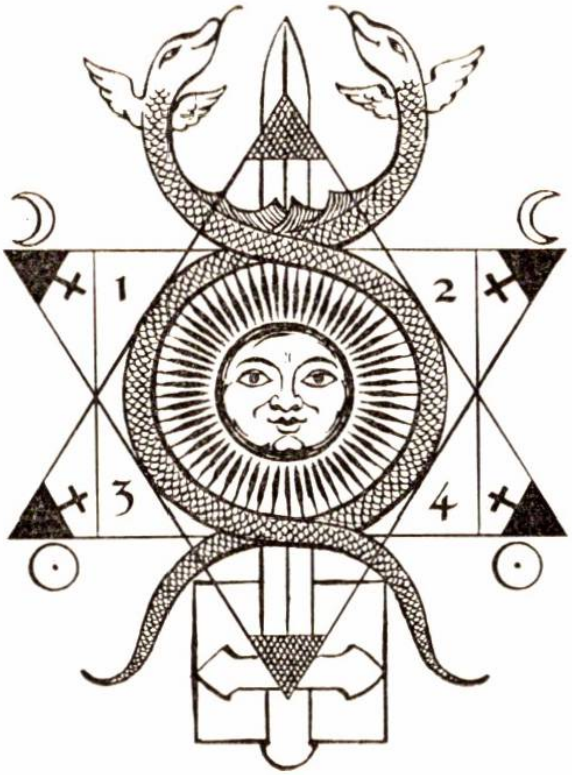
LIBELLUS DE ALCHIMIA

ASCRIBED TO ALBERTUS MAGNUS



TRANSLATED FROM THE BORGNET LATIN EDITION, INTRODUCTION AND NOTES BY

SISTER VIRGINIA HEINES, S.C.N.

WITH A FOREWORD BY PEARL KIBRE

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IN LOVING MEMORY OF

MY MOTHER

FOREWORD

The difficulties of translating a mediaeval scientific treatise into the modern English idiom are well illustrated by the present text. Not only are there the basic difficulties in such a work of choosing the correct words to convey the author's intended meaning, but also there is the added dilemma of how to express, in the exactness of modern scientific terminology, mediaeval terms which to us appear vague and general in character. It is therefore a happy circumstance that has led Sister Virginia Heines, a trained chemist, with a sympathetic interest in mediaeval science, to turn her attention to the translation of the *"Semita recta" or Libellus de Alchimia,* so consistently attributed to Albertus Magnus.

This treatise, to a considerable extent, bears signs of Albert's peculiarly didactic style, and provides an excellent introduction to the alchemical art of the late thirteenth and fourteenth centuries. The author, whether Albert, or one of his admirers, is vitally concerned with making known to his confrere or confreres, the aims, accoutrements, and processes of alchemists and the alchemical art. The detailed and even repetitious character of his instructions, together with the frequent cautions and admonitions, are largely practical in nature. Yet true to the professed author's ecclesiastical calling, the work opens with the Biblical phrase: "All wisdom is from the Lord God."

In translating this treatise, Sister Virginia Heines may be credited with fulfilling in the twentieth century the intention of the mediaeval author for his time. For she has, like him, opened to a wider audience, in this case to those not

versed in Latin, yet interested, as was that earlier public, in alchemy, a mediaeval text that served the author's contemporaries and those who followed him as a manual on the subject, and that may well serve this purpose today.

Hunter College of the
City of New York

PEARL KIBRE

preface

While browsing in the vast storehouse of scientific literature available today in our great libraries, I came upon the *Libellus de Alchimia,* one of several writings attributed to the great Dominican scholar, Albertus Magnus, Bishop of Ratisbon in the thirteenth century. Many of Albert's authentic writings contain information on the transmutation of metals, a subject in which he was apparently deeply interested and practically acquainted with. This little treatise on the art seemed to me to be of sufficient interest to present to the English reader. Such a task necessitated that my free time be given to translating, to searching through rare book rooms in various libraries, and to reading a variety of incunabula, microfilms, and photostatic materials from European libraries.

It is difficult to thank adequately the many persons who have encouraged and helped toward the completion of this little book. My grateful acknowledgments are due Professor Pearl Kibre, Hunter College of the City of New York; the Rev. Albert Moraczewski, O.P., and Brother Celestine Walsh, O.P., Saint Rose Priory, Dubuque, Iowa, for their critical reading of the manuscript, as well as for their invaluable suggestions on the translation and footnotes. A special indebtedness is also due Professor Kibre for the Foreword.

The Rev. C. R. Auth, O.P., and the Rev. Ignatius Smith, O.P., of the Dominican House of Studies, Washington, D.C., kindly placed at my disposal the *Opera Omnia* of Albertus Magnus, as well as other books of reference.

I am grateful for the assistance and interest of the Rev. William Mahoney, O.P., Dominican House of Studies, River Forest, Illinois, and the Rev. H. Ostlender of the Albertus Magnus Institute, Cologne, Germany.

Professor Norris W. Rakestraw, Scripps Institution of the University of California, La Jolla, interested the University of California Press in the publication of this translation.

My deep gratitude is offered here to Mother Bertrand Crimmins, Mother General of the Sisters of Charity of Nazareth, Kentucky, for the time allowed me to complete the translation. To Sister Margaret Gertrude Murphy, President of Nazareth College, and to other members of my Order my thanks for their generous encouragement of the work.

Thanks are also due the Vatican City Library, the University of Bologna Library, and the British Museum, London, for information and photostats of early alchemical manuscripts in their collections. The Istituto Nazionale Medico Farmacologico, Rome, has kindly permitted the reproduction of several illustrations from Giovanni Carbonelli's *Sulli Fonti Storiche della Chimica e dell'Alchimia in Italia.* The Bruce Publishing Company, Milwaukee, has permitted me to use a quotation from its publication *Saint Albert the Great,* by T. M. Schwertner, O.P. Appleton-Century-Crofts, Inc. has permitted the use of several quotations from J. M. Stillman's *Story of Early Chemistry.* Permission has also been given to reproduce a diagram from J. R. Partington's *Textbook of Inorganic Chemistry,* published by Macmillan & Company, Ltd., London, and by St. Martin's Press, Inc., New York.

THE TRANSLATOR

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Introduction

The thirteenth century has often been called the greatest of centuries and in that century lived and worked one man whose eminence was so lofty, whose influence so enduring that he alone of the century's scholars was surnamed "the Great." This man, the "dominant figure in Latin learning and natural science" [1] in his own time is also the only saint who, with all regard for twentieth-century notions, can justly be termed a scientist.

The writings of Albertus Magnus in the natural sciences cover a wide field; indeed his works comprise a compendium of the knowledge of his day. It has been said that Albert's works "follow the plan of the natural philosophy of Aristotle and parallel the titles of the works." [2] Albert wrote on cosmology, astronomy, physics, mineralogy, meteorology, botany, zoölogy, psychology, alchemy, and perhaps several tracts bordering on the occult sciences; in addition, numerous theological treatises. Scholars have discerned a gradual progression in his intellectual development and have found this most apparent in his many writings on natural science. In these he "does not merely repeat past ideas whether of Aristotle or others, but adds chapters of his own drawn in large measure from his own observations, experiences, and classification. It is in his scientific works that he is as superior to Aquinas as the latter is generally considered

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[1] Lynn Thorndike, *History of Magic and Experimental Science during the First Thirteen Centuries of Our Era,* II, 521.

[2] *Ibid.,* p. 528.

to surpass him in the purely metaphysical and theological field." [3]

It is precisely Albert's attitude toward the natural sciences that distinguishes him from his contemporaries and gives him a place as a precursor of the modern scientific approach to natural phenomena. In his *Liber de mineralibus* (II, ii, 1) he says: "The aim of natural science is not merely to accept the statements of others, but to investigate the causes at work in nature." [4]

According to tradition, Albert, the oldest son of the count of Bollstädt, was born at Lauingen in Swabia in 1193. This traditional birthdate has been questioned by various historians, and other years have been suggested: 1205 or 1206. Little is known of Albert's youth and early schooling. One chronicler states that Albert was only sixteen when he entered the Order of Friars Preachers in 1223. He studied as a young man at Padua and a few years later became a lecturer to the Dominicans at Cologne and taught successively at Hildesheim, Freiburg, Ratisbon, and Strassburg in the schools of his Order. In 1245 or thereabouts Albert was studying and teaching in Paris. His fame as a teacher had spread beyond the Alps, for the young Thomas Aquinas came to Paris to study with him and followed him to Cologne in 1248. In that year Albert was recalled from Paris to teach at the *studium generale* established by the Dominicans at Cologne. Several years later, in 1257, he was made Provincial of his Order in Germany and in 1260 became Bishop of Ratisbon. After holding both these high offices for about two years, Albert relinquished them to return to teaching at Cologne.

Albertus Magnus was widely traveled. In 1256 he was in Rome and other cities of Italy, for in one of his books he speaks of his attendance at the papal curia and of collecting

[3] *Ibid.*, p. 532

[4] Borgnet ed., Vol. V, 59.

books in Italy. Three years after this Italian journey he was in France attending the general chapter of the Order at Valenciennes. In 1263 he preached the crusade in Germany and was for a time a papal nuncio traveling in Germany and Poland. He was perhaps in France again in 1274 attending the Council of Lyons, possibly visiting Paris in 1277. During all these years of teaching, traveling, and studying, numerous writings came from his pen. It is generally thought that his works began to circulate about 1245 and were perhaps mostly written by 1256.

After a very long and active life Albert died at Cologne on November 15, 1280, having outlived his pupil Thomas Aquinas and many of his contemporaries, his fellow Dominican Vincent of Beauvais, Petrus Hispanus, and others. His life was first written by Petrus de Prussia in the late fifteenth century. In 1931 Pope Pius XI in his decretal *In Thesauris Sapientiae* elevated Albertus Magnus to the Altar of the Church and ten years later Pope Pius XII proclaimed him the Patron of the Natural Sciences.

Not all Albert's writings have come down to us, but an indication of the quantity is apparent from the two older editions of his collected works: one is in twenty-one folio volumes, the other in thirty-eight volumes. He was the most prolific writer of his times. A twentieth-century biographer has stated that the early lists of Albert's writings yield one hundred and thirty-eight separate works of varying sizes: sixty-five treatises have been printed in the *opera omnia,* five have been separately published, or seventy in all. "Of the remaining sixty-eight some were certainly wrongly ascribed to the Saint, others possibly; but many authentic works, for instance, the several mathematical treatises to which he himself refers, are still missing." [5] Among the numerous works are twenty-six books on animals, seven on

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[5] H. Wilms, O. P., *Albert der Grosse* [English trans.] p. 215.

vegetables and plants, five on minerals, eight on physics. It will suffice here to mention a few of his major works: *Summa theologiae,* Commentary on the *Sententiae* of Peter Lombard, *Liber de principiis motus processivi, De anima, De somno et vigilia, De meteoris, De natura locorum, De causis et procreatione universi, De mineralibus, De animalibus, De sensu et sensato.*

LIBELLUS DE ALCHIMIA

Among numerous alchemical works ascribed to Albertus Magnus is the *Libellus de Alchimia* or Little Book of Alchemy. There are about thirty-five manuscripts of various versions of the text extant in European and British libraries today.[6] The principal manuscripts are known as the "Semita recta" group. (*Semita recta de Alchimia,* The Right Path of Alchemy.) Three of these are in the Vatican Library collections, two in the library of the University of Bologna, and one in the British Museum. These manuscripts date from the fourteenth to the sixteenth century. The thirty-five so far identified or known are dispersed as follows: one in Copenhagen, two in Bologna, thirteen in Florence, one in Munich, two in Palermo, one in Paris, one in Prague, three in the Vatican Library, one in Vienna, two at Wolfenbüttel, one in the British Museum, two at Cambridge, one at Glasgow, and four at Oxford; in addition there are seven excerpts in various collections.

