler with clean water, and the various parts must be carefully ground in, which is done in the following manner:

After all the surfaces have been carefully turned, the parts are polished with emery, until they allow themselves to be pushed inside each other, when the grinding in, is finished by the addition of oil; the parts are then worked up and down.

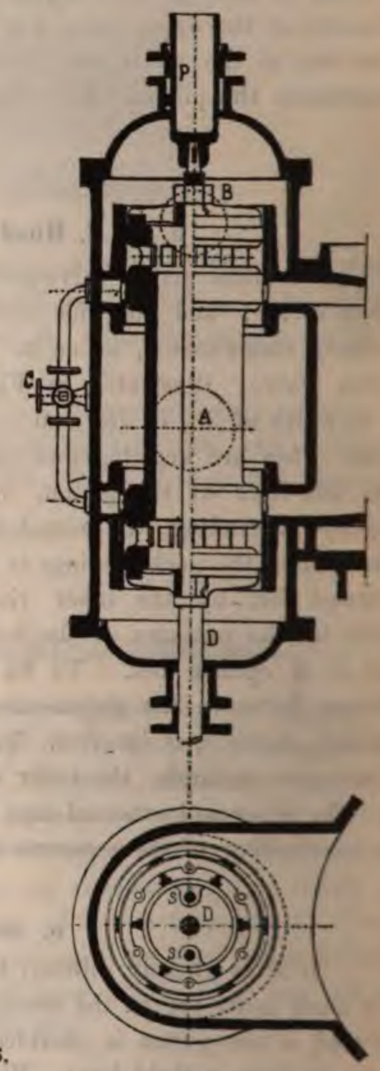
d. The Bochum Walzwerk-Verein, of Bochum.



Figs. 291—292.



Figs. 293—294.



Figs. 295—296.

Borrowing our illustrations Figs. 295—296 from the "Wochenschrift des österreichischen Ingenieur- und Architekten-Vereins", we find this expansion piston valve gear applied to an Engine, of the Bochum Rolling-Mills. On account of the Valve-chest being cast in one with the cylinder, (so as to compensate for the wear and tear), the valves work in separate and independent valve-surfaces let in. The steam enters at *B*, and exhausts through *A*. The connecting pipe *C*, is fitted with a three-way cock, which serves for starting the engine, when the steam-port is already closed. The main-slide is worked from the central-rod *D*; on the other hand, the expansion rod is worked by two external falling rods s, s_1 coupled together by a cross-beam. This cross-beam, which is guided by a long sleeve, along the valve-spindle of the main-slide, has the expansion eccentric rod coupled to it eccentrically. This eccentric only permits fixed expansion. The main-slide is packed against the valve-chest by spring rings, whilst its own weight is compensated for, by the plunger piston *C*; on the other hand, the expansion valve is simply ground in.

e. L. Guinotte, of Mariemont.

(With illustration on Supplement-Plate 12.)

A large Beam-Engine of L. Guinotte of Mariemont, represented on Plate 12, is also furnished with an expansion piston-valve gear. In this example, both main and expansion valves are packed steam-tight by spring rings. The former is worked by two lateral, the latter is driven by a central valve-rod. The coupling of the lower and upper portion of each of the slides is rendered sufficiently explicit by our Drawings. Steam admission takes place in the centre of the Valve-chest, whilst the two end-cavities of the chest, communicate with the Condenser. Barring a few alterations which depend on the mounting of the Engine, the external Valve-gear is the same as described on page 90.

f. P. Wirtz, of Deutz, near Cologne.

(With illustrations on Supplement-Plate 9, Figs. 9—15.)

Piston-Valves are also introduced on the Meyer Valve-Gear system in the patented type of P. Wirtz, of Deutz. An engine fitted with this gear, is illustrated in Supplement-Plate 9, Figs. 9—15. The central motioning of the two piston-valves is effected by making hollow the rod of the main-slide, and passing that of the expansion-valve inside it. The main-slide is drawn

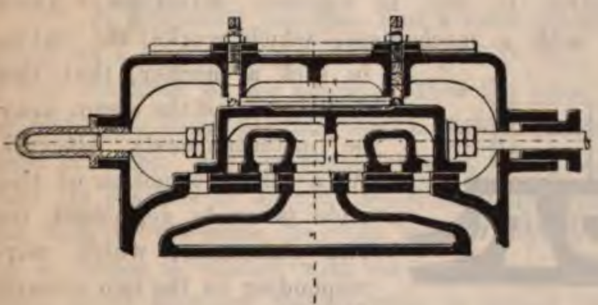


Fig. 296.

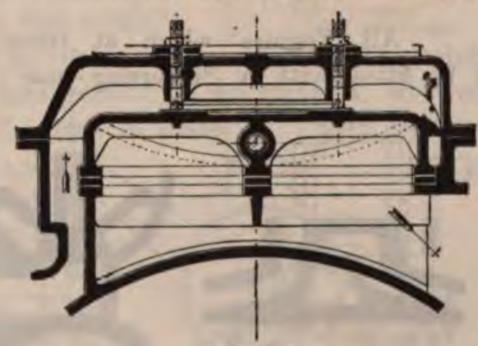
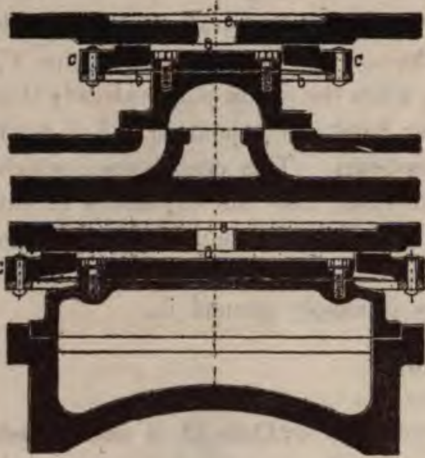


Fig. 297.

to an enlarged scale on Fig. 14, which also shews us the method of packing applied, as well as the four ribs *d*. The form of the expansion-valve is drawn in Fig. 15. To prevent the packing rings of the main piston-valve fastening themselves in the exhaust-port, when the main-slide is being removed from its cylindrical chest, it is arranged with eight ribs *c*, as shewn in Fig. 12.

The Balancing of slide-valves is generally restricted to Reversing-gears. One of the most usual constructions for balancing such slides, in which a circular portion of the slide is packed steam-tight, is shewn in our Figs. 296—297.



Figs. 300—301.

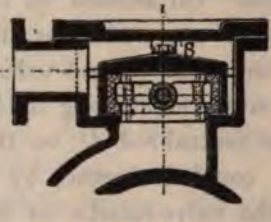


Fig. 298.

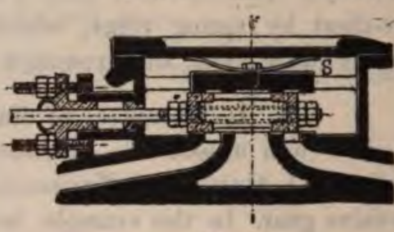


Fig. 299.

In this example, a tambac ring slides on the worked surface of the valve. This metal ring is grasped by a wrought-iron ring, which is guided in a slot of the Valve-chest cover, and which is pressed externally by springs by a second cast-iron and india-rubber ring. Very simple is the balancing method, shewn in Figs. 298 — 299. The valve, slides in a cast-iron strap, which, at its lower side is supported by the two sides of the valve. A spring *S*, prevents the accidental recession of the strap. In Figs. 300—301, we illustrate Dawes' balancing-method, which is much used here in England. The back of the slide has a rectangular plate *a*, attached to it, by four screws; clamped between, is a thin plate *b*, which is rivetted at its outer edges, with a cast-iron frame *c*, whose upper part slides on the worked surface of the cover. The opening *e*, serves the purpose of shewing any escape of steam, due to the valve not fitting steam-tight.

D. Reversing-Gears.

All Engines which at times are required to run in opposite directions, have to be fitted with a "reversing-gear", — i. e. with a mechanism, which works the valve in such a manner, that the distribution of the steam may be instantaneously altered. As a rule, the motion of the slide is made dependent on two eccentrics, which corresponding to the two rotary directions required, are keyed accordingly on the main-shaft.

Figs. 302—304.

On the other hand, two eccentrics are not always required, as will be explained by the following examples:

a. Danek & Co., of Prague.

(With illustrations on Supplement-Plate II, Figs. 1—5.)

The small Engine drawn on Supplement-Plate II, is made by Danek & Co., of Prague, and is of the double form shewn in Figs. 302—304. By turning the valve, the axis *A A*, or *B B* may be made to coincide with that of the cylinder. In the first case, the ordinary slide illustrated in Fig. 302 comes into play, and the engine works forward; the distribution of the steam is however immediately reversed by the E-slide shewn in Fig. 304, which acts as soon as the axis BB is brought normal to the cylinder-axis. In this valve-gear, the eccentric must be keyed 90° in front of the crank, whereby naturally no expansive working takes place.


Fig. 308.

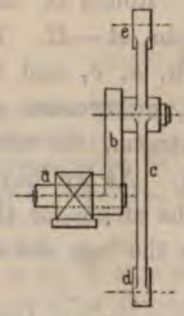
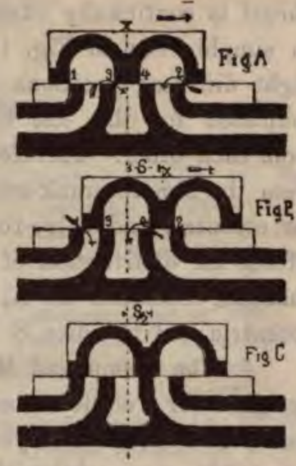


Fig. 309.



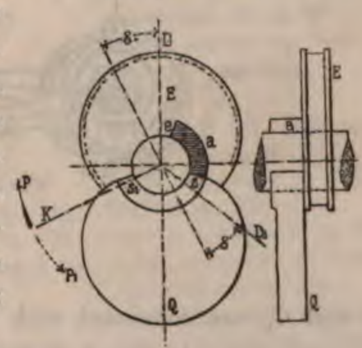
Figs. 305—307.

In Figs. 305—309, we illustrate a second reversing gear, also applied by these Engineers, and which only requires the application of one eccentric. In this case an E-slide is used, which reverses the steam-distribution, as soon as its oscillating centre x is shifted. The valve is drawn in its central position in Fig. *A*, when reversed, and in Fig. *B*, it is similarly drawn when forward-running, whereby the centre of the valve has been shifted to the distance *S*. But if it is merely shifted to $\frac{s}{2}$ (Fig. *C*), then the steam is so distributed as to cause the engine to stop. In these Figures, the acting edges of the admission are marked with 1, and 2, whereas those of the exhaust are represented by 3 and 4. The external mechanism is drawn in Figs. 308—309. The reversing-spindle *a*, carries the lever *b*, to which the double-lever *c* is suspended. It is connected at *d*, with the eccentric-rod, and at *e* with the valve-spindle. In Fig. 308, the lever *c*, is shewn in a position corresponding to the reversing-moment; but if the spindle *a* is turned, to the extent of *S*, then reversing takes place.

b. Joseph Bernays, of London.

(With illustrations on Supplement-Plate 21, Figs. 1—15.)

It frequently happens, that a loose eccentric is used in "Reversing Gears", which is carried along by a lug *a*, on the shaft. Figs. 310—311, shew this arrangement. If the crank *K*, revolves in the direction of the arrow *p*, then the loose eccentric *E*, which is connected with a counter-weight *Q*, for balancing purposes, is moved by the lug *a*, at *s*, in the same direction. For reversing purposes, the eccentric must be shifted from its position *D* towards D_1, i. e. round an angle of $(180 - 2\delta)$, and this in the same direction as the Engine is running, till the lug s_1 comes in contact with the opposite side *e* of the lug. With small sized Engines, the eccentric is turned by hand, whereas in large Engines the eccentric-rod is unhooked, and the valve is motioned by hand, so that the crank turns in the direction of the arrow p_1, whereby similarly the surfaces s_1 and *e* come in contact with each other.

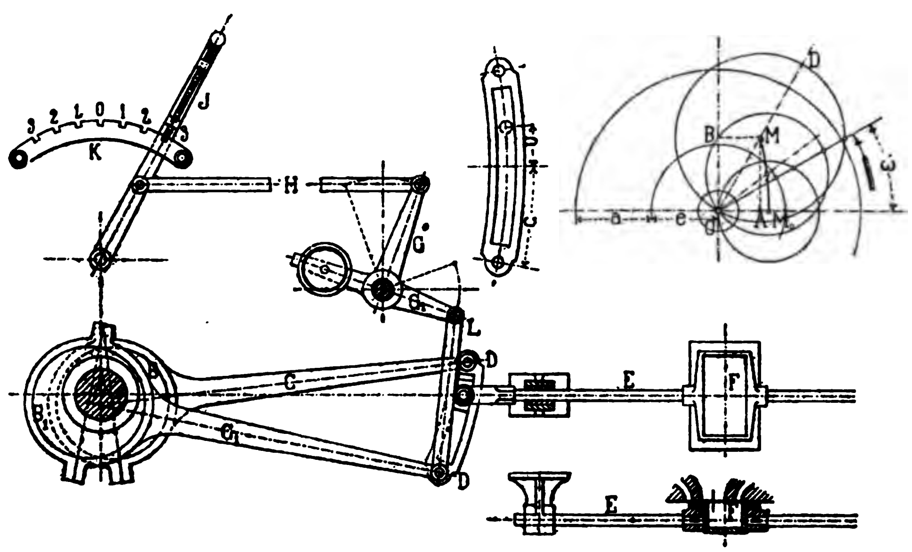

Figs. 310—311.