The "Semita recta" manuscripts vary greatly; some of the texts are actually abridgments, several show additions, others have interpolations of an obviously later date than the original matter, and others seem to be composites. The more

[6] Pearl Kibre, "Alchemical Writings Ascribed to Albertus Magnus," *Speculum,* XVII (Oct., 1942), 511–515. The following discussion of the manuscripts of the "Semita recta" group is based on Professor Kibre's article. The present translator has examined in mcirofilm six MSS of this group (see the Bibliography, below).

complete "Semita recta" manuscripts are arranged in unnumbered sections or chapters. In the Jammy and Borgnet editions the text has been arranged in sections with headings for each; in the Borgnet edition each section is numbered through the fifty-seven that make up the book. In three of the "Semita recta" manuscripts (Brit. Mus. Sloane MS 323, fols. 58, 68^{r}, 69, 72^{v}, 74–78, Florence, Biblioteca Riccardiana, MS 390, fol. 85^{r-v}, and Bologna, Bibl. Univ., MS 104, fol. 174^{v}) there are drawings in a contemporary hand of types of furnaces used in the alchemist's laboratory.

A number of early translations of the text of the "Semita recta" exist in different libraries. There are eight English translations all together; four among the Sloane MSS in the British Museum dating from the fifteenth to the seventeenth century; two at Cambridge, both fifteenth-century manuscripts; and two at Oxford, one of the fifteenth and the other probably of the sixteenth century. Of other language translations there is a sixteenth-century German one among the British Museum Sloane MSS; a Greek translation transcribed in the fifteenth century in the Bibliotheque Nationale, and two Italian versions: one from the fourteenth century in the Bibliotheca Marciana in Venice, the other from the fifteenth century in the Biblioteca Nazionale, Florence.

The Latin text of the *Libellus de Alchimia* was first printed in a collection of alchemical treatises in Basle in 1561 and again at Urcelli, probably Ober Ursel in Hesse-Nassau, near Frankfort, in 1602 and a third time at Strassburg in the years 1659–1661, although this last was an incomplete version of a "Semita recta" text. The collected writings of Albertus Magnus were first published at Lyons in 1651 by the Dominican Petrus Jammy. A corrected Latin text was edited by the Abbés Auguste and Aemile Borgnet and published in Paris between 1890 and 1899. The present English translation is that of the Borgnet text, the *Libellus de Alchimia* being part of volume 37 of the Borgnet edition

of Albertus Magnus' *Opera Omnia.* Both the Jammy and Borgnet editions present the text of the "Semita recta" manuscripts.

A new and critical edition of the *Opera Omnia, Alberti Magni* is now being published by the Albertus Magnus Institute at Cologne under the direction of Dr. Bernhard Geyer. To date the third volume has appeared, the twelfth in the numerical order of the *opera omnia.* The complete edition will comprise forty volumes and will include several treatises hitherto unpublished. This new edition of Albert's writings is a model of scholarly editing and will, of course, supersede the Jammy and Borgnet editions which lack the scholarly apparatus essential to a modern critical edition. The final volume will include the *Libellus de Alchimia* and other works labeled *Opera dubia et spuria.* The new edition of the Latin text of the *Libellus* will be prepared by Professor Pearl Kibre who has studied intensively both the "Semita recta" manuscripts and other alchemical manuscript materials attributed to Albertus Magnus.

The *Libellus de Alchimia* may be called a pocket edition of alchemy. It follows to a surprising extent the plan of a twentieth-century general chemistry text, highlighting the occurrence, preparation, and properties of the then known substances. In this little tract Albert endeavors to draw attention away from the magic of gold making toward the importance of experimentation. He looks backward and forward: backward to the Aristotelian theory of hotness, coldness, moistness, and dryness; and forward toward a trend to experimentation; that is, toward acquiring more accurate descriptions of the different kinds of matter.

Aside from its value in the history of scientific inquiry, the book has a kind of intrinsic charm for the modern technologist. There is no trace of magic or incantation in the work, and the recipes are given with clearness and conciseness. It is a cross section of the status of alchemy nearly

seven hundred years ago, reflecting the earnestness and perseverance of workers who had little equipment and few sources of information. Although most of the conclusions and observations are wrong in the light of our present-day knowledge, many foreshadowings of the great discoveries of later centuries are apparent.

This little treatise is divided into fifty-seven brief chapters. In the first chapter Albert tells his readers that he will write of nothing but what he has seen with his own eyes: "nihil aliud scribam nisi quod oculis meis vidi." He offers a derivation for the word "alchemy," a theory of the origins of metals; this is followed by eight precepts for the practitioner of the art to follow. He discusses the location of the laboratory, remarks on the best time of year to engage in certain experiments, discusses the mental attributes that are essential for the worker to possess, describes the order of his operation—the processes of sublimation, calcination, and the like; then in several chapters he takes up the equipment in the laboratory: tools, vessels, utensils, furnaces. This discussion is followed by an account of the "spirits" of metal, the elixir or philosophers' stone, descriptions of various minerals, chemicals, and dyes. Succeeding chapters give instructions for the making of powders, solutions, and other processes necessary to the art. The concluding chapters give short recipes for the making of precious metals.

Most of the chapters have one or more paragraphs of additional discussion. These, clearly, have been added to the original text at a date much later than the first recension of the text. In these "additions" titles of books written after Albert's time are cited, and reference is made to persons who lived long after the date of Albert's death.

A great number of alchemical tracts circulated under Albert's name in the fourteenth and fifteenth centuries, as Professor Kibre has pointed out. In mediaeval times it was a common practice, in order to assure the widespread circu-

lation of a treatise, to attribute the authorship to prominent ecclesiastics for the greater authority a well-known name might give to the *matière*. This practice seems to have been particularly common among writers on alchemical subjects.

The catalogue of the Cistercian monastery of Stams in the Austrian Tyrol, compiled about 1310, gives as item 18 in a listing of Albert's works, a treatise designated *De Alchimia*. It is not known whether this is the same as the "Semita recta de Alchimia."[7] However, this much is certain: by the fourteenth century the "Semita recta" was generally ascribed to Albert, for it is so listed in the early catalogues of Henry of Hereford and James of Soest;[8] it is also ascribed to Albert in a manuscript list of the writings of the Dominicans drawn up before 1350.[9]

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[7] P. G. M. Meersseman, O.P., *Introductio ad Opera Omnia B. Alberti Magni, O.P.,* p .147.

[8] Meersseman, *ibid.;* see also C. H. Scheeben, "Les Ecrits d'Albert le Grand d'après les catalogues," *Revue Thomiste,* n.s. XIV, No. 65 (March-April, 1931), 274–275, and table, p. 290.

[9] Thorndike, *op. cit.,* p. 571.

LIBELLUS DE ALCHIMIA

OF

ALBERTUS MAGNUS

BISHOP OF RATISBON, ORDER OF PREACHERS

PREFACE

"All wisdom is from the Lord God and hath been always with Him, and is before all time."[1] *Let whoever loves wisdom seek it in Him and ask it of Him, "who gives abundantly to all men, and does not reproach."*[2] *For He is the height and the depth of all knowledge and the treasure house of all wisdom, "since from Him and through Him and unto Him are all things":*[3] *without Him nothing can be done; to Him be honor and glory forever. Amen.*

Therefore, at the beginning of my discourse I shall invoke the aid of Him Who is the Fount and Source of all good to deign, in His goodness and love, to fill up by grace of His Holy Spirit my small knowledge so that I may be able by my teaching to show forth the light which lies hidden in the darkness and to lead those who are in error to the pathway of truth. May He Who sitteth on High deign to grant this. Amen.

Though I have laboriously traveled to many regions and numerous provinces, likewise to cities and castles, in the interest of the science called Alchemy, though I have diligently consulted learned men and sages concerning this art

[1] Ecclesiasticus, I, 1. [2] James, I, 5. [3] Romans, XI, 36.

in order to investigate it more fully, and though I took down their writings and toiled again and again over their works, I have not found in them what their books assert. Therefore, I examined books pro and con and I found them to be worthless, devoid of all profit and of usefulness. I found, moreover, many learned men of wealth, abbots, bishops, canons, natural philosophers, as well as unlettered men, who expended much money and great effort in the interest of this art, and yet failed because they were not capable of tracking it down.

Yet I have not despaired, but rather I have expended infinite labor and expense, ever going from place to place, observing, considering, as Avicenna[4] says, "If this is so, How is it? If it is not, How is it not?" I persevered in studying, reflecting, laboring over works of this same subject until finally I found what I was seeking, not by my own knowledge, but by the grace of the Holy Spirit. Therefore, since I discerned and understood what was beyond nature, I began to watch more diligently in decoctions[5] and sublimations,[6] in solutions and distillations,[7] in cerations[8] and calcinations[9]

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[4] Also known as ibn-Sīnā. Abu-'Ali al-Husain ibn-'Abdallah Sīnā (980–1037), the great Arabian philosopher and physician. Among Avicenna's numerous writings is the alchemical tract *De anima*, frequently quoted by thirteenth-century writers such as Albertus Magnus, Roger Bacon, and Vincent of Beauvais. This work was first printed in Basel in 1527. A great many alchemical treatises have been attributed to Avicenna, but most of them are probably spurious. See Lynn Thorndike, *A History of Magic and Experimental Science,* II, 471, n. 3; see also *ibid.,* V, App. 3, for a list of the writings attributed to Avicenna.

[5] *decoctionibus,* digestion; *decoquere,* to boil away. That is: the action of decocting or boiling water or other liquids in order to extract the soluble parts or principles of substances; to boil down or concentrate.

[6] See below, chap. 30, for a discussion of the process of sublimation.

[7] See below, chaps. 34 and 35.

[8] See below, chap. 36.

[9] See below, chaps. 31, 53, and 54. The words calx, calcining, and calcination occur frequently in the *Alchimia.* Alchemists sought to form a calx by roasting, thereby expelling volatile matter and reducing the substance to a more friable state.

and coagulations[10] of alchemy and in may other labors until I found possible the transmutation[11] into Gold and Silver,[12] which is better than the natural [metal] in every testing[13] and malleation.[14]

I, therefore, the least of the Philosophers, purpose to write for my associates and friends the true art, clear and free from error; however, in such a way that seeing they may not see, and hearing they may not understand. Therefore, I beg and I adjure you by the Creator of the world to hide this book from all the foolish.[15] For to you I shall reveal the secret, but from the others I shall conceal the secret of secrets because of envy of this noble knowledge. Fools look down upon it because they cannot attain it; for this reason they

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[10] See below, chaps. 32 and 50.

[11] *transmutationem.* The dream of all the ancient workers in alchemy was to convert the base metals such as iron, lead, and copper, into gold and silver. They were thoroughly convinced of the reality of transmutation. Albertus, in the *Alchimia*, although skeptical, maintains that transmutation may be possible.