An Engine, possessing one of these valve-gears is represented in Supplement-Plate 21 (Figs. 1—10), as designed by Joseph Bernays, of London. It deserves special mention on account of its peculiar design. It consists of two vertical cylinders, between which the crank-shaft is supported. By employing a ⊤-formed connecting-rod, which is connected to both piston-rods, the occurrence of dead-centre is obviated, as a thrust is continually exercised on one of the crank-pins. The geometrical connection is shewn in simple lines in Fig. 10. Round *O*, the crank-circle is described, and the crank is shewn in eight different positions from *A* — *H*. The corresponding positions of the pistons, which are indicated for the one by *a*, *b*, *c*, and for the other by a_1, b_1, c_1, result in travels differing from each other. Therefore, on account of the crank in relation to the piston-motion, differing from the simple crank-mechanism, the triangular connection in a smaller scale, must be repeated for eccentric and valve-rods. As we have merely one crank to deal with, only one eccentric effects the distribution of the steam for the two cylinders. Fig. 2, explains the reversing mechanism, inasmuch as *K*, is the lug, and *G*, the counter-weight, which is cast in one with the eccentric and the disc *S*.

The Compound Marine-engine drawn on the same Supplement-Plate, in Figs. 11—15, is designed for Paddle-steamers. The one eccentric works the two main-slides, whereas a second eccentric works the Meyer expansion plates of the small cylinder. The latter has a bore of 2 ft. 6 in. (762 mm.) whilst the low pressure cylinder diameter, measures 3 ft. 9 in. (1143 mm.); the stroke of the two cylinders amounts to 4 ft. 6 in. (1372 mm.).

c. Stephenson's Link-gear.

The most usual Reversing-mechanisms are the "Link-gears"; amongst which the Stephenson Link-gear is the most prominent; it is illustrated in Figs. 312—314. The shaft *A*, has two eccentrics *B* B_1 keyed on, which are mounted corresponding to the direction of rotation. The eccentric rods



Figs. 312—314.

C and C_1, are connected with the link *D D*, which is curved to a radius = the length *l*, of the eccentric rod. In this link the block of the valve-rod *E* glides. The link is suspended from its point *L*, and can be thus raised or lowered by the bell-crank *G* G_1, connected to the hand-lever *J*, by the rod *H*. Every point of the link can be utilised for working the valve-rod; the middle position, in which the hand-lever *J*, is notched in *O*, of the arc *K*, corresponds to the stoppage of the engine. But accordingly as the link is moved, causing the slide to be shifted more by the

List of Makers of Engines, described in Corliss and Slide and Piston-valve geared Steam-Engines.*

Great Britain and Ireland.

America.

France and Belgium.

* The pages to which an asterisk (*) is affixed, refer to the Supplementary Volume.

Slide and Piston-Va

Consecutive Number.	Page.	Supplement-Plate.	Supplement-Plate.	Valve-Gear Types.	Engineers.	Works.	Horse-Power. n = nominal, e = effective, i = indicated	Cylinder-Diameter. in.	Cylinder cross-area. sq. in.	Piston-stroke. in.	Revolutions per Minute.	Piston-speed per Sec. ft. in.	Admission-Diameter. in.	Admission-area. / Cylinder-area.
1	16	1	—	Single slide.	Tangye Brothers.	Birmingham.	2 n	3.97	12.40	8	180	3 11	0.98	1/16
2	18	2	—	" "	" "	"	10 n	10.00	78.58	12	150	4 11	2.48	1/16
3	22	1	—	" "	John Bourne & Co.	London.	35 e	5.98	28.05	10	300	8 2	1.50	1/16
4	31	—	VII	" "	Fürstl. Fürstenberg'sche Maschinenfabrik.	Immendingen.	8 n	7.67	46.48	9.45	90	2 3	1.65	1/22
5	45	—	VII	" "	H. Flaud.	Paris.	30 e	9.84	76.10	10.23	150	4 3	1.58	1/37
6	59	—	IX	Hartnell.	E. R. & F. Turner.	Ipswich.	8 n	6.29	31.15	10	270	7 6	1.50	1/18
7	61	3	—	Deprez.	Satre & V. Averly.	Lyons.	25 n	17.72	246.45	30	40	3 7	3.15	1/31
8	73	4	—	Two Slides.	Maschinenbau-Actiengesellschaft Danĕk.	Prague.	—	31.10	759.81	49.5	80	11 0	7.87	1/15
9	75	4	—	" "	Professor Salaba.	Prague.	40 n	15.75	194.83	27.56	70	4 11	2.95×4.52	1/14
10	76	5	—	Quadruple slides.	Allen Engine-Works.	New-York.	—	16.00	210.72	30	125	10 3	—	—
11	82	—	XII	Double slides.	G. A. Biffar.	Fratte.	16 n	8.00	50.22	16	115	4 11	1.97	1/16
12	96	6	—	" "	Buckeye Engine Co.	Salem, Ohio.	73 i	16.00	210.72	32	95	8 5	4.99	1/10
13	85	—	X	" "	Arthur Rigg.	London.	10 n	10.00	78.58	18	—	—	3.97	1/6
14	87	7	—	" "	A. Duvergier.	Lyons.	—	23.62	438.82	47.2	40	4 7	5.11	1/21
15	88	7	—	" "	L. Bréval.	Paris.	20 n	13.78	149.11	26	50	3 7	2.56	1/29
16	90	11	—	" "	Lucien Guinotte.	Mariemont.	—	25.59	470.32	25.59	—	—	5.51	1/21
17	151	12	—	Double Piston valve.	" "	"	—	55.1	2386.07	137.8	—	—	15.75	1/12
18	92	13	—	Double sides.	E. A. Wortmann.	Ruhrort.	—	10.23	82.30	19.69	—	—	2.76	1/14
19	99 106	8	—	Meyer.	G. Müller.		12 n	12.60	124.62	22	80	4 10	2.76	1/21
20	109	—	XV	"	Whieldon, Lecky & Lucas.	London.	60 n	24.01	452.91	48	—	—	4.99	1/23
21	111	10	—	"	Ch. Beer.	Jemeppes.	—	20.87	341.93	47.2	48	6 2	4.52	1/21
22	119	9	—	" (modified.)	Berliner Union.	Berlin.	—	14.57	166.63	28	55	4 3	3.15	1/20
23	151	9	—	" (Piston.)	P Wirtz.	Deutz.	50 n	15.75	194.83	30	—	—	3.54	1/20
24	119	—	XIX	Cario.	Nienburger Maschinenfabrik.	Nienburg.	—	19.69	304.42	3.15	—	—	5.11	1/14
25	126	16	—	Rider.	G. Sigl.	Vienna.	20 n	12.40	120.79	24.80	—	—	3.15	1/15
26	126	16	—	"	"	"	50 n	20.48	329.14	41	42	4 7	4.64	1/20
27	127	—	—	"	Gebr. Sulzer.	Winterthur.	10 n	7.87	48.67	19.69	85	4 7	1.77	1/19
28	127	15	—	"	Maschinenfabrik Augsburg.	Augsburg.	10 e	6.69	35.18	15.75	120	5 3	1.97	1/11
29	129	14	—	"	Gebr. Sachsenberg.	Rosslau.	42 i	13.39	140.74	26.77	82	5 10	3.35	1/18
30	129	14	—	"	Ch. Brown.	Winterthur.	—	9.84	76.10	19.69	—	—	2.76	1/13
31	130	17	—	"	Rheinische Maschinenfabrik.	Kalk nr. Deutz.	—	7.87	48.67	15.75	—	—	1.77	1/28
32	130	17	—	"	Gebr. Pfeiffer.	Kaiserslautern.	55 e	19.69	304.42	37.01	50	5 1	4.52	1/19
33	138	18	—	Farcot.	Gebr. Schmaltz.	Offenbach.	—	7.87	48.67	15.75	100	4 4	1.77	1/20
34	138	18	—	"	C. v. Liphart.		—	7.87	48.67	15.75	—	—	1.97	1/16
35	143	—	—	Krause.	Gebr. Decker.	Cannstatt.	50 n	15.75	194.83	31.5	54	4 8	3.15	1/3
36	145	20	—	"	Chemnitzer Werkzeug-Maschinenfabrik.	Chemnitz.	—	9.45	70.06	19 69	—	—	2.76	1/19
37	147	13	—	Guhrauer.	A. v. d. Becke.	Sundwig.	—	11.81	109.58	23.62	65	4 3	3.15	1/14
38	139	19	—	Farcot.	Compagnie de Fives-Lille.	Fives Lille.	40 n	19.69	304.42	39.37	40	4 3	—	—
39	117	—	XVI	Dack.	Hch. Berchtold.	Zürich.	—	7.08	39.37	15.75	160	6 10	1.58	1/21

* The numbers in this Column of the preceding Tables, should be "Roman Figures". — ** This Column in the prese

ed Steam-Engines.

	passages.		Main-slide Eccentric.			Fly-wheel.					Slide-block.** Surface-area.		Crosshead pin.		Crank Pin.		Crank Bearings.				
	Length.	Steam-pressure in Atm.	Excentricity.	Advance-Angle.	Width.	Diameter.	Width.	Fly-wheel radius. / Crank-radius.	Piston-thickness.	Piston-rod Diameter.	Length.	Width.	Diameter.	Length.	Diameter.	Length.	Diameter.	Length.	Main-shaft diameter.	Maximum Diameter of connecting-rod.	Remarks.
	in.		in.	degrees.	in.	ft. in.	in.		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
47	2.52	4.5	0.87	53	1,42	2 ft. 6 in.	2.95	3.75	3.43	0.79	3.86	1.65	0.91	1.50	1.30	1.77	1.93	2 82	1.89	1.18	Total Engine weight = 5 cwts.
97	7.47	—	1.50	10	1.97	5 ft.	8.26	5	3,23	1.77	7.47	0.08×3.97	1.73	4.44	3,27	4.99	3.50	6.76	3.50	1.97×2.99	
50	4.40	9	1.26	—	1.10	2 ft. 6 in.	8 46	3	1.50	0.98	8.46	2.95	1.50	2.24	2.48	2.95	2 48	4.32	2.48	1.26	
38	4.13	4.5	1.18	—	1.89	2 ft. 9 in.	4.13	3.5	2.76	1.30	5.31	11.22	1.18	—	2.60	4.25	2.95	3.78	3.35	0.79×2.17	Coupled Engine weight 3½ tons.
77	4.91	—	—	—	2.56	4 ft. 9 in.	9.84	5.5	3.74	1.58	5.90	2.44	2.36	4.32	3.15	5.90	3.15	5.11	3.94	2.36	
98	4.72	9	—	variable	1.50	3 ft. 5 in.	7.87	4.2	3.15	1.10	5.98	0.08×4.32	1.50	2.36	3.74	3.54	3.54	4.99	3.54	—	
97	9.45	5	2.76	90	3.35	—	—	—	5.90	2.36	9.05	0.08×8.07	2.76	0.08×3.94	3.54	4.72	6.29	9.05	6.29	3.74	
54	18.66	4	—	—	4.32	—	—	—	8.66	4.91	15.99	7.87	7.08	7.87	7.28	8.26	14 57	21.66	16.54	7.87	Rolling-mill Engine.
46	8.46	—	1.54	19	1.58	—	—	—	5.51	2.36	12.20	5.51	2.17	2.56	3.94	3.94	5.90	10.63	5.90	2.95	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
38	3.74	—	0.98	—	1.77	3 ft. 4 in.	0.08×5.11	2.5	3.74	1.38	7.47	2.36	1.38	0.08×1.77	3.15	2.83	3 35	5.11	3.94	1.58×2.17	Coupled Engine weight 10½ tons.
-	—	5.3	—	—	2 76	10 ft.	25.59	3.75	4.48	2.44	13.98	8.07	3.35	4.99	3.94	4.99	7.99	16.14	7.87	3.35	
58	4.72	—	1.50	29	1.77	6 ft. 6 in.	—	4.4	2.44	1.50	12.68	4.48	1.58	2.48	2.99	2.99	3.47	6.96	4.44	1.18×2.48	
58	13.39	6.3	1.77	—	4.32	9ft. 10in.	17.33	2.5	5.11	3.15	17.72	15.75	3.15	6.29	—	7.87	—	16.93	9.84	4.72	
77	5.11	5	1.02	11° 15′	2.76	12f. 15in.	5.90	5.75	5.90	1.97	8.85	3.94	3.15	0.08×3.54	—	5.70	—	7.47	6.29	3.94	
76	14.17	—	2.60	33	3.15	9ft. 10in.	0.08×6.29	4.6	4.52	3.62	15.75	7.87	4.13	5.11	5.31	6.69	7.87	11.81	9.45	2.76×4.52	Pair of verticals.
72	16.73	—	—	—	4.72	27ft. 6in.	0.08×9.84	2.4	11.41	7.87	25.20	9.45	16.54	0.08×11.81	6.69	7.87	17.33	23.62	18.11	—	Single cylinder Beam-engine.
97	—	—	1.38	—	2.56	5ft. 10in.	0.08×6.69	3.2	3.54	1.58	7.87	5.11	1.97	2.76	2.95	3.54	5.11	6.69	5.11	2.36	
42	7.08	5	1.18	20.5	1.77	8 ft. 2 in.	7.28	4.4	3.54	1.89	9.84	5.90	1.97	3.15	2.56	3.35	4.13	5.90	5 23	2.56	
76	14.96	—	2.21	—	2.76	15 ft.	8.26	3.75	5.98	3.23	11.61	7.87	4.48	4.48	4,99	5.98	7.99	10 00	7.99	4.72	
-	13.78	5	—	—	—	—	—	—	6.88	2.95	17.72	16.54	3.94	5.43	4.72	6.69	8.66	13.00	11.02	4.91	Pair of Winding Engines.
58	7.47	5	1.10	20	2.17	9ft. 10in.	10.23	4.2	3.94	2.05	11.81	7.87	2.17	3.35	3.15	3 54	5.51	9.45	5.90	3.35	
94	9.84	—	0.79	—	1.97	10ft. 6in.	5.90	4.2	4 52	3.35	13.78	6.29	2.17	0.08×2.36	2.56	3.35	5.51	6.69	6 29	3.15	Belt-pulley: 7 ft. 4 in. diam. 10 in. face.
36	15.16	—	1.77	—	3.15	9 ft. 1 in.	—	3.5	4.72	2.83	15.35	13.78	2.36	3.54	3.54	4.72	7.08	10.23	7.08	3.54	
17	6.88	—	—	—	2.36	9 ft.	—	4.4	5.11	2.05	11.41	6.69	1.77	4.32	2.36	3.35	4.72	7.67	5.70	2.95	
40	9.84	5	—	—	2.76	15ft. 5in.	11.02	4.5	8.66	2.95	13.78	15.75	3.15	3 62	3.78	4.52	7.47	11.41	9.45	4 72	Coupled.
-	—	5	—	—	—	8 ft. 2 in.	—	5	—	1.18	6.49	4.32	1.38	2.76	1.97	2.36	3.94	6.69	3.74	—	
18	4.32	6	0.83	—	1.50	5ft. 10in.	—	4.5	3.15	1.26	6.88	4.32	1.50	2.56	1.97	2.44	3.35	6.10	4.52	2.17	
95	7.08	—	—	—	2.36	9 ft. 3 in.	6.10	4	5.90	2.17	11.81	7.87	2.56	3.54	3.15	4.13	5.11	7.87	5.51	2.39×3.94	
97	5.51	—	—	—	1.58	6 ft. 6 in.	13.78	4	4.32	1.97	11.02	5.90	2.24	2.21	4.72	7.87	4.72	9.45	4.72	3.15	
58	3.35	—	—	—	1.97	6 ft. 6 in.	—	5	3.15	1.50	5.90	4.91	1.38	2.17	1.97	2.36	3.35	6.10	3.94	1.97	Engine weight = 1¾ ton.
17	9.84	7	1.89	20	2.76	15ft. 9 in.	16.54	5	5.51	2.76	15.75	9.45	2.95	4.72	3.94	5.11	7.87	11.81	8.66	3.94	
98	3.35	6	1.38	5	2.56	5ft. 10 in.	5.51	4.5	3.35	1.38	6.29	4.91	1.77	2.36	1.97	2.95	3.62	5,51	3.94	1.97	
8	3.94	—	1.02	20	2.36	6 ft. 6 in.	4.72	5	3.54	3 54	7.47	4.72	1.58	1.97	1.97	2.36	3.54	5.51	3.94	2 36	
6	6.69	6	—	—	—	13 ft. 7in	15.75	5.2	—	—	11.81	9.84	2.76	4.32	3.94	5.11	6.69	12.60	9.84	—	
8	3.94	—	0.87	18	1.97	7 ft. 10in.	—	4.8	3.94	3.94	10.23	5.51	1.77	3.15	1.97	3.15	4.52	6.69	4.52	2.56	Divided Slides.
8	6.69	—	—	—	2.76	8 ft. 2 in.	10.63	4.2	3.94	3.94	11.02	7.08	1.77	3.54	2.36	3.54	—	6.88	5.51	3.15	
8	—	—	1.58	—	3.15	14ft. 9 in.	14.96	4.5	5.70	5.70	13.75	—	—	—	—	5.51	7.47	11.02	9.84	4.52	
8	4.32	—	—	—	—	4ft. 11 in.	5.90	3.75	3.94	3.94	8.66	5.51	1.18	1.18	3.15	3.94	3.35	7.87	3.35	1.97	