[12] *in Solem et Lunam*, into Sun and Moon. This use of planetary signs to designate metals dates from the infancy of alchemy. The *Liber de mineralibus* (III, i, 6; Borgnet ed., V), attributed to Albertus Magnus, gives the reasons for the planetary names of the metals. The Jammy (1651) and the Borgnet (1898) editions of the *Alchimia* frequently employ: *Sol* for gold, *Luna* for silver, *Venus* for copper, *Mercury* for mercury, *Saturn* for lead, *Jupiter* for tin. When the planetary name is used in the Borgnet edition, the present translation capitalizes the name of the metal; for example, *Venus* is translated as Copper, but *cuprum* as copper. On the planetary designation of metals, see J. R. Partington, "Report of Discussion upon Chemical and Alchemical Symbolism, *Ambix*, I (1937), 61; and Pearl Kibre, "The *Alkimia minor* Ascribed to Albertus Magnus," *Isis*, XXXII (2) (June, 1949), 270.

[13] *examinatione.*

[14] *malleatione.*

[15] This phraseology was commonly used by the alchemists. Marcellin Berthelot quotes from a Greek manuscript (Paris, Bibl. Nat., Gr. MS 2419): "Wishing to write for my friends, so that seeing they may not see, and hearing they may not understand, I adjure you, in the name of God, to hold this book hidden from the ignorant." See M. P. E. Berthelot, *Introduction à l'étude de la chimie des anciens et du moyen âge*, pp. 205-207.

consider it odious and believe it impossible; they are, therefore, envious of those who work in it and say that they are forgers. Beware, then of revealing to anyone our secrets in this work. A second time, I warn you to be cautious; persevere in your labors and do not become discouraged, knowing that great utility will follow your work.

1

ON VARIOUS ERRORS

Now, in this little work of mine, I shall describe for you, briefly and simply, how you should undertake the practice of such a great art. I shall first point out, however, all the deviations, errors, and stumbling blocks of this art, into which many and, [indeed], nearly all [are inclined to] fall.

For I have seen some who, with great diligence, were performing certain sublimations and were incapable of carrying them out, because they failed to grasp the fundamentals.

I have seen others making a good beginning, but who, because of excessive drinking and other follies, were unable to carry on the work. I have seen others who made a good decoction,[16] distillation, or sublimation, but because of the excessive length of the work, they left it uncompleted.

I have seen others who possessed the true art and who performed their operations with skill and diligence, but who lost spirits[17] in sublimations because of porous vessels,[18] and for this reason doubted, and cultivated the art no further.

I have seen still others who, desiring to pursue the art, but incapable of waiting the required time, performed too rapid sublimations, distillations, and solutions, because of which they found the spirits contaminated and decomposed,[19] and the aqueous solutions and distillates turbid; and therefore they too lost faith.[20]

I have seen many who were carrying forward the work

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[16] *decoctionem.*

[17] *spiritus.* The alchemists used the word spirits to indicate volatile vapors lost by substances during heat digestion; or, Albertus may here be referring to the four volatile substances: mercury, sulphur, auripigmentum, or sal amnoniac referred to in chap. 10, below.

[18] *vasa.* The common utensils of the alchemists.

[19] *rubiginatos.*

[20] *dubitaverunt.*

with diligence and yet at length failed because they did not have the necessary means of support. Hence the verse:

> When the work is in danger, mortal need increases:
> You may know many things, [yet] without money, you will be nought.[21]

Hence this art is of no value to paupers, because one must have enough for expenses for at least two years. Thus, if one should happen to err in one's work or prolong it, one need not be reduced to penury, as I have seen occur many times.

I have seen some who made pure and good sublimations as many as five times, but then were unable to make any more and became deceitful; they whitened Copper, adding five or six parts of Silver, and thus cheated both themselves and others.

I have seen others who sublimed spirits and fixed them wishing with them to color Copper and Tin, and when they made no impression or penetration, they became doubtful [about the art].

I have seen also those who fixed spirits, covering them with a penetrating oil, until they made a penetration into the bodies, adding yet another part of Silver, and thus they whitened Copper—which is similar to Silver in malleation and testing and in whiteness—which withstood even a second and a third testing,[22] and yet had not been perfected, for the Copper had not been calcined nor purged of its impurity. Hence Aristotle[23] says: "I do not believe metals

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[21] *Cum labor in damno est, crescit mortalis egestas:*
Multa licet sapias, re sine, nullus eris.

The source of this verse is not given in the Jammy or Borgnet editions.

[22] *examinationem.*

[23] Thorndike (*op. cit.*, II, 568) says that Avicenna and not Aristotle is responsible for this remark (in *De mineralibus*, III, i, 8) regarding the transmutation of metals. According to F. S. Taylor (*St. Albert, Patron of Scientists*, pp. 6-7), "It was the task of St. Albert and St. Thomas to 'purge Aristotle of Arabian errors' and to accomplish the synthesis of Aristotelian philosophy and science with Catholic doctrine. Thus his [St.

can be transmuted[24] unless they are reduced to prime matter, that is, reduced to a calx by roasting in the fire, then [transmutation] is possible."

Yet I saw other wise men who finished sublimations and fixations of powders and spirits, prepared solutions and distillations from the powders, then coagulated them and calcined the metals, whitened the bodies to white,[25] and reddened the bodies to red,[26] after which they reduced them to a solid mass and colored them to produce Gold and Silver, which were better than the natural in every testing and malleation.

Since seeing so many who have erred, I resolved that I would write of the true and tested works and of the better [ones] of all Philosophers, among whom I have labored and have had experience; nothing else shall I write beyond what I have seen with my own eyes.

2

HOW DO METALS ARISE?

Alchemy is an art invented by [the] Alchemist: the name is derived from the Greek *archymo,*[27] which in Latin is *massa.* Through this art, corrupted metals in minerals are restored and the imperfect made perfect.

It should be noted that metals differ from one another only in their accidental form, not in their essential form; there-

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Albert's] scientific works are each based upon one of Aristotle's scientific treatises, or those at that time attributed to Aristotle."

[24] *transformari.*

[25] That is, to silver.

[26] That is, to gold. The use of *ad rubeum* or *ad album* for gold- and silver-making recipes frequently appears in the thirteenth and fourteenth centuries. Kibre, *op. cit.*, p. 270.

[27] Gr. μάζα, Lat. *massa,* a lump, mass. Footnote (Borgnet ed., p. 547) reads: *Vel melius ex articulo arabico* al *et verbo graeco* Χυμός. This note does not appear in the Jammy edition.

fore the stripping of accidents in metals is possible. Hence, it is also possible, through this art, to bring about a new body, since all species of metals are produced in the earth from a commixture of sulphur and quicksilver[28] or because of foetid earth. Just as a boy in the body of his mother, contracts infirmity from a diseased womb by reason of the accident of location and of infection, though the sperm is healthy, yet, the boy becomes a leper and unclean because of the corruption of the womb. Thus it is in metals which are corrupted, either because of contaminated sulphur or foetid earth; thus there is the following difference among all the metals, by which they differ from one another.

When pure red sulphur comes into contact with quicksilver in the earth, gold is made in a short or long time, either through the persistence [of the contact] or through decoction of the nature subservient to them. When pure and white sulphur comes into contact with quicksilver in pure earth, then silver is made, which differs from gold in this, that sulphur in gold will be red, whereas in silver it will be white. When, on the other hand, red sulphur, corrupt and burning, comes into contact with quicksilver in the earth, then copper is made, and it does not differ from gold except in this, that in gold it was not corrupt, but here [in copper] it is corrupt. When white sulphur, corrupt and burning, comes into contact with quicksilver in the earth, tin is

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[28] *argento vivo*. The sulphur-mercury theory of the origin of metals was important to mediaeval alchemists. "The mercury and sulphur of this theory were not held to be identical with the common substances bearing these names. . . . The names stood rather for combinations of properties or quantities: for example, sulphur was sometimes held to typify visible properties, such as colour, while mercury represented the invisible or occult properties." John Read, *Prelude to Chemistry*, p. 25. "Geber postulated an intermediate formation of sulphur and mercury, from the exhalations, in the interior of the earth. Finally, sulphur and mercury, by combining in different proportions and in different degrees of purity, gave rise to the various metals and minerals." *Ibid.*, p. 18. For information on Geber, see below, chap. 18, n. 106.

made, [as is indicated from the fact that] it crackles between the teeth and quickly liquefies, which happens because the quicksilver was not well mixed with the sulphur. When white sulphur, corrupt and burning, comes into contact with quicksilver in foetid earth, iron is made. When sulphur, black and corrupt, comes into contact with quicksilver, lead is made. Aristotle says of this that lead is leprous gold.

Now sufficient has been said about the origin of metals and how they differ from one another in accidental but not in essential form. It remains now to examine the proofs of the philosophers and authorities, to see how they demonstrate that this is the true art, so that we may be able to contend with those who maintain that it is not true.

3

THE PROOF THAT THE ALCHEMICAL ART IS TRUE

Some persons, and they are many, wish to contradict us, especially those who neither know anything about the art nor are acquainted with the nature of metals, and who are ignorant of the intrinsic and extrinsic properties of metals, understanding very little about their dimensions and densities.[29] To these, when they set against us the words of Aristotle, who says, "let the masters of Alchemy know that the species of things cannot be changed," we must answer that he said this about those who believe in and wish to effect the transmutation of metals that are still corrupt, but this, without doubt cannot be done. Let us, therefore, listen to the words of Aristotle which say the following: "It is true that experiment destroys the form of the species, and especially in metals, and this is the case when some metal is calcined and hence is reduced to ashes and calx, which can be ground, washed, and softened with acid water until made white and

[29] *profunditates.*

natural: and thus these bodies through calcinations and various medicines[30] may lose the brown corrupt vapor,[31] and acquire an airy, vivifying vapor, and the whitened calx will be reduced to a solid mass, which can be colored white or red." [32] For this reason, Hermes[33] says that spirits cannot enter bodies unless they are purified, and then they enter only through the instrumentality of water. Aristotle says: "I do not believe that metals can be transmuted[34] unless they are reduced to prime matter, that is, purified of their own corruption by roasting in the fire." [35]

To those still dissenting and unbelieving, I wish to make myself clearer because we know whereof we speak and have seen what we are asserting: we see different species receive different forms at different times; thus it is evident that by decoction,[36] and persistent contact, what is red in *arsenicum* will become black and then will become white by sublimation; this is always the case.

If, by chance, someone should say that such species can easily be transmuted from color to color, but that in metals it is impossible, I will reply by citing the evident cause through various indications and proofs, and will thoroughly destroy their error.

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[30] *medicinas.*

[31] *humiditatem corruptam et adustivam.*

[32] See above, n. 23.

[33] All the ancient Egyptian writings relating to the different sciences such as mathematics, music, and medicine were attributed to Hermes. Neoplatonists, mystics, alchemists, and others regarded the Egyptian god, Thoth, as more or less identical with the Greek god, Hermes. "Among the Arabs and in medieval Latin learning the reputation of Hermes continued not only as an alchemist, but as a fountain of wisdom in general." Thorndike, *op. cit.*, II, 219.

[34] *transubstantiari.*

[35] This partly repeats the earlier statement attributed to Aristotle. See above, n. 23.

[36] *perdecoctionem.*

For we see that azure,[37] which is called *transmarinum,*[38] is produced from silver; since, as is more easily seen, when it is perfected in nature losing all corruption, the accidental is destroyed rather than the essential. We see, furthermore, that copper receives a yellow color from calamine stone,[39] and yet neither the copper nor the calamine stone is perfect, since fire acts on both.

We see that litharge[40] is made from tin, but tin through too much decoction turns a golden color; however, it is possible to convert it to a species of silver, since it is of this nature.