quoted as "Cross-head", Surface-area.

Germany and Austria.

Switzerland and Italy.

one or the other eccentric, the engine runs in the direction answering to the manner in which that eccentric is keyed on the crank-shaft. The end-positions of the link, correspond to latest cut-offs, whereas in the intermediate positions, the engine is made to work more expansively.

d. Ch. Beer, of Jemeppes (Type: Gooch).

(With illustrations on Supplement-Plate 10, Figs. 1—6.)

As a second link-gear, we present the one used by Ch. Beer on the Engine illustrated on Supplement-Plate 10 (Figs. 1—6). This valve-gear is almost exclusively used on "Winding-engines", where the Engines are long in design. The link is no longer shifted, but its block is; for this reason, the straight-working valve-rod is connected to the link-block by an intermediate rod. The link is consequently curved to the radius of this rod (Fig. 1), and is driven by a fixed lever. The reversing shaft carried transversely under the engine bed, as well as the reversing lever are illustrated in Fig. 6. This Engine also shows the combination of the Meyer Valve-type with a Reversing gear; in this case, the link merely serves for reversing purposes.

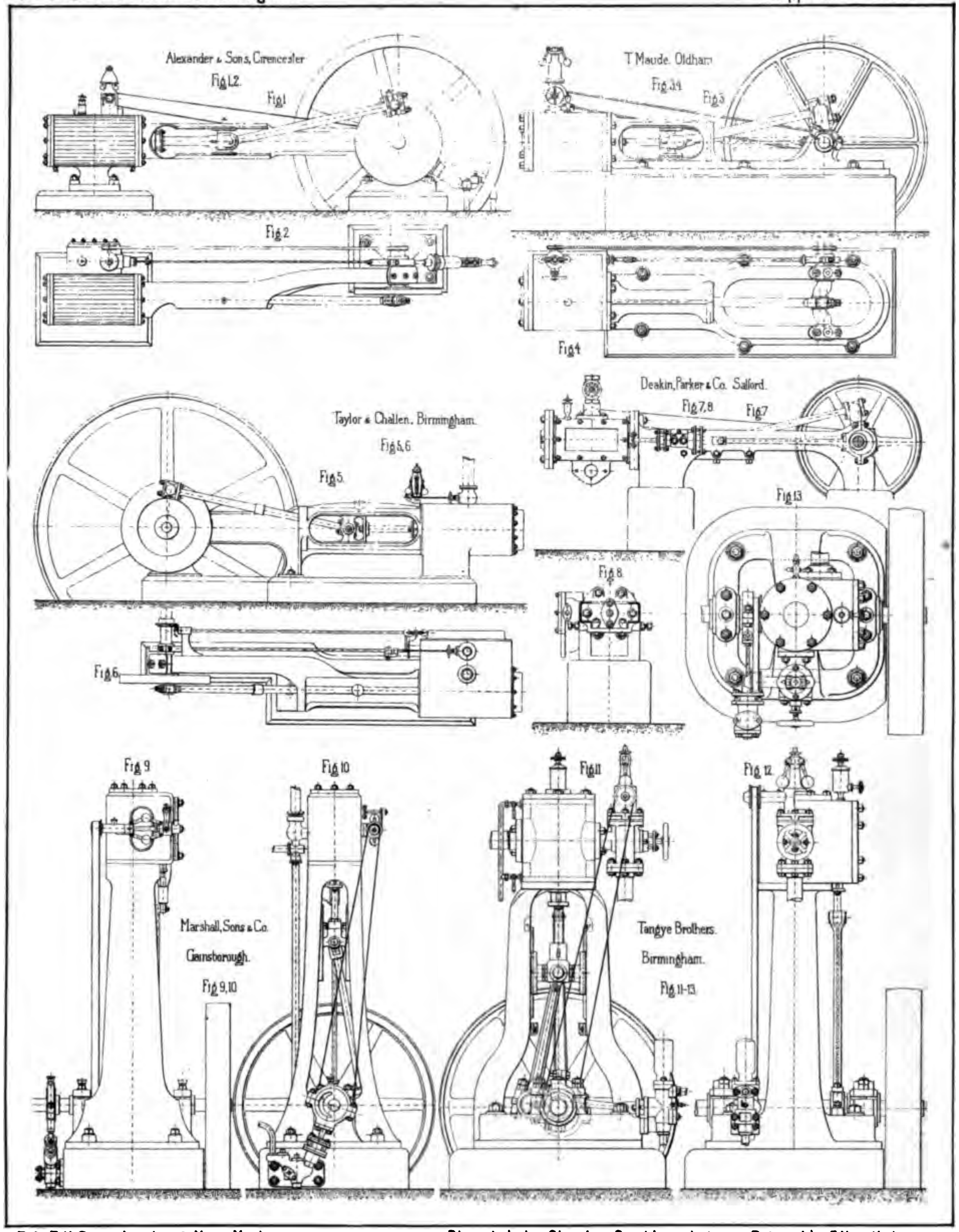
e. and f. Deprez & Pius Fink.

In conclusion, we will merely revert to the two Reversing-gears of Deprez and of Pius Fink. These link-gears may be easily referred to the Expansion Valve-gears of the same Engineers. The first was illustrated on Supplement-Plate 3. The link *C*, merely requires to be symmetrically prolonged downwards beyond the engine-axis, for then, these inferior link-block positions command a contrary steam distribution. Naturally, the rod T_1, may no longer be connected with the governor.

The same remark applies to the link-gear of Pius Fink, when brought in relation to the gear described on page 63. Here also, it is merely requisite to prolong the link downwards, beyond the machine axis, whereby the point of impact *Q*, of the guide-rod has to be arranged between the eccentric and the link. The screw-spindle is dispensed with, and a hand lever is substituted, for the guide-rod N_1, of the valve-spindle.

As a reversing-gear, this arrangement has found little application, and is inferior to the Stephenson and Gooch types, on account of its merely permitting early cut-offs.

Printed by Julius Klinkhardt of Leipzig.



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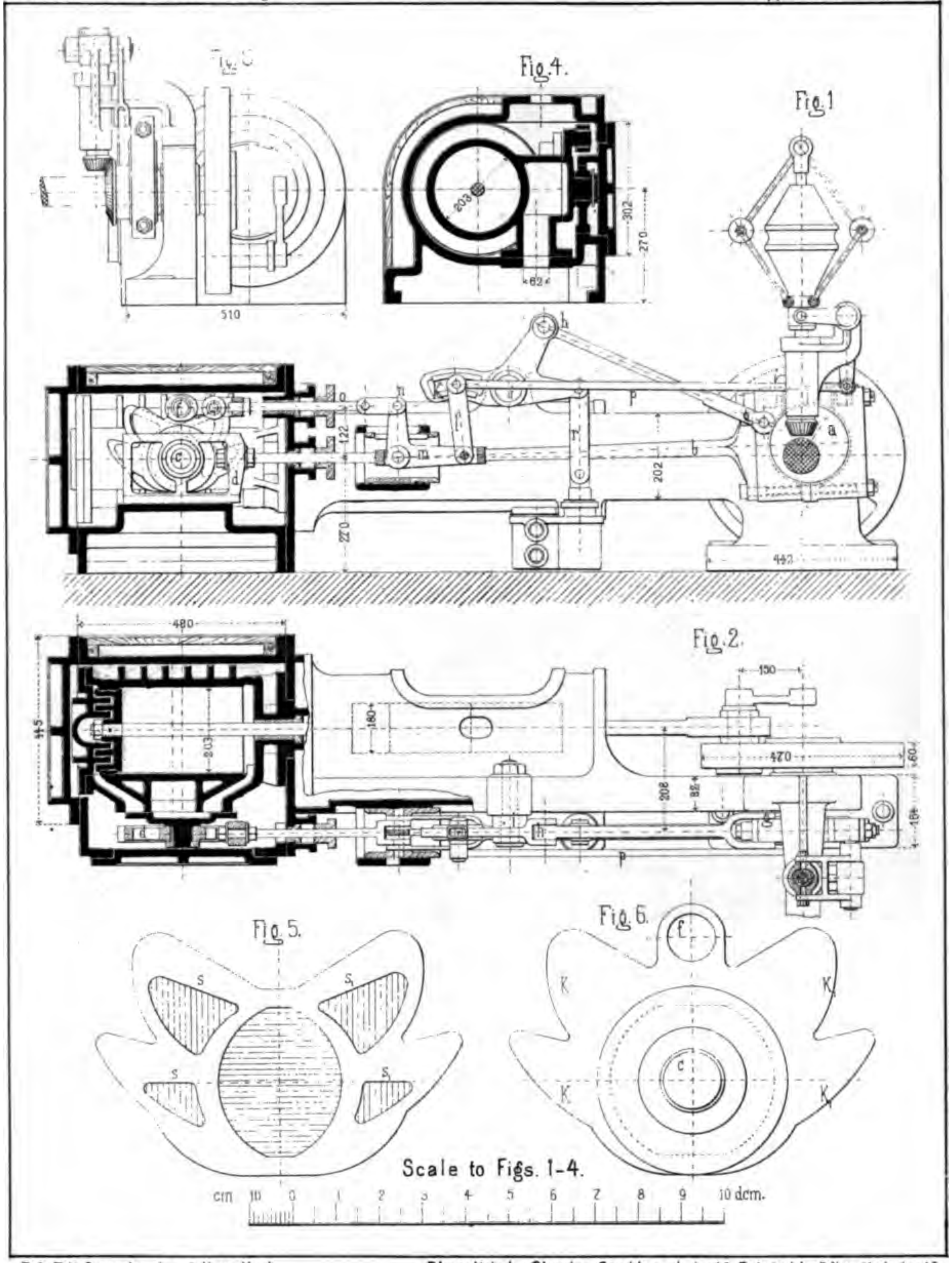
Druitt-Halpin, C.E. of London.



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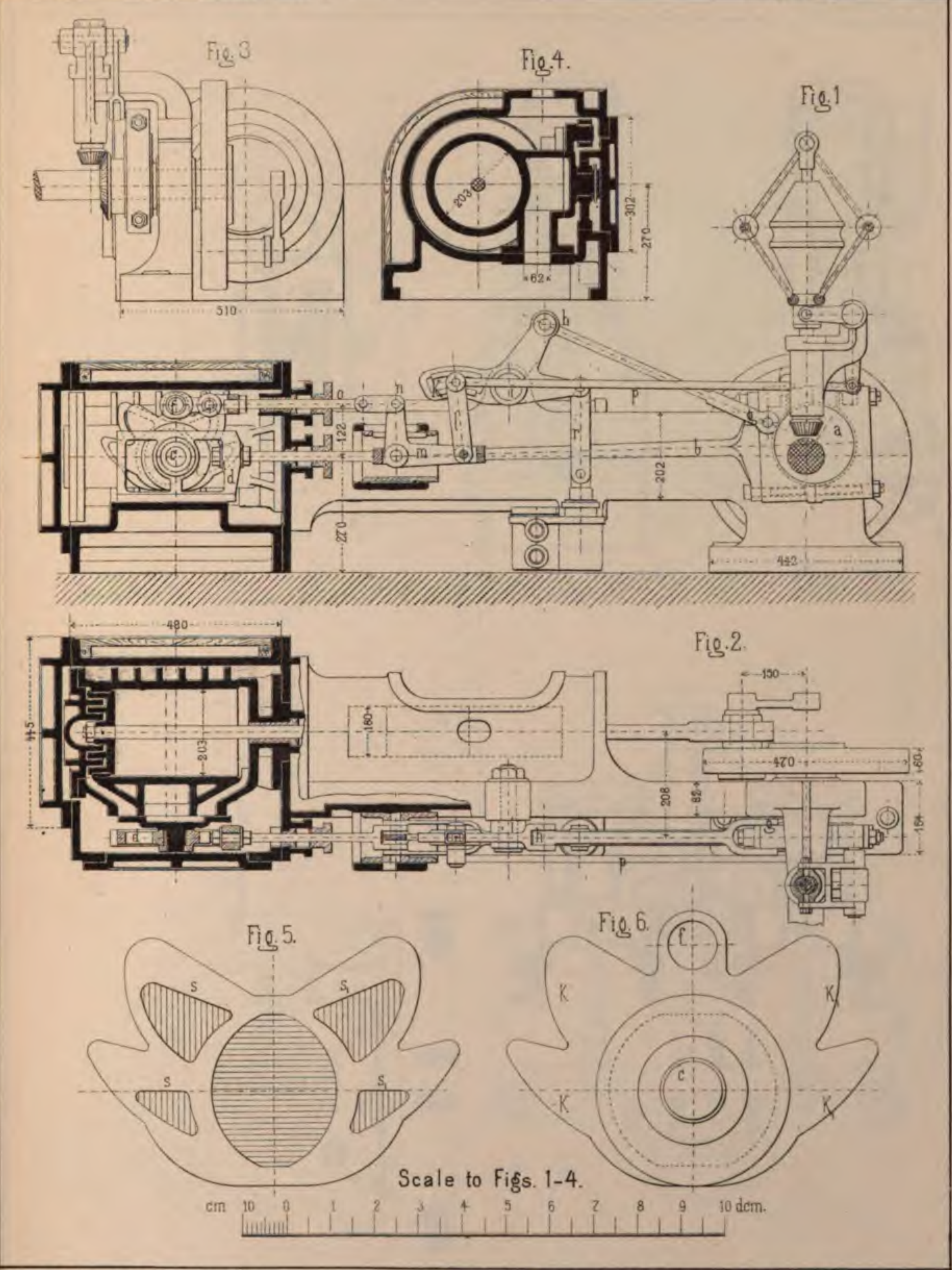

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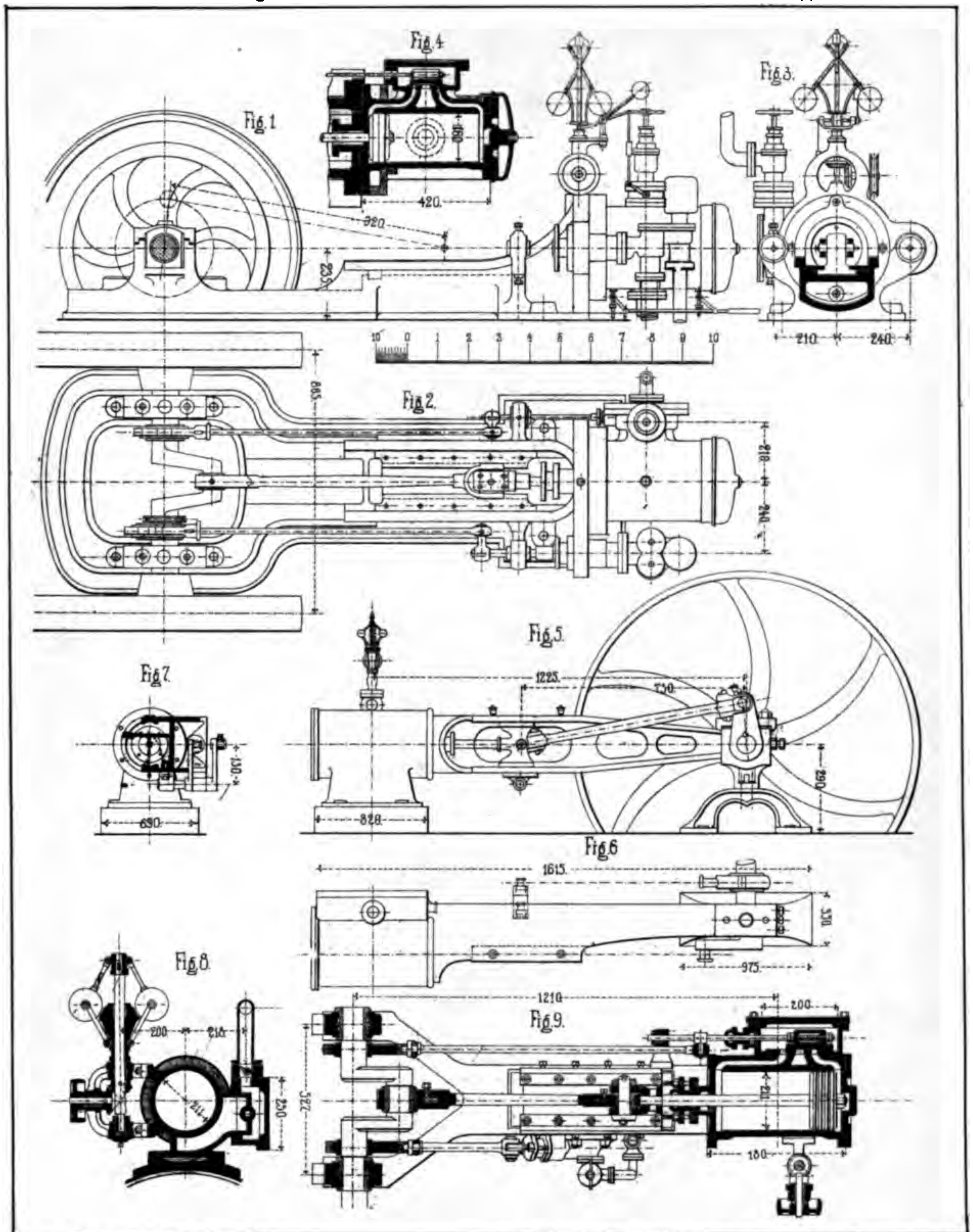
The Simmering Machine-works, near Vienna (Figs.1-4), A.F. Brown, Engineer of New-York (Figs.5-7).



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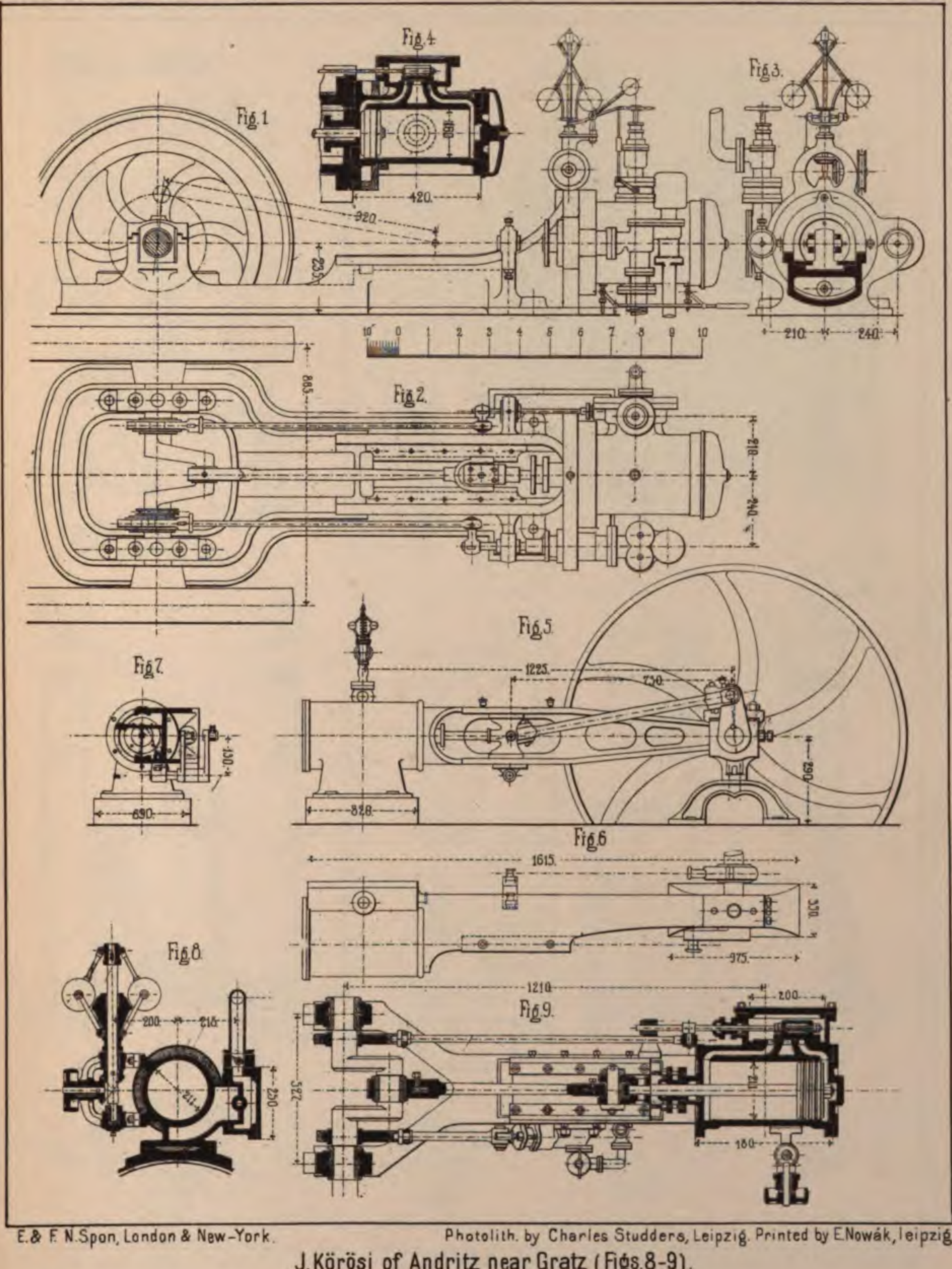
J. Körösi of Andritz near Gratz (Figs.8-9).

The Simmering Machine-works, near Vienna (Figs. 1-4), A. F. Brown, Engineer of New-York (Figs. 5-7).