We see iron converted to quicksilver, although this may seem impossible to some; why it is possible I have already stated above; namely, that all metals are made from quicksilver and sulphur; wherefore, since quicksilver is the origin of all metals, it is possible also for iron to be reconverted to quicksilver. Do you not perceive, for example, that water solidifies in the winter time through excess cold, and becomes ice, and that ice melts by the heat of the sun and returns to water as before? Thus from quicksilver, wherever it is in the earth, and from sulphur, if this also is present, a union of these two comes about and through a very mild decoction over a long period of time, in which they are combined and hardened to a mineral stone, from which the metal may be extracted.

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[37] *azurum.* This may be the lapis lazuli stone, which is a complex silicate commonly called the sapphire by the ancients. The most important mineral in the stone is lazurite, which is a rich azure blue in color.

[38] Perhaps ultramarine.

[39] This word was used by the ancients to designate ores of zinc.

[40] Lead was known to the Egyptians and was sometimes confused with tin by the early alchemists. Lead monoxide or litharge is generally made by cupellation of lead. See below, chap. 28, n. 149.

Likewise, we see that cerussa[41] is made from lead, minium[42] from cerussa, and lead from minium.

Behold, now, it has already been sufficiently proved how species are changed[43] from color to color even to the third or fourth form. From this it must not be doubted at all, that corrupted metals can become pure by their own medicines.

Since the foundation for this art has now been laid, let us see what we shall build upon. For if we build upon hay or wood or straw, fire will consume all. Therefore, let us procure stones, which are neither destroyed by fire nor by decay; then we will be free from all anxiety.

From what we have said concerning the difficulties of the art—its principle, and, finally, concerning its proof—it is evident that we have established that it is the true art. Now it remains to be seen how to proceed, and at what time and in what place.

First, at the outset, certain precepts are to be laid down.

The first precept is that the worker in this art must be silent and secretive and reveal his secret to no one, knowing full well that if many know, the secret in no way will be kept, and that when it is divulged, it will be repeated with error. Thus it will be lost, and the work will remain imperfect.

The second precept is that he should have a place and a special house, hidden from men, in which there are two or three rooms[44] in which are carried on the processes for sublimating and for making solutions and distillations, as I will show later.

The third one is that he should observe the time in which the work must be done and the hours for sublimations and

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[41] See below, chap. 27.

[42] See below, chap. 28.

[43] *permutantur*.

[44] *in qua sint duae camerae vel tres; "camerae"* can also be translated as "arches."

solutions; because sublimations are of little value in the winter; but solutions and calcinations may be made at any time: All these things, however, I will show clearly in [the discussion of] these operations.

The fourth is that the worker in this art should be careful, and assiduous in his efforts, and not grow weary, but persevere to the end. For, if he begins and does not persevere, he will lose both materials and time.

Fifth, it should be done according to the usage of the art: first in collecting [supplies], second in sublimations, third in fixations,[45] fourth in calcinations, fifth in solutions, sixth in distillations, seventh in coagulations, and so on in order. If he should wish to color besides subliming, and to both coagulate and distill, he will lose his powders, because when they will have been volatilized [46] he will have nothing left of them whatever, but they will be very quickly dispersed.[47] Or, if he wishes to color with fixed powders which are neither dissolved nor distilled, they will neither penetrate nor mix with the bodies [to be colored].

The sixth is that all vessels in which medicines may be put, either waters or oils, whether over the fire or not, should be of glass or glazed. For, if acid waters[48] are placed in a copper vessel, they will turn green; if placed in an iron or lead one, they will be blackened and corrupted;[49] if placed in earthenware, the walls will be penetrated and all will be lost.

The seventh is that one should be on one's guard before all else against [associating oneself] with princes or potentates in any [of these] operations, because of two dangers: If

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[45] Probably a stable solid material was formed.

[46] *projecti.*

[47] *sed revolabit citissime.*

[48] Arabian chemists did not attempt to distinguish by their choice of words the specific character of vinegar and acid water. J. M. Stillman, *Story of Chemistry*, p. 282.

[49] *inficiuntur.*

you have committed yourself, they will ask you from time to time, "Master, how are you succeeding? When will we see some good results?" and, not being able to wait for the end of the work, they will say that, it is nothing, it is trifling, and the like, and then you will experience the greatest dissatisfaction. And if you are not successful, you will suffer continued humiliation because of it. If, however, you do succeed, they will try to detain you permanently, and will not permit you to go away, and thus you will be ensnared by your own words and caught by your own discourses.

The eighth precept is that no one should begin operations without plenty of funds, so that he can obtain everything necessary and useful for this art: for if he should undertake them and lack funds for expenses then he will lose the material and everything.

4

THE KIND AND NUMBER OF FURNACES THAT ARE NECESSARY

Now it must be seen how furnaces are made as well as the number and kind needed.

Regarding which it should be observed that the quantity of the work at hand should determine the number of furnaces to be made. For if you have sufficient supplies and want to undertake a great amount of work then you should construct many of them. If, on the other hand, there is a scarcity, construct the furnaces according to the amount of powders and medicines you have.

I desire to set forth a plan of furnaces as well as the number, which will be suitable to the rich workers as well as to the poor ones.

First, the philosopher's furnace must be described. Build it near a wall, where the wind can approach: so that the furnace is about an arm's distance from the wall, in this

fashion. Dig a pit in the earth to the depth of the elbow, about two spans wide or a little more, and spread all over with the clay[50] of the master [potter]: above this [pit], erect a circular wall lined with the same clay.

5

ON THE QUALITY AND QUANTITY OF FURNACES

Take common clay[51] and to four parts add a fifth part of potter's clay and grind well, and add a little sand, grind again (some prudently add manure[52] or salt water in which manure will have been dissolved); after doing this make a wall, as mentioned before, above the pit, two feet high or a little less, one span thick, and permit to dry. Then have a disc made of potter's clay, which can sustain strong fire, everywhere perforated with fifty or sixty holes, according to the size of the disc [with the perforations] made like a finger, the upper part narrow and the lower wider so that ashes can easily descend. Below, in the earth, make a canal[53] through earth and wall before the disc has been put in place; this should be narrow at the pit end, while outside, at the wall, it should be wider, about one span in width, so that the wind may enter. This canal should be lined with clay; then the disc should be placed on top, in such a way that the wider openings of the perforations are on the underside. Next a wall is built upon the first wall and the disc, to the thickness of one span, but the wall should be

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[50] *argilla magisterii.*

[51] *argilla simplici.* Good fire clays are made from a mixture of sand and clay with traces of iron, lime, and magnesia, and can stand a very high temperature. Potter's clay (*argilla figulorum*) was no doubt added for its great plasticity.

[52] *aliqui apponunt consulto fimum equinum, aut saltem aquam, in qua ille fimus fuerit dissolutus.*

[53] *meatus.*

above the disc to about the distance of one arm. The furnace should have a hole in the middle above the disc where the coals[54] will be laid. At the top there should be a hole through which calcining vessels may be placed: this hole is to be covered over afterwards with a tight cover. The furnace may also have beneath[55] four or five small holes about three digits[56] wide.

This is the general plan of the furnace.

Note also that a clay tripod should be placed above the disc, upon which are to be placed the calcining vessels, and under which the coals.

6

HOW MANY, WHAT KIND, AND OF WHAT USE ARE THE SUBLIMATION OVENS?

Now sublimation ovens must be considered, of which there should be at least two or four, and made throughout with disc, canal, and perforations[57] like the philosopher's oven, but smaller in size: moreover, they should be in one place for convenience [of supervision].

7

HOW ARE DISTILLATION OVENS [TO BE MADE]?

Distillation ovens are to be made in the following way: they are constructed like those [described] above, of clay.

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[54] *carbones.*

[55] *alibi, supra.* (Parenthetically in text.) The translation gives an alternate reading from various manuscripts.

[56] Measures and weights have been Anglicized in this translation. The H. C. and L. H. Hoover translation of Georgius Agricola's *De re metallica* gives (App. C) the following values of the Roman long measure: 1 digitus = 0.726 inches; 4 digiti = 1 palmus = 2.90 inches.

[57] *cum rota, et meatu, et foraminibus.*

A circular wall is to be made on the earth four digits thick and three palms wide [i.e., in diameter]. And let the furnace have a hole in its side three digits in width; the oven should be wider at the top than at the bottom, as this illustration shows.[58]

Make only two of these ovens which will suffice for the distillations. [Make] vessels which are suitable for furnaces, some for distillations, some for calcinations, others for coagulations, the plan for which we shall place at the end of the book.[59]

8

ON GLAZING OVENS

The glazing furnace is made in the same way as the others, which are satisfactory for glazing purposes.

9

HOW ARE CLAY VESSELS GLAZED?[60]

Select a vessel to glaze, namely a clay one, well fired; and smear well with minium prepared as follows. Dilute the

[58] *ut ejus figura demonstrat.* Marginal illustrations appear in the fourteenth-century Brit. Mus. Sloane MS 323 (Semita recta) on fols. 58, 68^{v}, 69, 72^{v}, 74-79, in a contemporary hand. See D. W. Singer, *Catalogue of Latin and Vernacular Alchemical Manuscripts in Great Britain and Ireland* . . . , I, 153. There are no illustrations in the Jammy or Borgnet editions of the *Alchimia.*

[59] The last sentence in this chapter is "*Reperies in Caelo Philosophorum Ulstadii, etc.*" You will find these in the Caelum philosophorum of Ulstad. (This addition was doubtless made by Jammy.) Philip Ulstad or Ulsted was an alchemist who, according to Stillman (*op. cit.*, p. 297) was teaching medicine at Freiburg im Breisgau in 1500. Thorndike (*op. cit.*, V, 542) says that the *Caelum philosophorum* was first printed in Fribourg in Switzerland in 1529.

[60] *Quomodo vasa fictilia devitreantur*? Albertus here emphasizes earthenware (*fictilia*) vessels.

liquor from beer or wine fermentation with water in the proportion of ten to one, then add as much minium as you wish, mix well, and smear the vessel with a brush[61] or with the hand, and let dry: then place it in the furnace, turning the concave side underneath, so that it may rest above two strong iron supports which are placed in the middle of the furnace. If you wish to put in additional vessels, it is better to close the mouth of the furnace with stone and clay. Fire slowly at first for the space of an hour, then increase the fire until you see the minium flow like wax, then permit the vessel to cool, open it and take out the well-glazed vessel.[62] Yet, note this, that minium from cerussa is ten times as valuable as cerussa itself, or as minium made from ashes of lead.

Since this ends our discussion on the structure of furnaces, the spirits and medicines will now be treated.

10

THE FOUR SPIRITS OF METALS WHICH COLOR

Note that the four spirits of metals[63] are mercury, sulphur, auripigmentum or arsenicum, and sal ammoniac. These four spirits[64] color metals white and red, that is, in Gold

[61] *penicillum*, a painter's brush.

[62] The heating of clay vessels which had been coated with red lead imparted a glass-like surface to the vessels, and thereby prevented a loss of liquid through the porous walls. White lead is here recommended because red minium varies in its composition. It is known that the minium of the alchemists was anything but a pure product.

[63] The four spirits of metals were frequently mentioned by the early alchemists. "I say therefore first, that spirits (spiritus) are four . . . The four spirits are quicksilver, sulphur, orpiment, and sal armoniacum." This quotation (Stillman, *op. cit.*, p. 245) appears in a Latin manuscript published by Berthelot and attributed to Djaber. On Djaber, see below, chap. 18, n. 106.

[64] Each of these substances is discussed in separate chapters. See below, chaps. 13-17.

and Silver: yet not of themselves, unless they are first prepared by different medicines for this, and are not volatile,[65] and when placed in the fire burn brilliantly. These spirits fashion Silver from Iron and Tin, or Gold from Copper and Lead.

Thus, as I shall say briefly, all metals may be transmuted into Gold and Silver, which are like all the natural metals, except that the iron of the Alchemist is not attracted by adamantine stone[66] and the gold of the Alchemist does not stimulate the heart of man, nor cure leprosy, while a wound made from it may swell, which does not happen with natural gold.[67] But it is evident that in all other operations, as malleation, testing, and color, it will last forever. From these four spirits the tincture[68] is made, which in Arabic is called *elixir*,[69] and in Latin, *fermentum*.

11

WHAT IS ELIXIR, AND HOW MANY OF THE METALS ARE TRANSMUTED THROUGH THESE FOUR SPIRITS?

Elixir is the Arabic name and *fermentum* is the Latin: because, just as bread is leavened and raised through good yeast, so the matter of metals may be transmuted through these four spirits into white and red, but especially through mercury, because it is the source and origin of all metals.

[65] *et non effugiant ignem*, and they do not flee the fire.

[66] That is, magnetite, an important iron ore.

[67] Albertus here shows his distrust of the gold produced by the alchemist.

[68] *tinctura*.

[69] Ar. *al-iksēr*, Gr. ξηριον, powder, Lat. *fermentum*. The alchemists understood by the words elixir, tincture, magisterium, medicine, or philosopher's stone, a compound that was supposed to possess the power of transmuting baser metals into gold and silver. "Of this substance they recognized two sorts—a white powder transmuting metals into silver and a red powder transmuting them into gold." J. C. Brown, *History of Chemistry*, p. 185. See also Thorndike, *op. cit.*, III, 74-75, 81-82.

12

ON THE GENERA OF MEDICINES AND THEIR NAMES

The following is a list of the other spirits and medicines and how they are named: sal commune [common salt], sal alkali, sal nitrum,[70] sal borax,[71] Roman alum,[72] alum from Yemen,[73] tartar, atramentum,[74] green copper, calamine stone, copperas,[75] tutia,[76] cinnabar, minium, cerussa, hen's eggs,[77] eggshells, vinegar, urine, cadmia,[78] marchasita,[79]

[70] No chapter in the *Alchimia* gives a detailed description of *sal nitrum*, although many of the substances mentioned in this chapter are described in detail in later chapters. The *Liber de mineralibus* (V, vii, 101) states: "Nitrum is so called from the island where it was first found. The Arabs called it *baurac*. It is a kind of salt less [well-] known than *sal gemme*, yet it is transparent but [occurs] in thin plates. It is roasted in the fire and then, all superfluous substances being driven off, it is burned well and becomes sharper." George Sarton (*Introduction to the History of Science*, II, ii, 1036) notes that the nitrum used by ancient workers was actually potash or soda or any other alkali salt.

[71] Agricola mentions borax that is thought to be the same as our modern variety. (*Op. cit.*, Hoover trans., p. 560.) It is reported that Geber (see below, chap. 18, n. 106), used the word *baurach*, but, of course, that is not to say that he meant our modern borax.

[72] *alumen zucharium*.

[73] Said to be the preferred kind; see Robert Steele, "Practical Chemistry in the Twelfth Century," *Isis*, XII (1929), 12. See also Berthelot, *op. cit.*, p. 236; and Kibre, *op. cit.*, p. 274.

[74] A crude mixture of copper and iron sulphates. See below, chap. 22.

[75] Perhaps the black oxide of copper or ferrous sulphate.

[76] The *Liber de mineralibus* (VIII, viii, 102) describes this: "Tuchia, which is frequently used in the transmutation of metals, is an artifical and not a natural mixture, for tuchia is made from the smoke which rises and is coagulated by adhering to hard bodies, when the brass is purified from the stones and tin which are in it; but the best kind is from that which is sublimed . . . There are many kinds of tuchia: white, and [ranging] from yellow to red."

[77] *ova gallinarum*.

[78] An impure zinc ore containing copper and lead.

[79] "Marchasita, or Marchasida, as some call it, is a stone in substance and there are many species, wherefore it takes the color of any metals

magnesia,[80] and many other things of which we have no need in this book.

These substances do not color, but the spirits are serviceable, for they are quickly prepared and dissolved, and with their solutions they macerate the calx of the metals, and [cause] these bodies to take on rectifying vapors.

Their preparation, occurrence, and the manner of calcining and solution, we will show in order in the following chapters.

13

WHAT IS MERCURY AND WHAT IS ITS ORIGIN?

Mercury[81] is viscous fluid united in the interior of the earth with a white subtile earth, through the most moderate heat until there is equal union of the two. It rolls on a flat plane with ease and, despite its fluid nature, does not stick to it, and it may possess a viscous form because of its dryness, which tempers it, and prevents adherence [to a surface].

It is the matter of metals when combined with sulphur, that is, as a red stone[82] from which quicksilver[83] can be extracted; and it occurs in the mountains, especially in old drains, in great quantities.

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whatsoever and is thus called silver or gold marchasita . . ." *Liber de mineralibus*, III, viii, 102; quoted in Stillman, *op. cit.*, p. 253.

[80] "Magnesia, which some call magnesium, is a black stone which the glassmakers frequently use." *Liber de mineralibus*, III, viii, 208; Stillman, *op. cit.*, p. 253.

[81] Mercury as a metal dates from *ca.* 1500 B.C. E. R. Caley ("Mercury and Its Compounds in Ancient Times," *Journal of Chemical Education*, V [1928], 419), states that Aristotle (*Meteorologica* IV, 8, 11) gives us the first written evidence of the metal. He called it fluid silver.

[82] That is, red sulphide of mercury—our cinnabar. The alchemist often confused the red color of cinnabar with red lead oxide.

[83] *argentum vivum*.

By nature mercury is cold and moist[84] and is the source of all metals, as has been said above. It is created with all metals, is mixed with iron, and without it no metal can be gilded.[85]

ADDITION. Quicksilver and sulphur, sublimed with sal ammoniac is converted into a brilliant red powder,[86] but when burned in the fire returns to a fluid and humid substance.

14

WHAT IS SULPHUR, ITS PROPERTIES, AND ITS OCCURRENCE?

Sulphur,[87] the fatness of the earth, is condensed in minerals of the earth through temperate decoction, whereby it hard-

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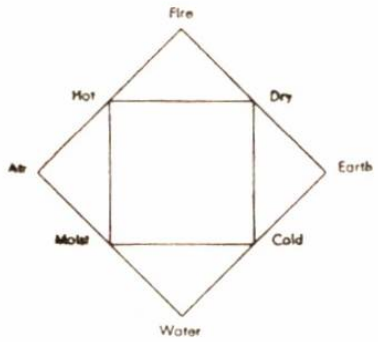
[84] "Aristotle's elements are really fundamental properties of metals, for which he chose hotness, coldness, moistness, and dryness. By combining these in pairs as in the diagram, he obtained four elements." J. R. Partington, *Textbook of Inorganic Chemistry* (London, Macmillan & Company Ltd.; New York, St. Martin's Press, 1950), p. 58. Reproduced by permission of the publisher.



[85] The use of mercury to amalgamate gold and silver is an ancient practice.

[86] When mercury is heated in the air for a long time just below its boiling point, in a long-necked flask, it forms a red crystalline powder: mercuric oxide. Mercuric sulphide, the pigment vermilion formed by sublimating mercury with sulphur, may be the product mentioned here.

[87] "Sulphur is a fatness of the earth, thickened until hardened and made dry, and when it is hardened it is called sulphur." Geber in the *Summa Perfectionis Magisterii*, as quoted in Stillman, *op. cit.*, p. 280. See also below, chap. 18, n. 106.

ens and becomes thick; and when hardened it is called sulphur.

Sulphur has a very strong action,[88] and is a uniform substance throughout;[89] for this reason its oil cannot be separated from it by distillation, as from other substances having oil, but rather by means of acute waters, by boiling sulphur in them. It occurs in the earth, sometimes in the mountains and sometimes in the marshes.[90] There are many varieties; namely white, red, green, yellow, or black: and besides it occurs in the dead form.[91] It is living when extracted from fusible earth, and is effective against the itch. It is dead when it is poured into cylinders, as it is found among apothecaries.

Addition. Sulphur has a fiery nature, liquefies as gum and is entirely smoky.

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[88] This may signify the properties of some of its compounds; for example, sulphur dioxide, a suffocating gas, or sulphuric acid, a highly corrosive liquid.

[89] *et est uniformis substantiae in partibus suis.* T. M. Schwertner, O.P. (*St. Albert the Great*, p. 366, n. 35) says of this passage that it might well mean that sulphur was an element in the modern meaning of the term, that is, a substance which is chemically indivisible into other substances. If this be so, it must be admitted that Albert the Great and not Lavoisier, was the first to recognize the elementary nature of sulphur. Schwertner gives as his source for this note: J. W. Mellor, *A Comprehensive Treatise on Organic and Theoretical Chemistry*, I, 46.

[90] H. Casey, O.P. ("The Scientific Works of St. Albert the Great," *Irish Ecclesiastical Record*, XXXIX, 1932, p. 378) points out that St. Albert showed keen powers of observation, for sulphur does not occur in large quantities in the marshes, but is produced by the action of "sulphur bacteria—*beggiatoa alba* which infest water containing protein matter. Probably St. Albert observed this sulphur in some stagnant marsh which had been contaminated by organic refuse."

[91] *Living* carries the connotation of natural, native, crude; and *dead*, that of being already worked, that is, burned by exposure to the fire or treated chemically.

15

WHAT IS AURIPIGMENTUM AND WHAT IS ITS ORIGIN?

Auripigmentum[92] is a mineral stone and is made thus. Earthen dung pits[93] in the bowels of the earth through long processes of decoction transform[94] it into the substance of auripigmentum. Its viscosity is twofold: one is fine and the other coarse: one is freed through washing and decoction in urine; another through sublimation, as stated below.

ADDITION. Auripigmentum is active and burning, unless whitened. After sublimation it may whiten copper into a species of silver: this is done by adding two parts of sal ammoniac to four of rock salt, placing the latter on top of the former, and repeating the process three times until you are satisfied [with your work].

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[92] The early alchemists thought this mineral contained gold, hence the name. It is our orpiment, As_2S_3, a yellow sulphide of arsenic. The Greek name, ἀρσενικόν *arsenikon,* was often used by the ancients.

[93] Casey (*op cit.,* p. 386), gives an explanation of the use of dung pits: "What appears to be absurd crudities in laboratory methods . . . is that of his [Albertus Magnus] custom of putting things into 'sterquilinium' for varying periods. This is strictly scientific. Saint Albertus Magnus would have had the occasion to require a warm temperature which would remain more or less constant over a prolonged period. Possessed of no thermostat with electric heating and fire controls . . . Saint Albert's practical turn of mind cast about for a suitable means of attaining this end. Nature provided him with 'sterquilinium' (dung pit). It contains thermophilic bacteria which are capable of producing a temperature of 50–70° by their biological activity. The temperature is automatically maintained about this figure, for should it rise higher than the optimum temperature of the organisms, their activity is diminished and, consequently, the temperature falls. The result is a natural incubator which will even hatch eggs."

[94] *transit.*

16

WHAT IS ARSENICUM?

Arsenicum[95] is a subtle substance of a sulphurous color and occurs as a red stone. By nature it is like auripigmentum: the flowers are white and red. It is easily sublimed and is whitened in two ways:[96] through decoction and sublimation.