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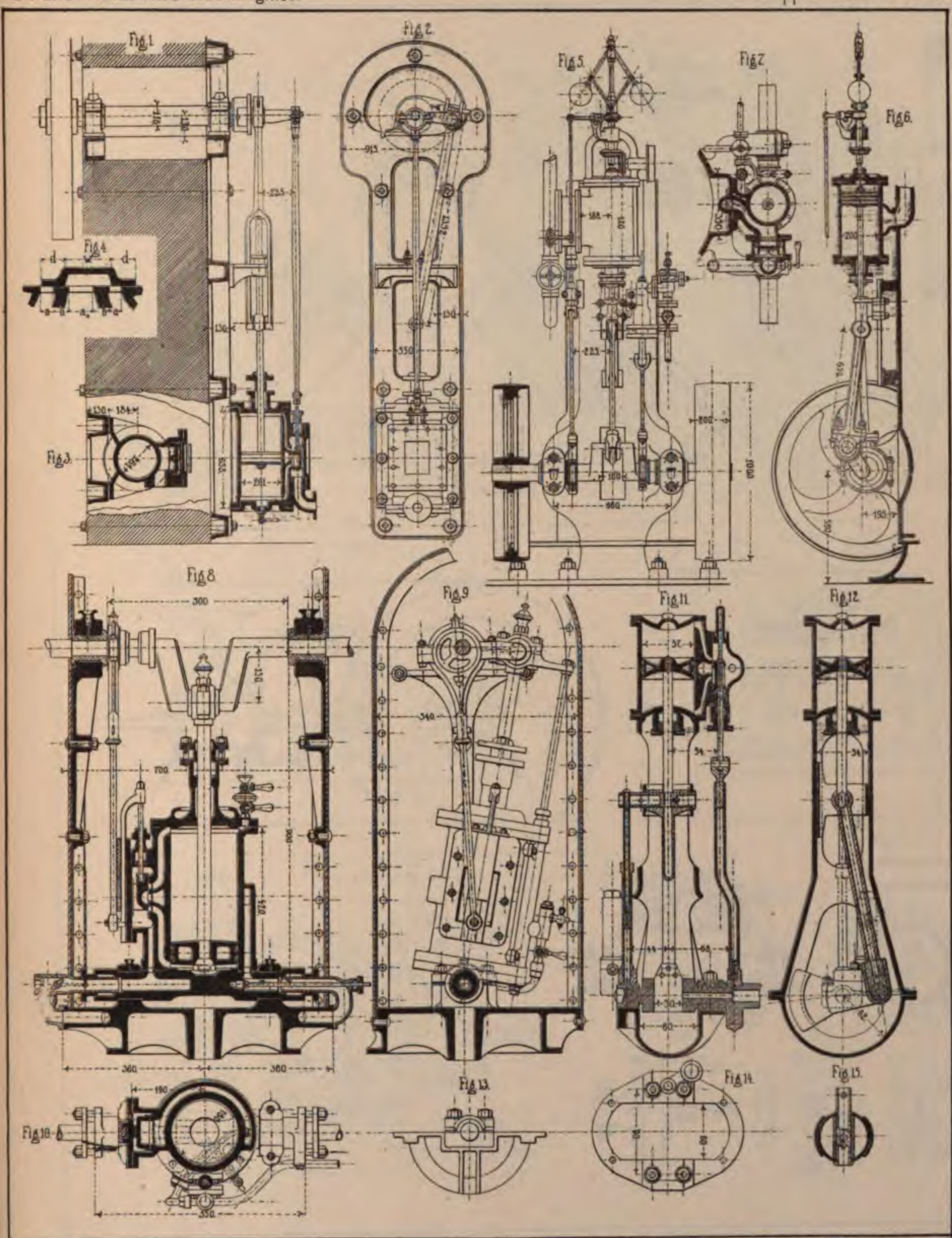
J. Körösi of Andritz near Gratz (Figs. 8-9).

The Humboldt Machine-works, of Kalk, near Cologne (Figs. 1-4), G. Pétau of Paris. (Figs. 5-7).



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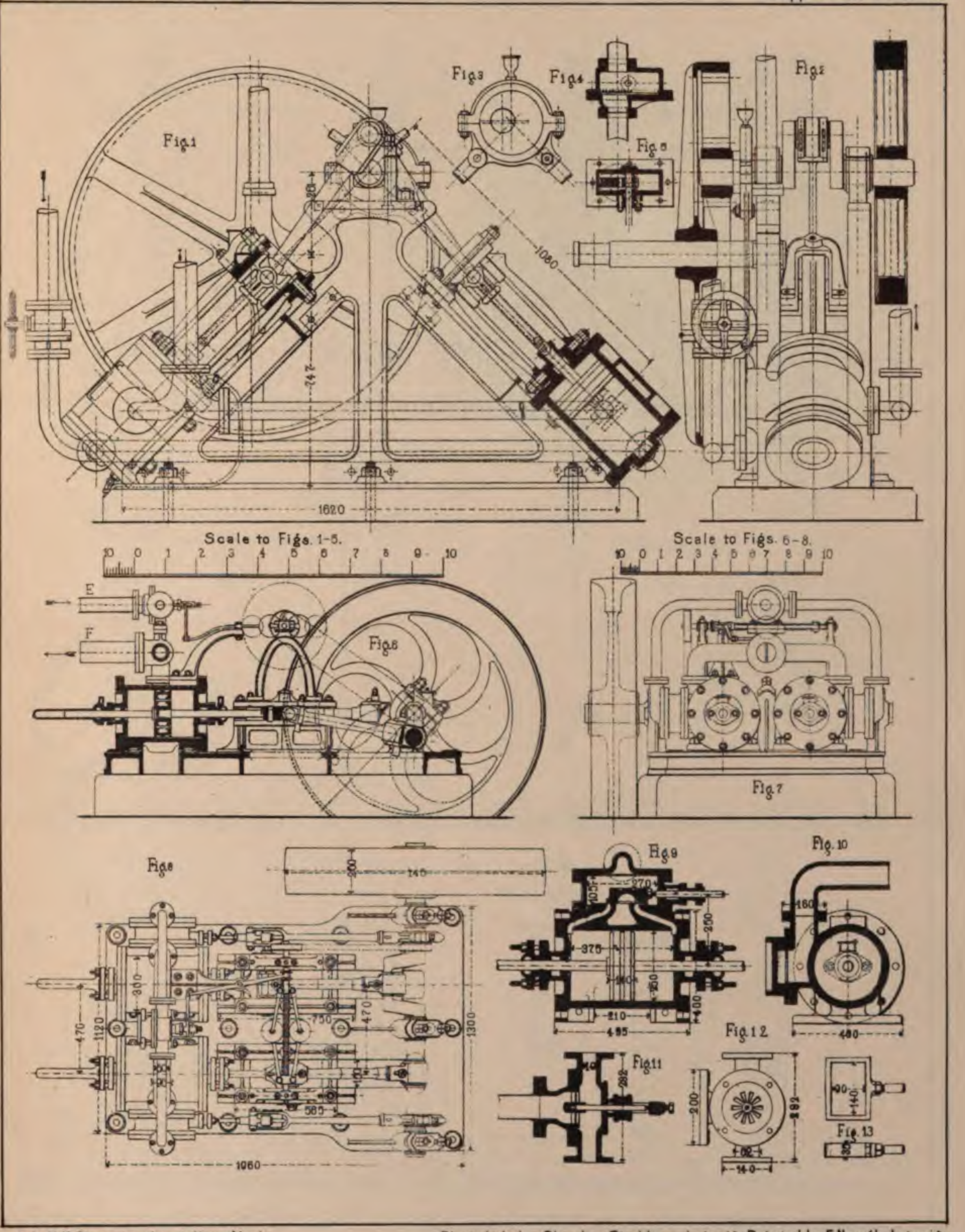
E. Bréval of Paris (Figs. 8-10), B. Herreshoff of London (Figs. 11-15).

The Fuerstliche Fürstenberg Machine-works of Immendingen. (Figs. 1-5).



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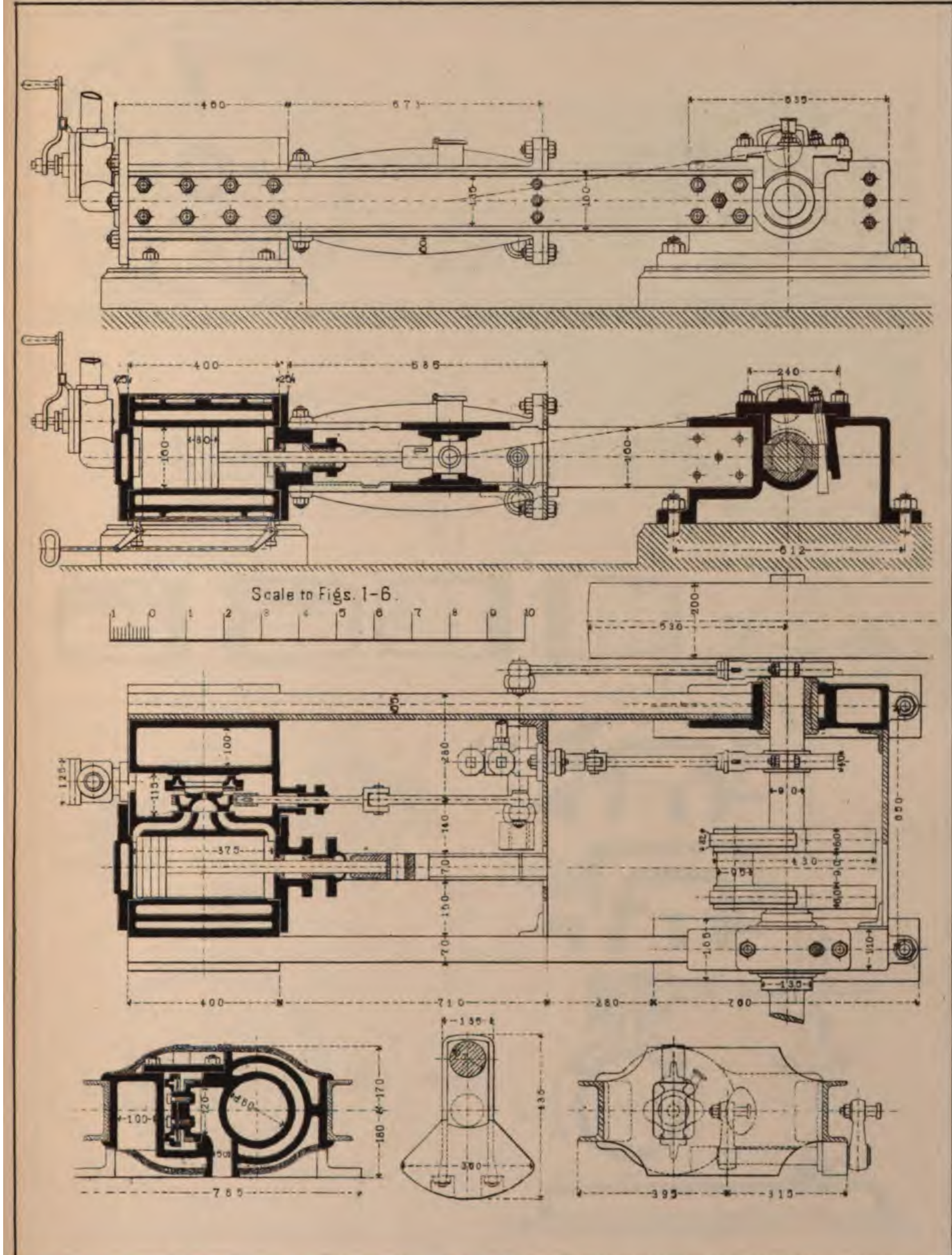
H. Flaud, Engineer of Paris. (Figs. 6-13).

E. R. & F. Turner, Jpswich.



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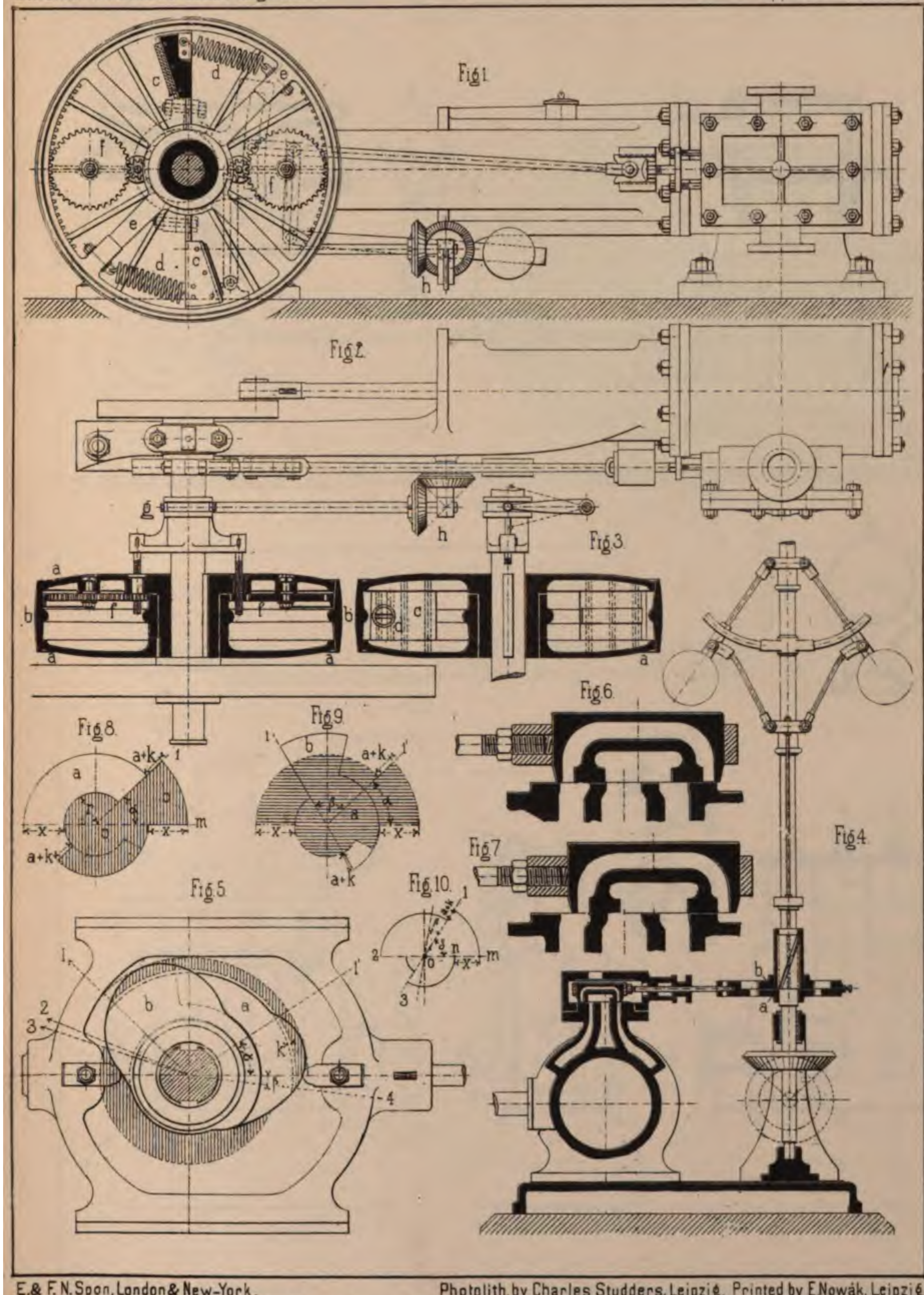

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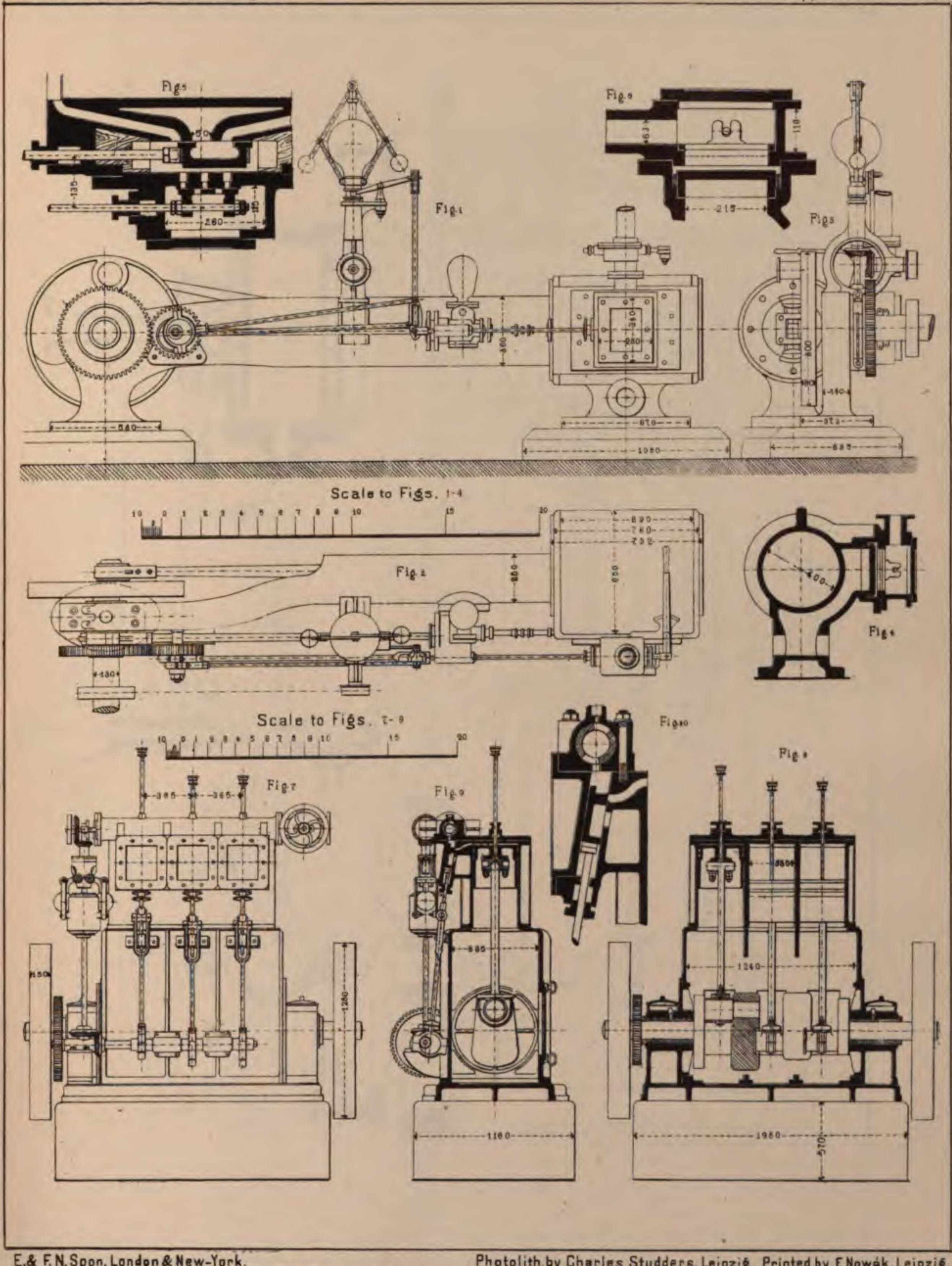
E. Earnshaw & Co. of Nürnberg. (Figs. 4-10).

Davey Paxman & C° of Colchester. (Figs.1-6).



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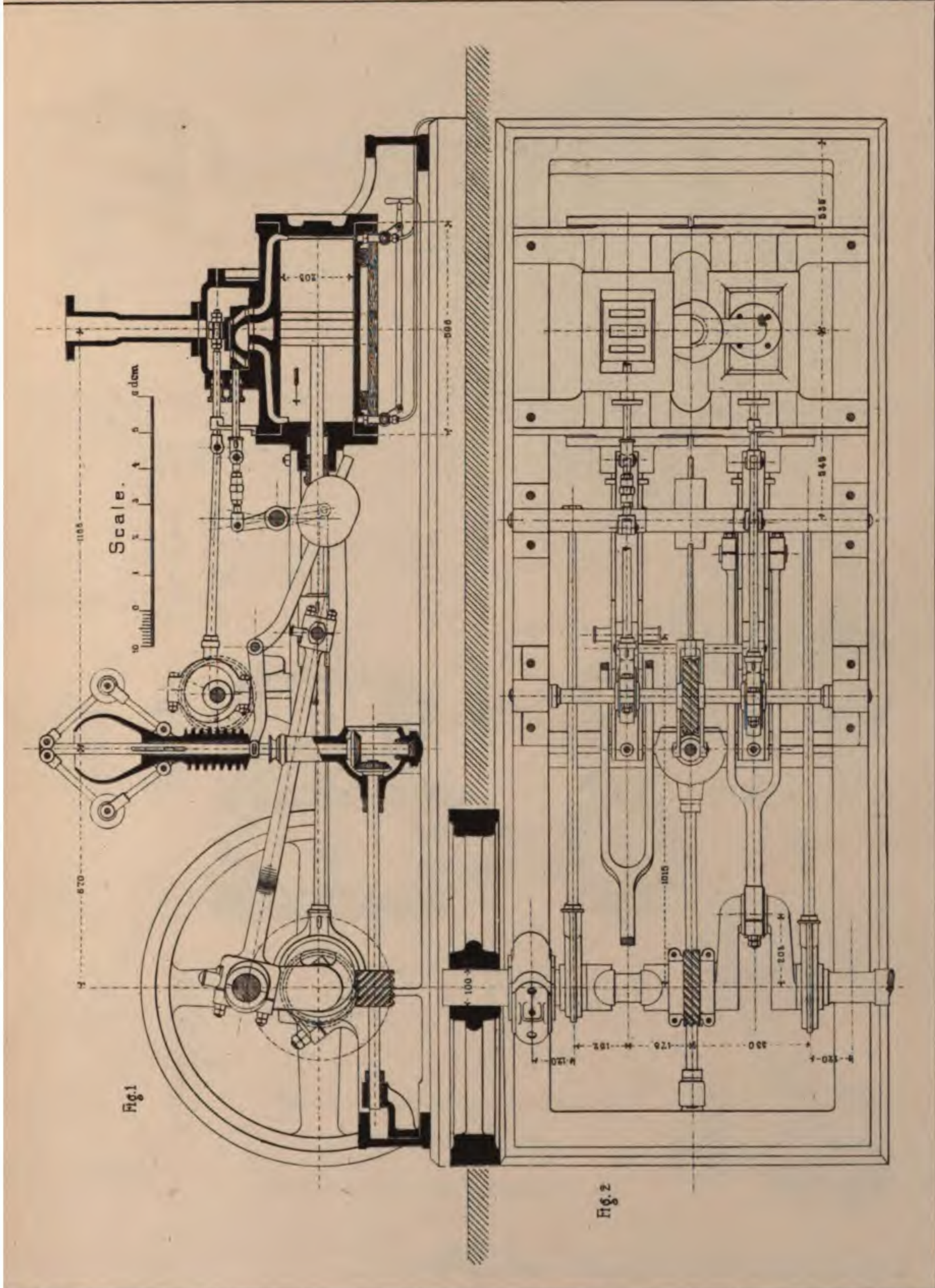
Ch. Beer, of Jemeppe, (Belgium).(Figs.7-10).



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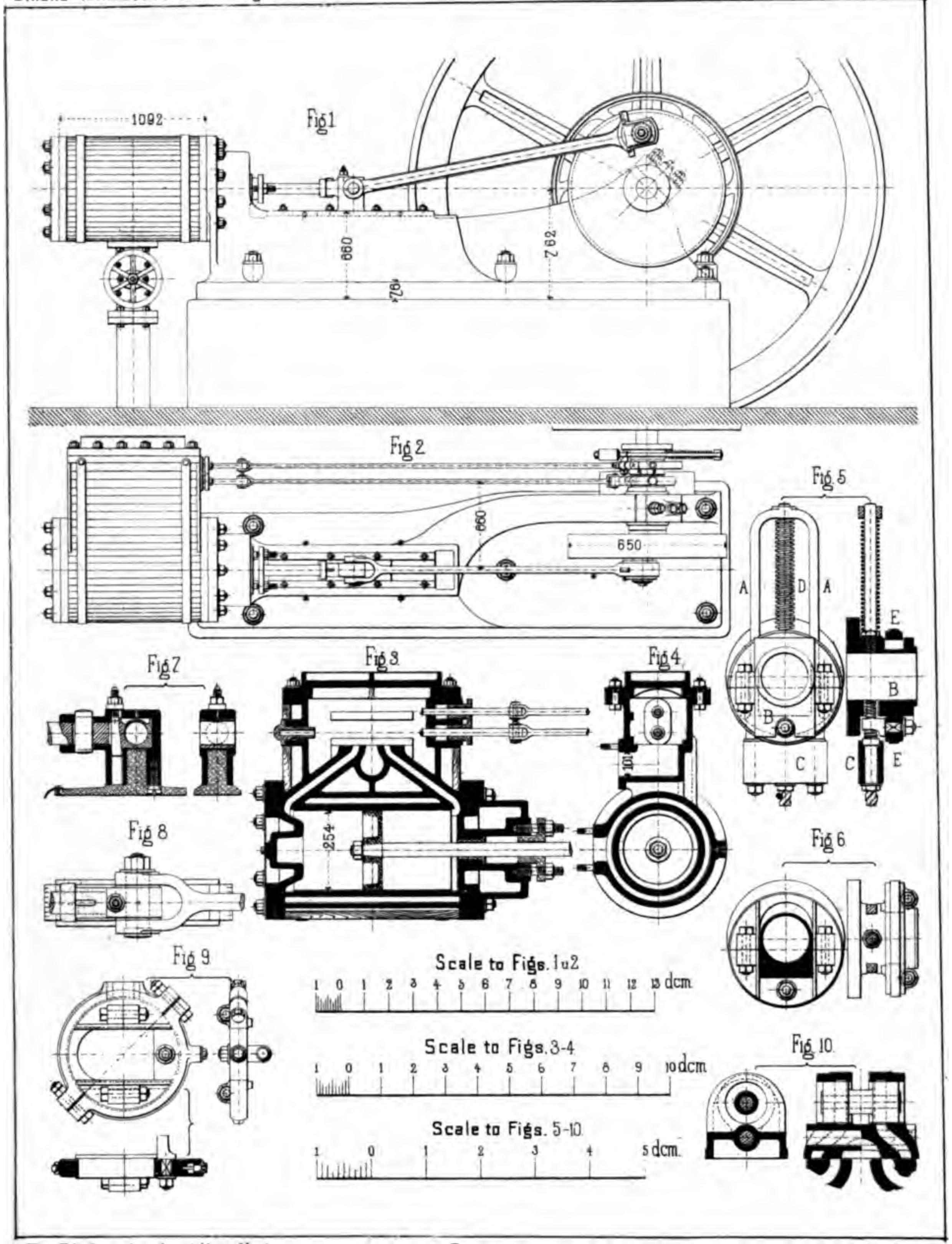