17

SAL AMMONIAC IS TWOFOLD

Sal ammoniac[97] is of two kinds, natural and artificial. The natural variety occurs in the earth as both white and

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[95] Agricola, *op. cit.* (Hoover trans.) V, lll, n.: "Metallic arsenic was unknown although it has been maintained that a substance mentioned by Albertus Magnus (*De Rebus Metallicis*) was the metallic form. Agricola, who was familiar with all Albertus' writings, makes no mention of it, and it appears that the statement of Albertus referred only to the oxide from sublimation."

[96] The red stone here is our red realgar (As_2S_2). The disulphide becomes yellow when exposed to light, from the formation of the mixture, As_2S_3 (yellow), and As_2O_3 (white). Both sulphides burn to white trioxide and sublime when heated in the air.

[97] " 'Sal armoniacum' is with Albertus, as with ancient writers, classed as a variety of common salt, though he refers to a salt of which he has heard, that is prepared from human urine, chiefly of young boys, prepared by the operations of alchemy, by sublimation and distillation. As he characterises this salt no further, it leaves a doubt as to whether he considered this as essentially different from common salt, though Arabian writers had previously made the distinction clear." (Stillman, *op. cit.*, pp. 250-251.) "It is often difficult however to tell in the case of medieval Latin writers whether in writing sal ammoniacum, sal hammoniacum, sal armeniacum, etc., they mean with Pliny the superior grade of common salt, or sal ammoniac, as the confusion of spellings and signification is great and often no clue is given as to properties of the salt alluded to." (*Ibid.*, p. 246.) Sal ammoniac (NH_4Cl) was often used by the early alchemists as a flux in soldering, just as it is today.

red; both may be extracted from a hard and crystalline mineral, with a very salty taste, which is by nature warm and dry. It is used in washing, for cleansing, and for the refining [of metals]. The artificial kind is better than the natural for our work and it is more noble than all other salts. It converts Mercury into a liquid when it is roasted and ground with it. When [it is] set in some damp place to dissolve: it dissolves iron and lead. It is also an oil which the dryness of fire congeals. By its nature it is warm and moist and serves as a subtle spirit for the elixir: for without it, substances cannot be dissolved nor well mixed.

Note that this spirit neither whitens, reddens, nor transmutes bodies like other spirits; but it aids the penetration of other bodies[98] purging and cleansing the bodies of blackness. Thereupon it leaves behind spirits mixed with these bodies, aiding their reaction and itself passing away.[99]

Addition. A solution of sal ammoniac, sublimed or not, but filtered or passed several times through a thick, fine-textured cloth, aids the penetration of any calcinated body into another fusible body, provided the calcinated body is given opportunity to be absorbed in it, and afterwards it is itself congealed and finally dissolved.[100] When saffron iron[101] is prepared in this way, it provides a tincture of the best gold for silver.

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[98] *sed ipse dat aliis introitum.*

[99] *recedit.*

[100] *et postmodum congeletur, et ultimo pulverizetur et dissolvatur.* The translation is an alternate reading. In the second interpretation the subject would be the calcinated body and not the sal ammoniac.

[101] *crocus ferri.* Iron oxide is used here for treating silver to make it resemble gold. This process is given in more detail in chapter 53, below.

18

OF WHAT USE IS COMMON SALT AND HOW IS IT PREPARED?

Common salt[102] is the key to this art, because it opens and closes all things, and no work of the Alchemist can be completed without it. It is prepared in this manner: take any desired amount of the salt, dissolve it in a small mortar[103] by agitation with warm water, filter through a thick cloth into a linen vessel, and bring to solution any residue left over by adding more warm water to it. Boil[104] this solution in a glass, lead, or copper vessel until the water has evaporated, and the solid salt remains. Put this salt into a new olla[105] (the olla should be closed), and set in a calcining furnace, and dry thoroughly. Then set [it] aside until I can teach you the process of dissolving and distilling.

ADDITION. I have found that glazed earthenware and not metallic vessels should be used in this work, as Geber says in the first part of his book, *De Investigatione Perfectionis*,[106] "Dissolve the salt in warm water, distill by

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[102] See above, n. 97.

[103] *mortariolo*. Later in the text of this book *mortarium*, an ordinary size mortar, is used.

[104] *coque*.

[105] Olla; pl. ollae; a round pot or jar with a wide mouth, made of baked clay and in general use in Spain, Latin America, and the southwestern part of the United States. It is used in cooking and in cooling water by evaporation. In the following chapters of this book, the word "jar" is used instead of olla.

[106] Abū Mūsā Jābir ibn Hayyāñ (commonly, Djaber, Jabir, Geber), an Arabian alchemist who lived in the eighth or ninth century. Several of the Arabic manuscripts, now at Leyden, of this writer have been translated by Berthelot, who has shown that they deal with metaphysical matters and are characterized by verbosity and obscure allusions and, generally, fail to reveal why their writer achieved his great reputation among later Arabian alchemists. Various treatises in alchemy and

filtering, congeal in a suitable vessel with slow fire." Others place it afterward in a calcination furnace or a baker's oven,[107] drying well and putting it aside.

19

THE WATER OF ANY SALT [YOU PLEASE]

The fusing of salt[108] is done in this way: secure pictavian[109] salt, grind it well in a copper mortar, and then fill four

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chemistry were attributed to Djaber in the Middle Ages, but these works were actually written by a person who chose to have his writings accepted as Latin translations of the Arabic texts of Djaber, perhaps in order to obtain greater prestige for his work. The unknown writer is usually referred to as Geber or the pseudo-Geber to distinguish him from Djaber. Berthelot's critical comparison of the Arabic writings of Djaber and the pseudo-Geber's Latin treatises has shown that the pseudo-Geber was not following an Arabic text. According to Petrus Bonus, a fourteenth-century writer on alchemical matters, the pseudo-Geber was a Spaniard. Bonus calls him "Geber Hispanus" and makes several references to his writings. The pseudo-Geber's principal works are the *Summa Perfectionis Magisterii*; *De Investigatione Perfectionis,* here cited in the *Libellus de Alchimia*; *De Inventione Veritatis*; *Liber Fornacum.* These treatises were accepted and often cited by alchemists as genuine works of the Arabian, Djaber.

One of the arguments against the attribution of the *Libellus de Alchimia* to Albertus Magnus is the fact that its author refers to the *De Investigatione* of the pseudo-Geber. Albertus Magnus died in 1280, and the pseudo-Geber is generally supposed to have lived at the end of the thirteenth or at the beginning of the fourteenth century, hence his writings could not have been known to Albertus. The citation probably represents an addition made in a later recension of the text of the *Libellus*; we shall note others (see below, nn. 130, 185, 186, 192, 222). For information on Djaber and the pseudo-Geber, see Thorndike, *op. cit.*, III, 41; V, 682; Sarton, *op. cit.*, I, 532-533; II, 769; Berthelot, *La Chimie au moyen âge*, III, 163 ff.; Stillman, *op. cit.*, pp. 176-181 on Djaber; pp. 276-278 on the pseudo-Geber, and references therein.

[107] *furno . . . panis,* a bread oven and much smaller in size than an alchemist's furnace.

[108] This chapter is an early description of dialysis, the separation of crystalloids and colloids through a natural or artificial membrane. Casey, *op. cit.,* p. 386.

[109] *sal de pictavia.* That is, from Aquitanian Gaul, modern Poitou.

different bladders,[110] tie cords around the necks, making [them] airtight. Fill a large pot[111] with rain water, place a stick across it to which you suspend two of the bladders, and submerge in the water up to the neck, and leave them there through the natural day. Then, withdraw and filter the solution; look inside for a residue. If there is any left, replace in the pot for another day and repeat the procedure as before, until all the salt is dissolved in the water. Afterwards distill and congeal; place the solid part in an earthen pot[112]—previously well lined—above a coal fire, heating on all sides, and leave in the fire or furnace until the fire goes out. [Then] cool; uncover the salt, which will be like a metal, and do this at least seven times.

20

WHAT IS THE USE OF SAL ALKALI, AND HOW IS IT PREPARED?

Sal alkali[113] is important in this art and, when it has been well prepared, frees all the calxes of bodies as a solid mass. By nature it is warm and moist. It is prepared in this manner: take a large quantity of putrid oaken ashes, or better clavellated ashes,[114] which are used for washing

[110] *mutonias.*

[111] *cacabus.* A large cooking pot, a boiler; shaped somewhat like present-day steamers used in quantity cooking.

[112] *pottus* (Med. Lat.), a vessel of general use to the alchemist.

[113] This salt is "a white solid, closely resembling soda in many of its properties, [it] was prepared by extracting the white ash of burnt wood with water in earthenware pots. It was known as potash (originally 'pot-ash') or 'pearl ashes.' During the Middle Ages, until the time of Boyle [1627–1691], potash was the only alkali used in Europe; afterwards, however, soda was prepared from the ash of sea weeds and was used on a large scale, under the name of 'barilla,' for the manufacture of soap." (T. M. Lowry, *Inorganic Chemistry,* p. 51).

[114] Clavellated ashes were burned lees or dregs of wine, from which potash was obtained.

garments, grind very finely, add a sixth part of quicklime, mix once and put a closely woven cloth over a *tina*[115] and upon it as much of the ashes mixed with the calx as it will hold, and pour hot water over the whole from above. Then filter into the lye[116] until all the bitterness has been extracted.[117] Remove this solution and replace it by a fresh one, and repeat [the procedure] as before. Put all the filtrates into the same vessel until morning, and then distill through a filter. Heat in a small cauldron[118] until the solution evaporates and does not fume. Allow to cool and a hard stone will remain which is called alkali, that is, dregs of bitterness. Half fill an earthen jar with this salt and set it uncovered in the furnace. Apply a slow fire at first, heating gently so that it does not boil over (or bump); afterwards increase the heat until the alkali reddens and liquefies as wax; then, using tongs, pour at once into another jar, for if you delay it quickly gets too hard to pour. Place this white alkali salt in a glass vessel in a warm, dry place, since it dissolves in a moist one.

Addition. Or this alkali salt can be made in another way. Take ashes of certain herbs, called Soda,[119] crush well, [and] boil in a jar with water. Pass through a mesh,[120] as with claret[121] once or twice, [and] then distill through a filter. Afterwards place [the salt] in a new earthen pot and congeal with a slow fire at first, [then] increase the heat until the salt solidifies. Place the salt in a clean dry place.

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[115] A vessel for holding wine.

[116] *lixivium.*

[117] The method described here is the modern fundamental procedure for preparing caustic soda.

[118] *caldarium.* A large tub used as a water bath.

[119] Agricola, *op. cit.* (Hoover trans.), XII, 558: "The actual difference between potash and soda—the nitrum of the Ancients, and the *alkali* of Geber . . . was not understood for two hundred years after Agricola . . ."

[120] *caligam.*

[121] *claretum.*

Plant alum[122] is called alkali alum, alkali salt,[123] and clavellated ashes, or [it] is made from them.

Crush and dissolve alum of Yemen in three pounds of distilled urine water, distill through a new filter, then harden white, and, when this is done, crush on a marble slab.[124] Sprinkle another marble slab with distilled vinegar, place the ground alum from the first slab upon it, raising the slab on one side so that the clear liquid may be drained into a glass vessel, while the residue remains on the slab as a white earth. This should be done in a cold and moist place, and [the solution] should be collected in a well-stoppered glass vessel. This liquid can be hardened in a slow, moist fire [water bath]. With this alum a spirit may be fixed, and with this liquid calcinated bodies may be washed.

21

HOW IS ALUM WHITENED AND DISSOLVED IN WATER?

Take as much alum[125] as you wish, and half fill (or less) a jar, cover it, place in a furnace, and heat slowly at first

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[122] *Alumen faseolum. Faseolus, phaseolus,* an edible bean; the kidney-bean.

[123] *alofer;* probably should be *alafur,* alkali salt. See Carbonelli, *Sulle Fonti Storiche della Chimica e dell'Alchimia in Italia,* p. 196.

[124] Marble slabs were used then as today in the laboratory for exposing materials to the air.

[125] So many kinds of substances were called alum that references to this substance are about as numerous as to nitrum. Many astringent salts were also called alum. The text of this chapter has *alumen.* Pliny says of alum: "Of no less importance, nor indeed very dissimilar, is the use of alumen, which is believed to be a salt exudation of the earth. There are several varieties of it. In Cyprus you find a white kind and one rather darker, the difference in colour being slight, but the difference in employment great, for the white liquid variety is used especially for dyeing wool bright colours, and the darker for cleaning gold." K. C. Bailey, *The Elder Pliny's Chapter on Chemical Subjects,* II, 103.

and afterwards strongly and allow to dry through the whole day at full heat. When cool remove the snow-white alum to a marble slab and keep in a damp, cool place. Alum is used for making the liquid for whitening.

ADDITION. By this method you can resolve any alum into a liquid, either by grinding with a little sal ammoniac or dissolving on the marble, or in a dung [bath], or in the fumes of warm water vapor, or some other way.

22

HOW CAN ATRAMENTUM BE REDDENED AND DISSOLVED IN WATER?

Atramentum[126] is a black earth which burns with a sulphur-like odor. Its black color changes to permanent red through calcination. Take as much as you wish of crushed atramentum, fill a jar halfway or to the top, put on a small cover, smear [the jar] with clay, dry, and place in the calcining furnace. Heat slowly at first for three hours; then, more intensely, for three more hours, until the whole jar becomes red hot. Continue such heat through the day and night; take care lest it liquefy; afterwards cool and then remove. You will then have red atramentum which is called flower of atramentum. Reserve it for the spirits and bodies that can be colored a permanent red with its solution.

ADDITION to the paragraph above on alum.

Feather alum[127] is prepared thus: grind well and boil in purged urine, [which is done by] placing [the alum] in only that amount of urine water that comes above the

[126] Atramentum here designates crude mixtures of copper and iron sulphates. After ignition these turn red. (See below, chap. 47.) The value of *atramentum sutorium,* used by the ancients for coloring leather black, depended, doubtless, on the presence of tannin. See Albertus Magnus, *Liber de mineralibus,* III, i, Chap. ii: "De natura et substantia atramentarum."

[127] Perhaps a variety of aluminum sulphate.

alum by two digits; boil until the alum is dissolved in the liquid. Afterwards, distill through a filter, then congeal and harden between two earthen pans[128] above a slow fire. Thus you should dry the substances which cannot dry by the sun unless they are spirits. Since their drying is of another fashion, you should dry thus: place in a vessel closed on all sides, except at the top where there may be a small opening, shaped for size[129] [of the vessel], and place the vessel with the material in an oven to be dried [at the temperature] [at which] bread would be taken out, or made slightly hotter, and leave it the whole night, and by morning it will be dry. This preparation is said to be dessicated. You may look it up in Aristotle's *De Perfecto Magisterio.*[130]

23

HOW TARTAR IS PREPARED SO THAT THE OIL FROM IT CAN DISSOLVE CALXES

Tartar[131] is very useful for this art. It is prepared thus: fill a jar with crude tartar from thick red or white wine and

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[128] *patellae.* Small plates or pans.

[129] *ubi sit parvum foramen ad quantitem pisi. Pisi* from *pinso* (*piso,* archaic), to beat, to pound.

[130] One of the many spurious works attributed to Aristotle in the Middle Ages. The same work is also attributed to Arnaldus de Villanova, the late thirteenth-century physician. As with the citation to the pseudo-Geber's *De Investigatione Perfectionis* (see above, chap. 18, n. 106), this is a later "addition" to Albertus Magnus' text of the *Libellus de alchimia.* Note that the specific title is cited only in the additions (cf. chaps. 22, 46, 53, 57). On the writings of the pseudo-Aristotle, see Thorndike, *op. cit.,* II, 246-278; see also, for the treatises attributed to Arnaldus de Villanova, *ibid.,* III, App. 4, 664. The *incipits* of works ascribed to Arnaldus have been listed by Thorndike and Kibre in *Catalogue of Incipits of Medieval Scientific Writings in Latin* (Cambridge, Mass., The Medieval Academy of America, 1937).

[131] Argol is the crude acid tartrate of potassium crust which is deposited on the sides of the casks in which wine ferments.

close; afterwards place it in a furnace, heat slowly at first and then more strongly. Continue this for three days and nights, until the jar glows, withdraw and save. I will show you how to make oil from this, with which you can dissolve in water all the calxes of bodies and spirits, for it is one of the bonds [of spirits and of bodies].

ADDITION. It is well not to fill the jar in a strong fire, as I have experienced many times.

24

HOW IS GREEN COPPER MADE AND REDDENED AND ABOVE ALL OF WHAT USE IS IT FOR THIS ART?

Make green copper[132] thus: Copper plates[133] are first treated with sal ammoniac and honey and then joined together and suspended above the vapors of strong vinegar in a strong well-closed jar, lest the vapors be lost. Then [the whole] may be put in a warm place to evaporate the vinegar. Allow to stand three or four weeks, then open [the jar] and you will find green copper clinging to the plates; scrape this off and save. As at first, again suspend the plates above the vinegar until all is converted into green copper. Afterwards put it on a fire for calcining, as I have taught concerning atramentum, and a permanent red color will result.[134] Atramentum is soluble in water and gives a

[132] *Viride aeris. Aes* designated an alloy, mostly copper and tin; *aes Cyprum* is copper from the island of Cyprus, whence comes *cuprum,* the common name for copper. Partington (*op. cit.,* p. 730) notes: ". . . the basic acetate $Cu(C_2H_3O_2)_2 \cdot Cu(OH)_2$ is the bright green pigment *verdigris,* made by allowing plates of copper to stand with alternate layers of 'marcs' (grape skins after pressing the juice from the grapes in wine factories), then packing the sheets on end and moistening with sour wine, which forms acetic acid."

[133] *laminae.* These were thin sheets or plates of impure copper.

[134] Cuprous oxide, a red solid, may have been formed here, if some of the copper metal or an alkali was present to cause reduction of the cupric compound.

permanent red color to bodies and spirits. It is itself one of the bonds of the spirits, and many hidden properties are in the water itself.[135]

ADDITION. Or green copper may be made thus: take one pound of Copper filings, one half weight of vitriol[136] and sal ammoniac, and use strong vinegar to make a paste. Place [this paste] in a glass vessel in horse dung; there it will putrefy and an excellent green copper will be produced.

Flower. Take the cleanest of copper plates,[137] suspend [in a jar] above the most astringent vinegar and let it stand in the sun. After fourteen days open and take out the plate, and collect the flower, and you will make the purest [green copper] [by this means]. Note well what Geber says in his book, *Liber Fornacum*,[138] in the chapter on Silver: that Copper should be purified and dissolved and from this the cleanest sulphur can be extracted, already colored and fixed.

25

HOW AND FROM WHAT IS CINNABAR MADE?

Cinnabar is a noble substance: it pertains to this art [of Alchemy] and is called *usifur*[139]. It is made from quicksilver and sulphur thus: take two parts of mercury, and a third part of sulphur, and grind as with vermilion.[140] Place [the

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[135] This probably refers to the many uses made of the water.

[136] The first use of *vitriolum* is often attributed to Albertus Magnus, but the word was in use about the eighth century, for it appears in a collection of technical recipes known as the *Compositiones ad Tingenda*. See Thorndike, *op. cit.*, I, 766; Berthelot, *La Chimie au moyen âge*, I, 7 ff.; Stillman, *op. cit.*, pp. 185-186.

[137] *patellam . . . aeramine;* doubtless impure copper plates.

[138] Another of the works of the pseudo-Geber. See above, nn. 106 and 130.

[139] *Usifur, uzifur,* from Arabic *zanjifur,* cinnabar. See Steele, *op. cit.*, p. 49.

[140] Here vermilion means minium. See below, chaps. 28 and 29.

mixture] in a glass vessel with a narrow neck, smear all over with clay to the depth of one digit and, after drying, place above a tripod; close the mouth of the vessel well and apply fire slowly for half a day. Afterwards increase the fire, roast through the entire day, until you see red fumes appear above, then allow to cool, break the vessel, and take it out; you will find good and fine cinnabar. Therefore, work hard, and you will arrive at the truth.

As you watch the cinnabar, note when moisture begins to escape from the vessel, and when you see yellow fumes come out, open very cautiously. After less than an hour these will become red, that is, [the color of] cinnabar. Then, put a stick into the *ampulla*,[141] and draw out some of it to examine. If it is satisfactory, allow to cool.

Addition. But mercury should first be washed with ashes and salt and passed through a loose-textured cloth.[142] In like manner, sulphur may be boiled[143] in urine and in vinegar to remove supernatant cloudiness. After it is dried, it should be immersed[144] for one day in vinegar and a second day in urine. But I have seen this [recipe] in writings: take two parts of mercury, three parts of sulphur, and four parts of sal ammoniac. This is according to Hermes.

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[141] A glass or earthenware flask of globular shape. Today's Erlenmeyer flasks are similar in shape.

[142] Before attempting to make cinnabar the writer here recommends purifying the mercury and the sulphur.

[143] *bulliatur.*

[144] *decoquatur.*

26

HOW AND FROM WHAT IS AZURIUM MADE?

Although azurium[145] is not necessary in our art, yet, I should like to propose a method for making it. Take two parts of mercury, a third part of sulphur, and a fourth part of sal ammoniac and grind these, as I taught concerning cinnabar, and put into a glass vessel; then, roast as was done with cinnabar. [The work] is finished when you see blue smoke through the glass. When it is cold, break the vessel and you will find excellent azurium; crush on the stone[146] without water. You can pay expenses from the result [i.e., by the sale of the azurium].

ADDITION. Some say that the glass vessel should stay open on the fire until the moisture has evaporated. I saw in a certain tract that about one weight of azurium with twenty-two weights of mercury, eight of sulphur, and four of sal ammoniac [could be used].

In like manner, I saw another tract that [recommends] one weight of sal ammoniac, twice as much living sulphur, and triple the amount of mercury. This is put into a luted vessel and placed in dung for three days, and afterwards boiled as Hermes says above.

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[145] Although azurium here no doubt means the blue mineral azurite, a compound containing copper, this recipe, using mercury, sulphur, and sal ammoniac, may have described the preparation of blue ultramarine. This is particularly true if silicates were present. A mixture of clay, sodium carbonate, sulphur, and wood heated to redness in a closed crucible forms white ultramarine. If powdered sulphur is added and the mass heated again, blue ultramarine is formed. See Partington, *op. cit.,* p. 813. Note that the writer here calls it *ultramarine azurium.* The two substances are distinguished by the fact that azurite contains copper, and ultramarine is a sodium aluminum silicate containing sulphur in some form. See above, chap. 3, nn. 37 and 38.

[146] *super lapidem.*

To this add another way: take one pound of mercury, four ounces of sulphur, two of sal ammoniac: grind and sublime, and ultramarine azurium will be made by a slow fire.

Another way: take twelve drachma[147] of mercury, four of living sulphur, and three of sal ammoniac.

Another: take two parts of mercury, a third part of sulphur, and an eighth part of sal ammoniac: pulverize and put into a luted glass [vessel] with a constricted neck, and hole luted. [A] moderate fire is applied for half a day and then increased. If blue smoke comes out it is finished, and so on. Others say [use] twenty-two weights of mercury, eight of sulphur, four of sal ammoniac; and follow the procedure given for usifur.