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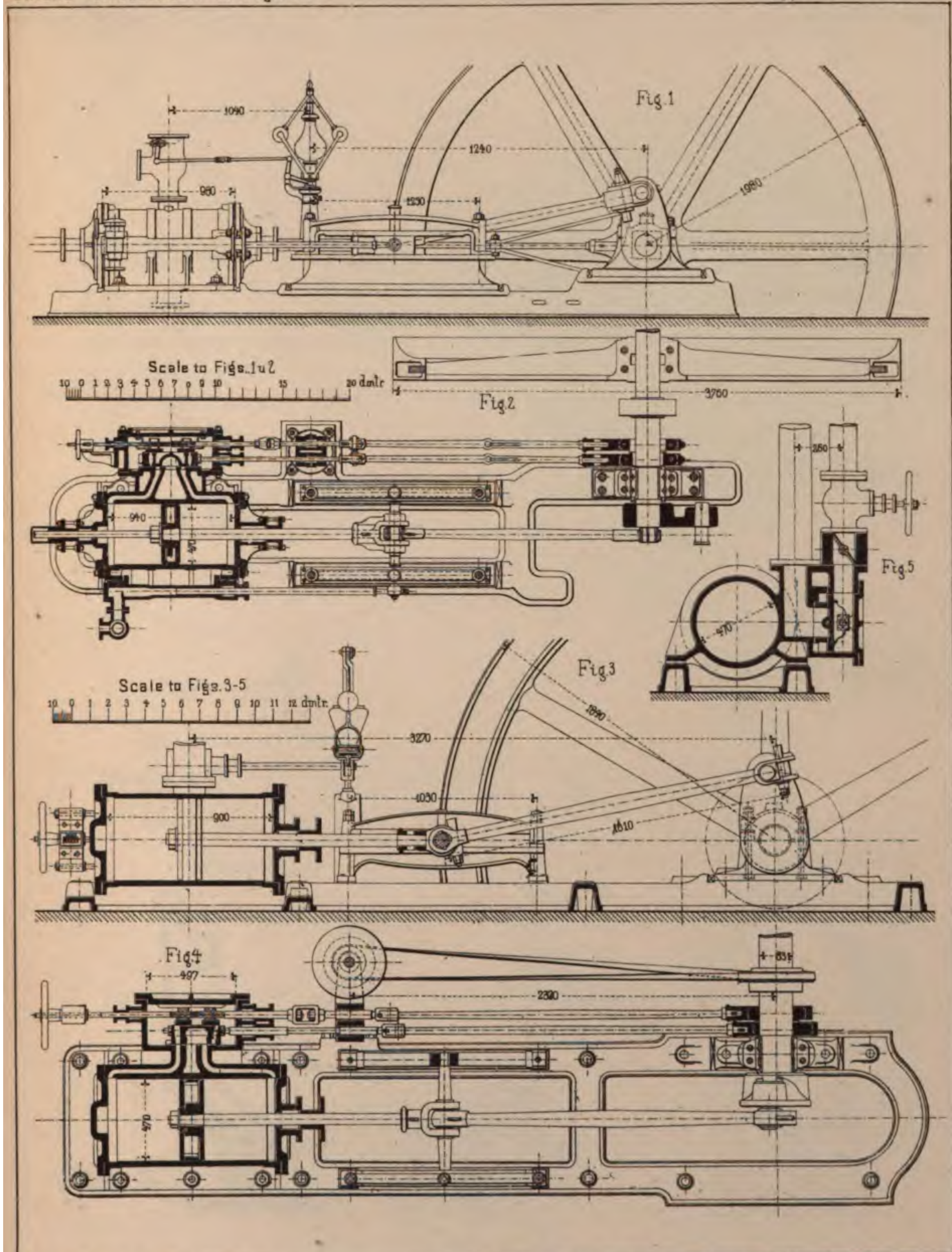
The „Kölnische Maschinenbau-Actiengesellschaft" of Cologne. (Figs. 1-2).



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The „Maschinenbau-Actiengesellschaft Humboldt" of Kalk, near Cologne. (Figs. 3-5).

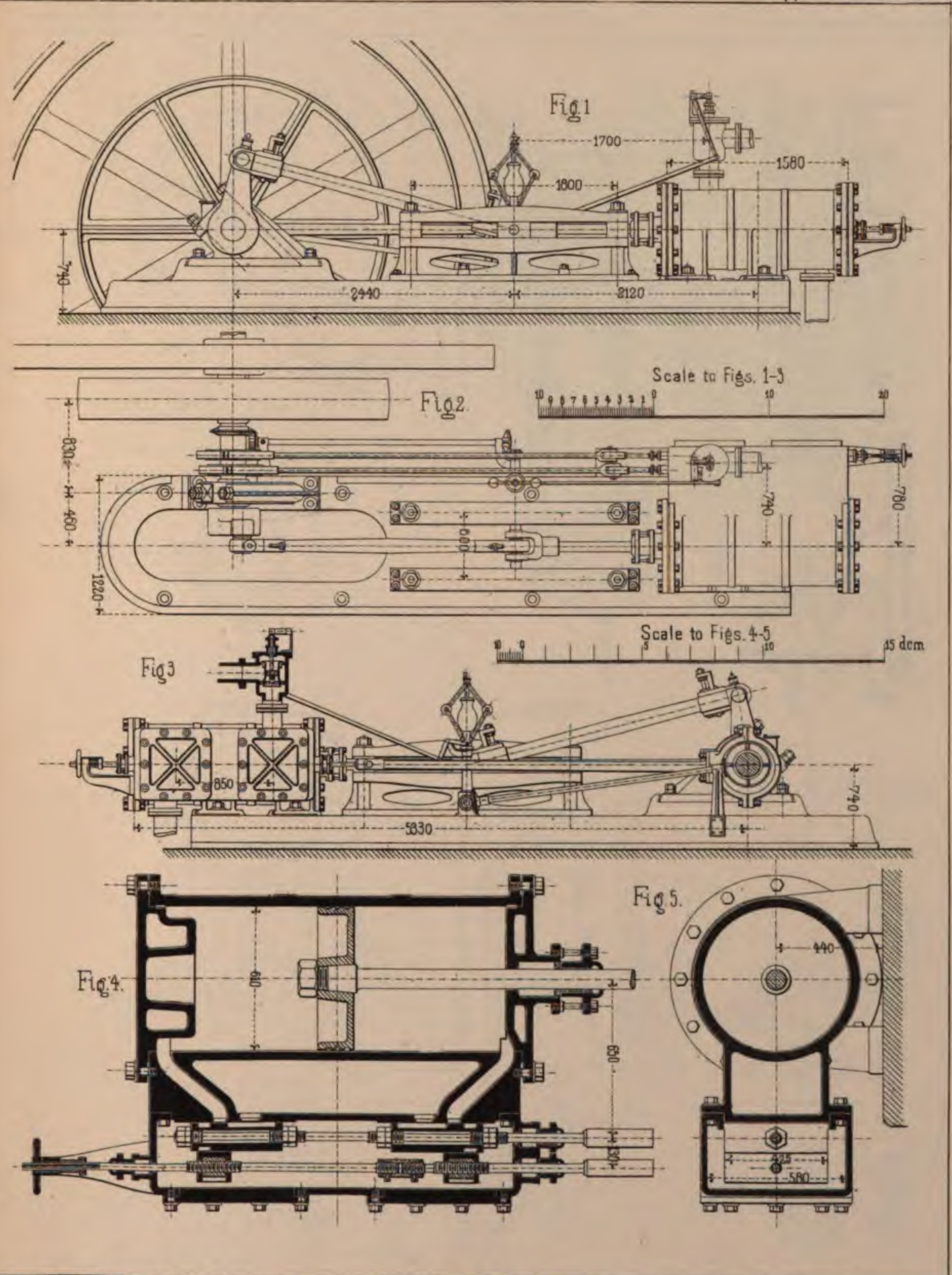
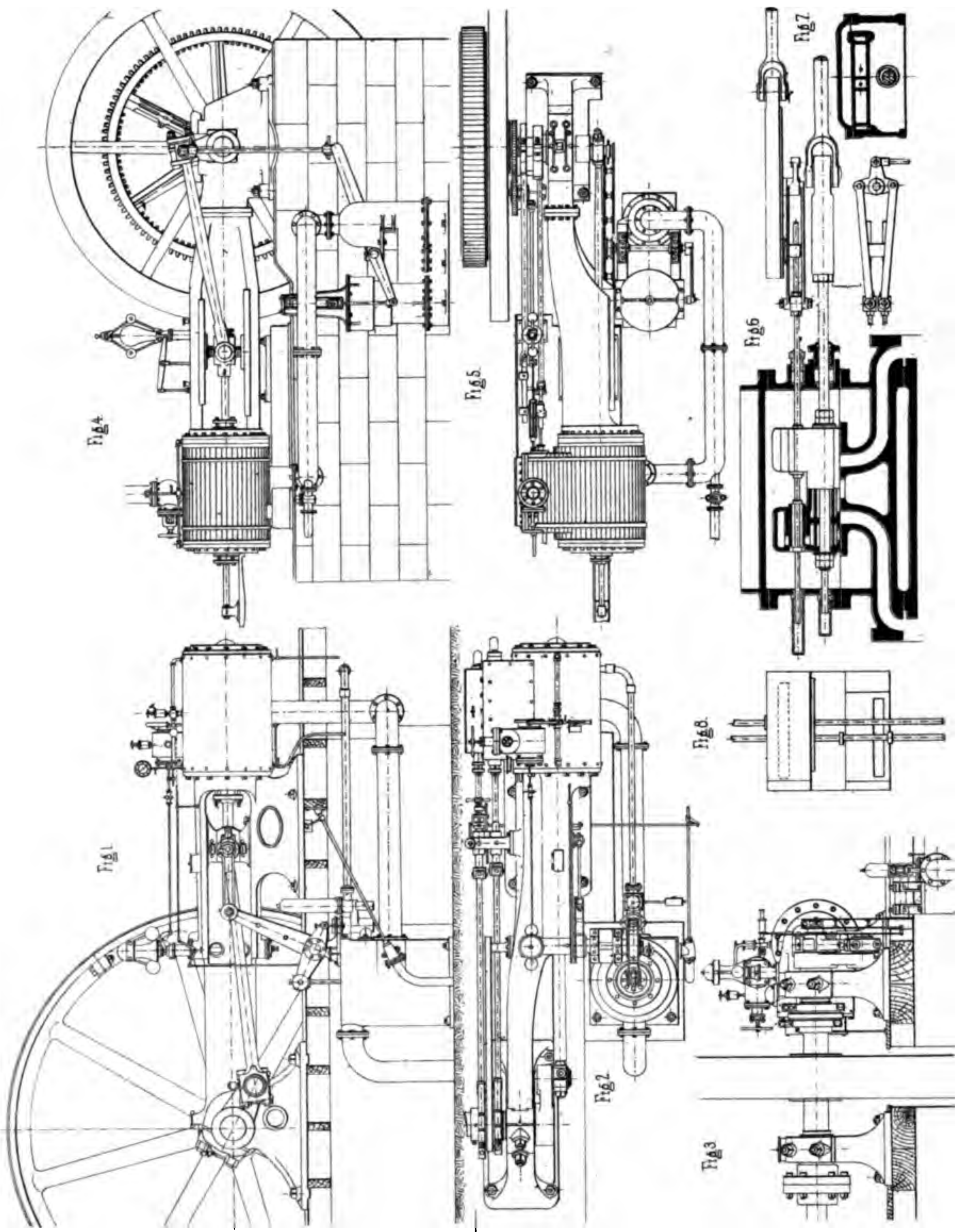
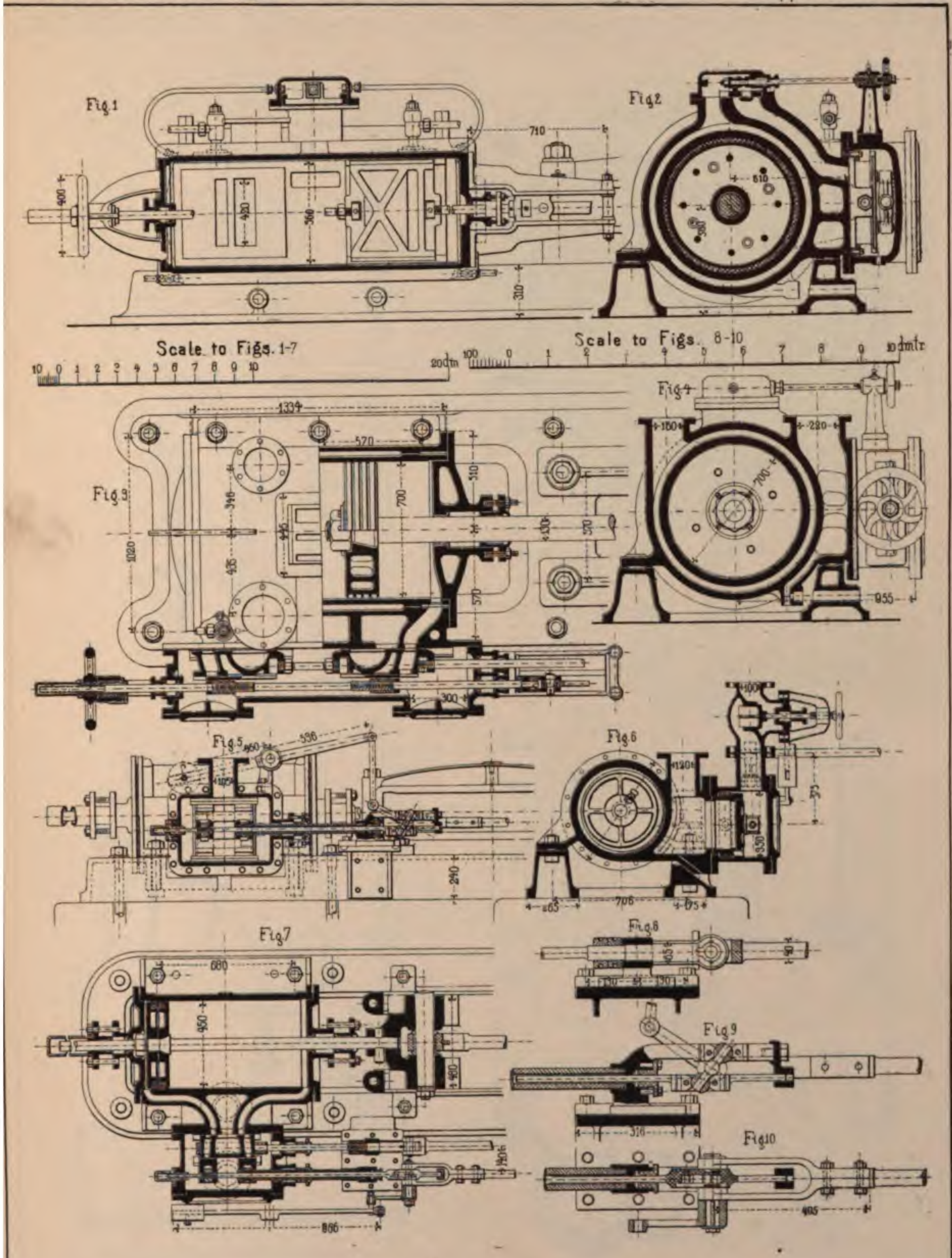


Fig. 1
1700
1800
1580
740
2440
2120
Fig. 2
Scale to Figs. 1-3
830
460
1220
740
780
Scale to Figs. 4-5
15 dcm
Fig. 3
850
5830
740
Fig. 4
680
130
Fig. 5
440
580

Dick & Stevenson, Engineers of Airdrie. (N.B.) Figs. 1-3. Bertram, Engineer of Edinburgh. Figs. 4-8.



Neut & Dumont of Paris. (Fig.1-4).



Louis Soest of Düsseldorf. (Fig.5-10).

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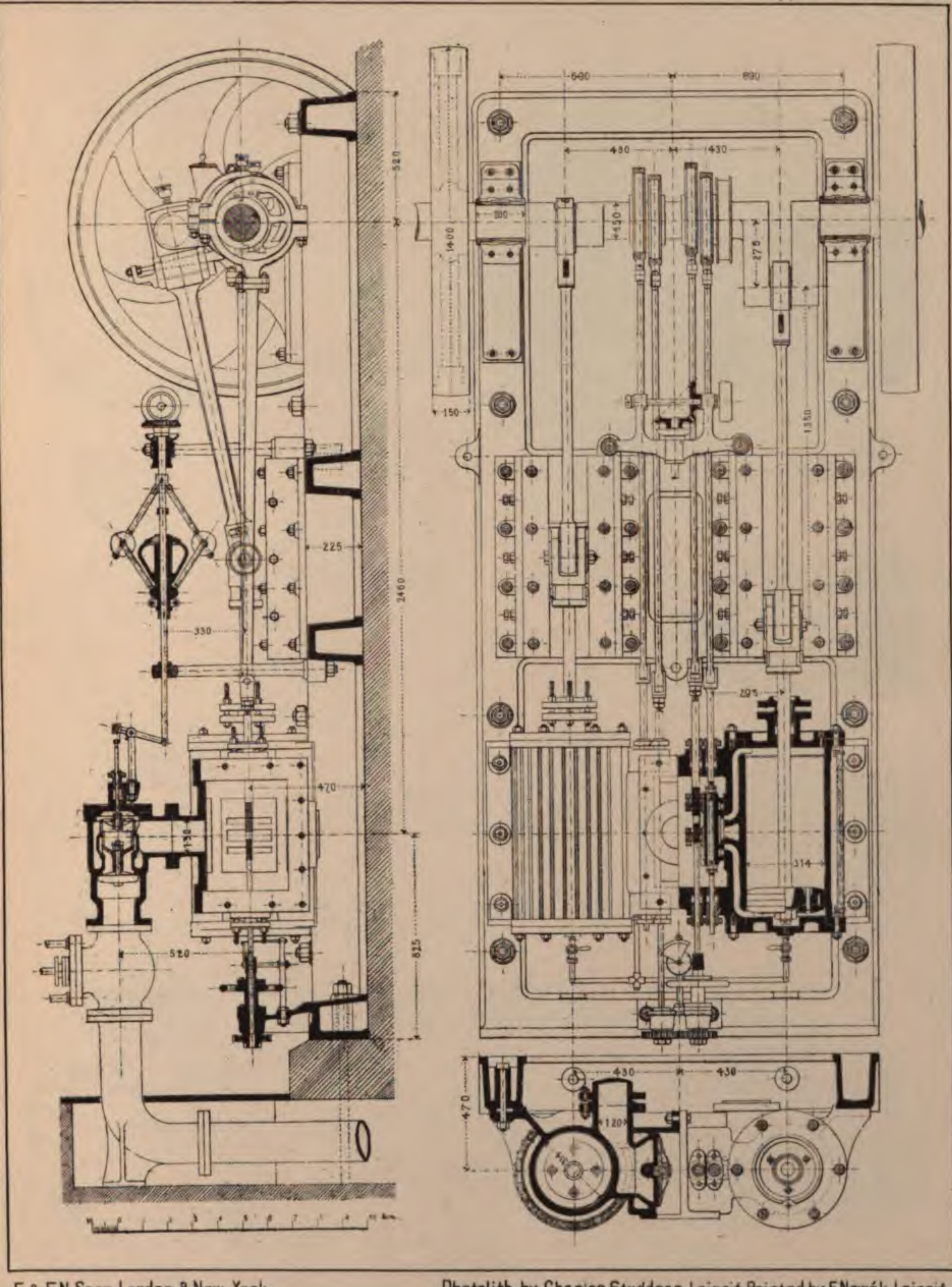
Coupled Wall-engines.



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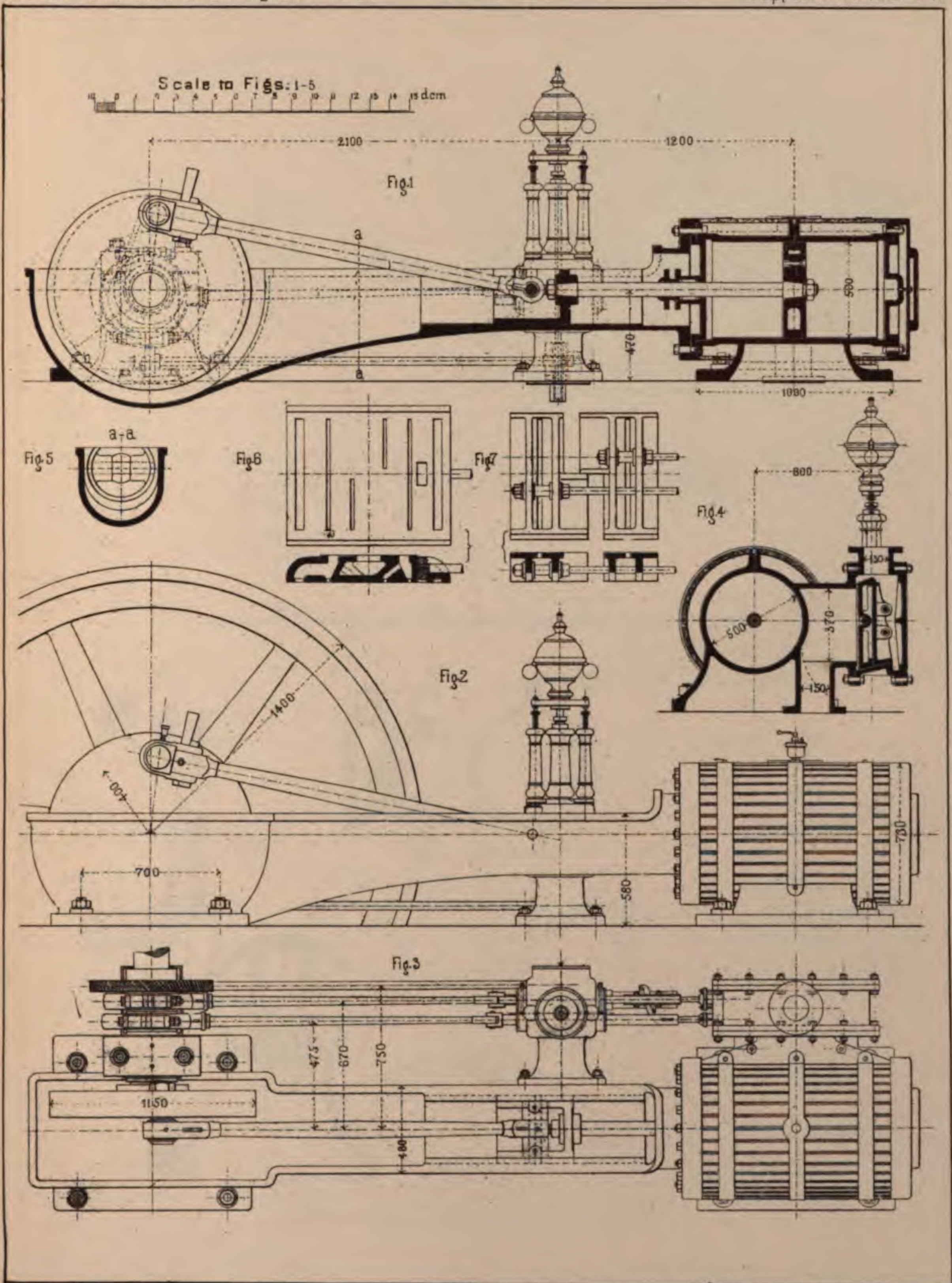
The Nienburg, Machine-works, of Nienburg.



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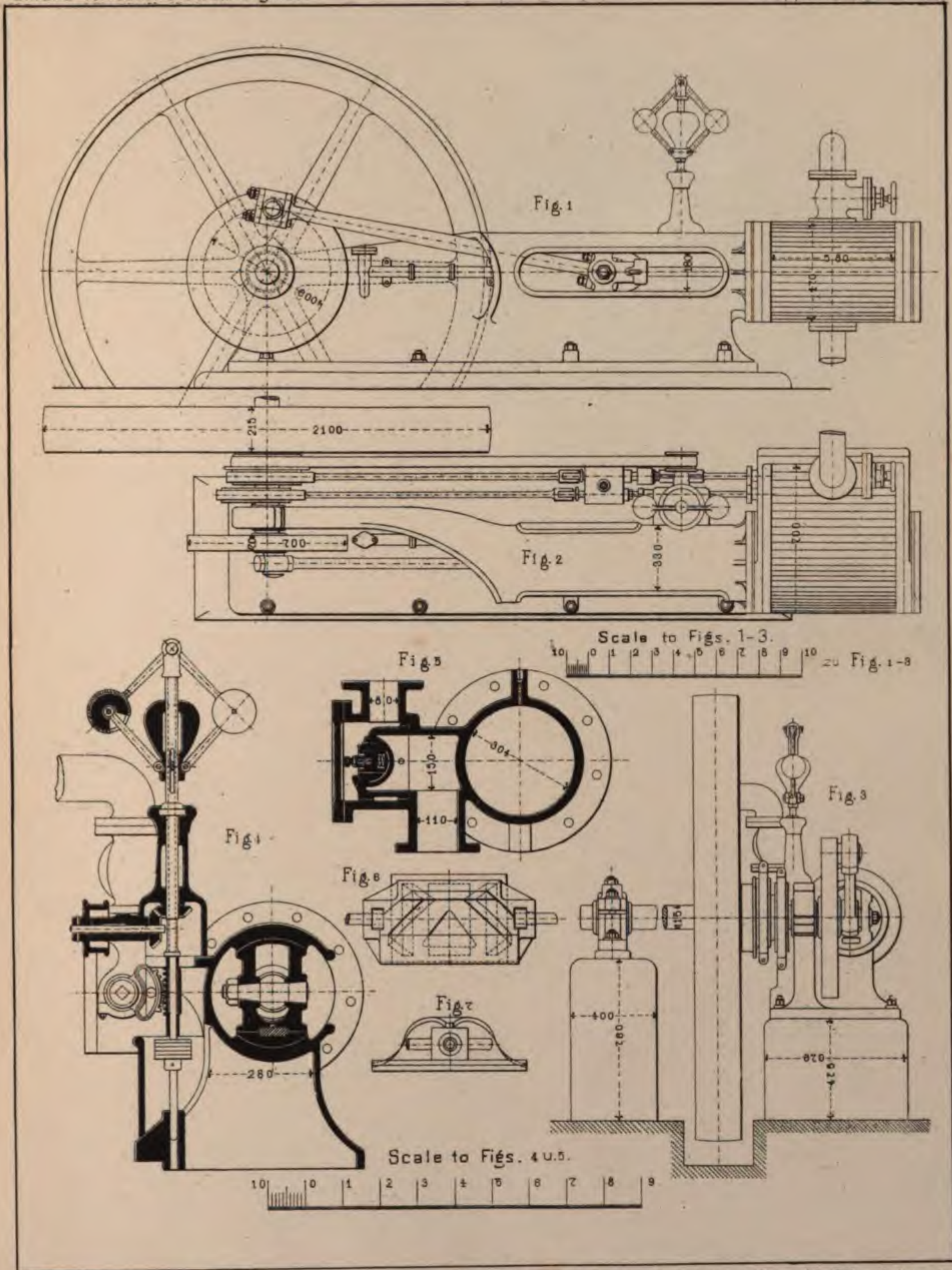

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