27

HOW AND FROM WHAT IS CERUSSA MADE?

Cerussa[148] is made thus: take lead plates and suspend them above the vapors of strong vinegar in a stout jar; close the vessel and put it in a warm place, then follow directions for [making] green copper. You will find cerussa adhering to the plates; scrape off and save until you have a large quantity and then make minium.

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[147] About the same as our dram. By apothecaries' weight one dram is one-eighth of an ounce or 3.888 grams.

[148] "Cerussa (our white lead), used as a pigment, and externally in medicine, was obtained by submitting lead to the action of the fumes of vinegar in closed vessels for ten days, after which time the 'rust' was scraped off, and the process repeated." (Stillman, *op. cit.*, pp. 19-20.) This is the centuries-old Dutch process still used for making white lead.

28

HOW IS MINIUM MADE FROM CERUSSA?

Minium from cerussa[149] is made thus: crush cerussa well with water upon the stone, and form into the shape of lozenges[150] and place in an earthen vessel shaped like a basin[151]—neither round nor long. [For support] first place a large jar on a stone or on two clay walls, each one span high; place the jar on them so that its mouth lies on one wall, and the bottom on the other. Then put a *vasculus*[152] containing cerussa inside the jar and close it with another vessel fitted to it.[153] Now apply a slow fire, then increase it through half a day; allow to cool, and you will have cerussa, moderately red.[154] Again repeat, grinding for half a day, then take it out, and you [will] have good minium.

29

HOW IS MINIUM MADE FROM LEAD ASHES?

Take a jar and place it above two walls, as I have described above; put in some lead and heat strongly. When it [the

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[149] Casey (*op. cit.*, p. 386) says of this procedure, that by heating the cerusite, litharge, the yellow oxide of lead was obtained. By carefully regulating the heat the litharge was converted to red lead or minium, otherwise, strong heat would have produced litharge again. Lead was, of course, known in antiquity, and cerusite or native white lead was used then as today for a pigment.

[150] *pastilla.*

[151] *bacinus.* A small basin.

[152] A vase-like vessel.

[153] The alembic. See below, chap. 35, n. 174.

[154] This is very close to our modern method. "When white lead, massicot, or finely ground litharge is heated in air at about 340° it absorbs oxygen and forms a scarlet crystalline powder, red lead or minium . . . Above 450° this decomposes again into lead monoxide and oxygen." (Partington, *op. cit.*, p. 839.)

lead] has liquefied, stir continually with a long iron spoon, so that it quickly burns to ashes. [Continue] to do this until the whole has burned; sift what remains when cooled through a linen cloth or fine sieve. Place again in a jar, stirring as before until all of it is reduced to a fine powder; then sift again onto a stone, crush once more with water, and treat it in every way as I taught about cerussa, grinding and roasting, until you have minium.

Addition. Minium is also made thus: put five or six pounds of Lead into whatever pot you wish, melt by strong heat and grind the iron within the vessel until the whole has been completely pulverized, and leave quietly for two hours. Moisten with urine, and heat it in a pot, which has been well warmed for one-eighth hour, above the fire for three hours. Let the fire die down by itself; the material will then have a red color. Afterwards it should be ground upon a table, then poured into small vessels,[155] and left in a suitably warm fire for a day; then it is finished.

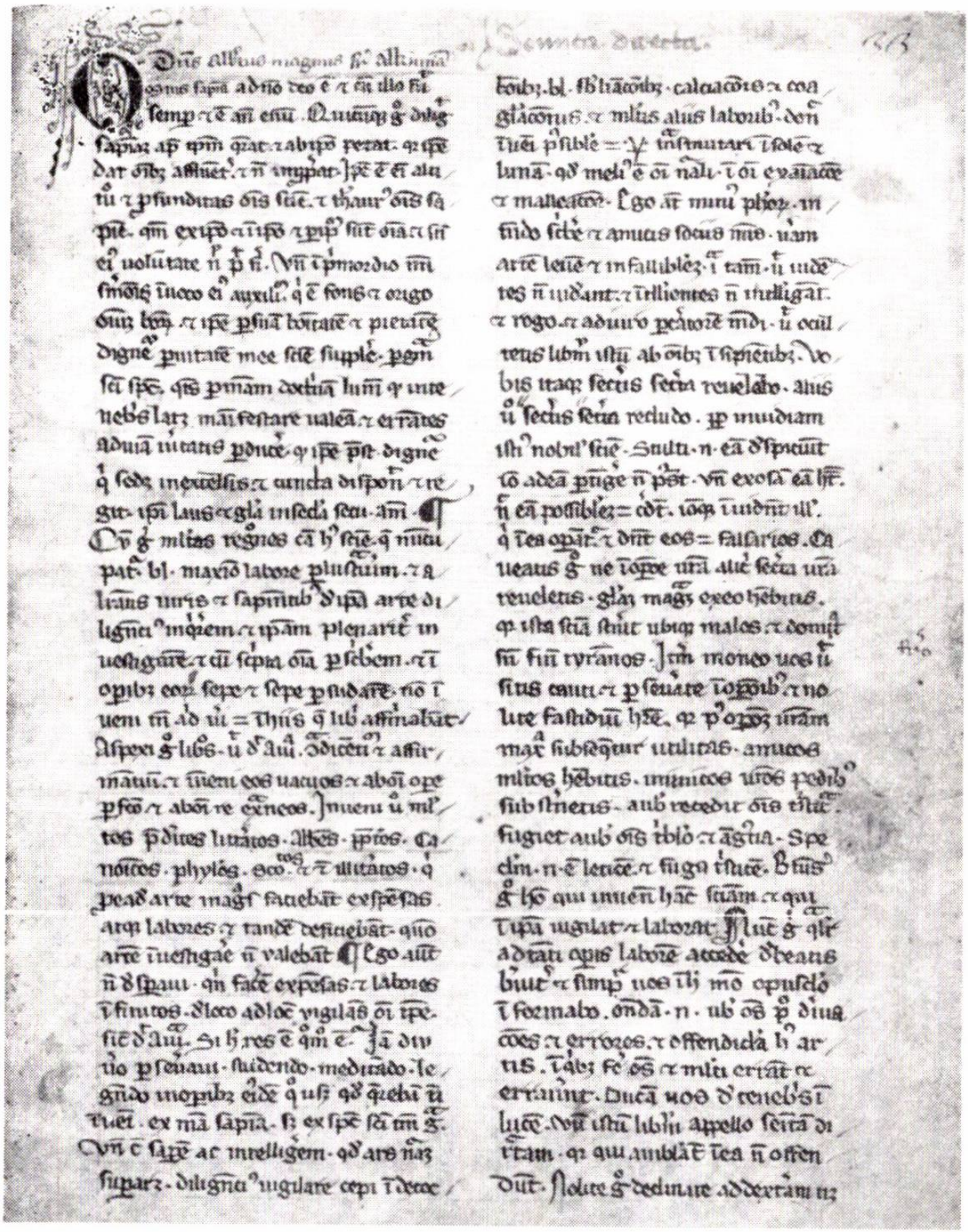
Another. Take a third part of rock salt, two parts of red arsenicum, and just as much of quicksilver, mix together, and thus you will have minium.

30

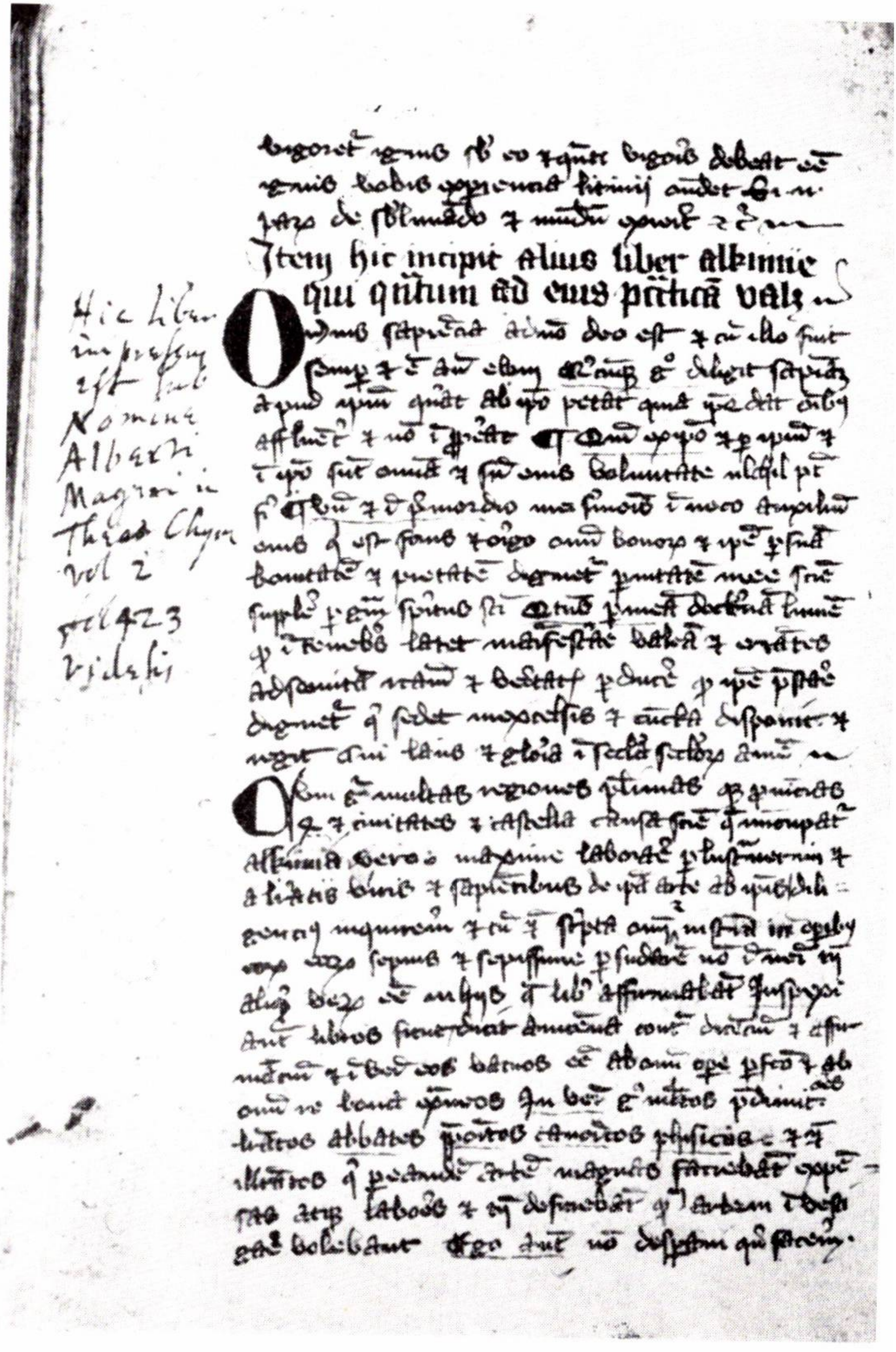
WHAT IS SUBLIMATION AND IN HOW MANY WAYS CAN IT BE DONE?

Sublimation is the volatilizing of a dry substance by fire, causing it to cling to the sides of the vessel. Sublimation in fact is diversified according to the diversity of the spirits of those things to be sublimated. One kind [is accomplished] by ignition, as with marchasita, magnesia or tuchia; another with moderate ignition as with mercury and arsenic; and still another with a low fire as with sulphur. Indeed, in one

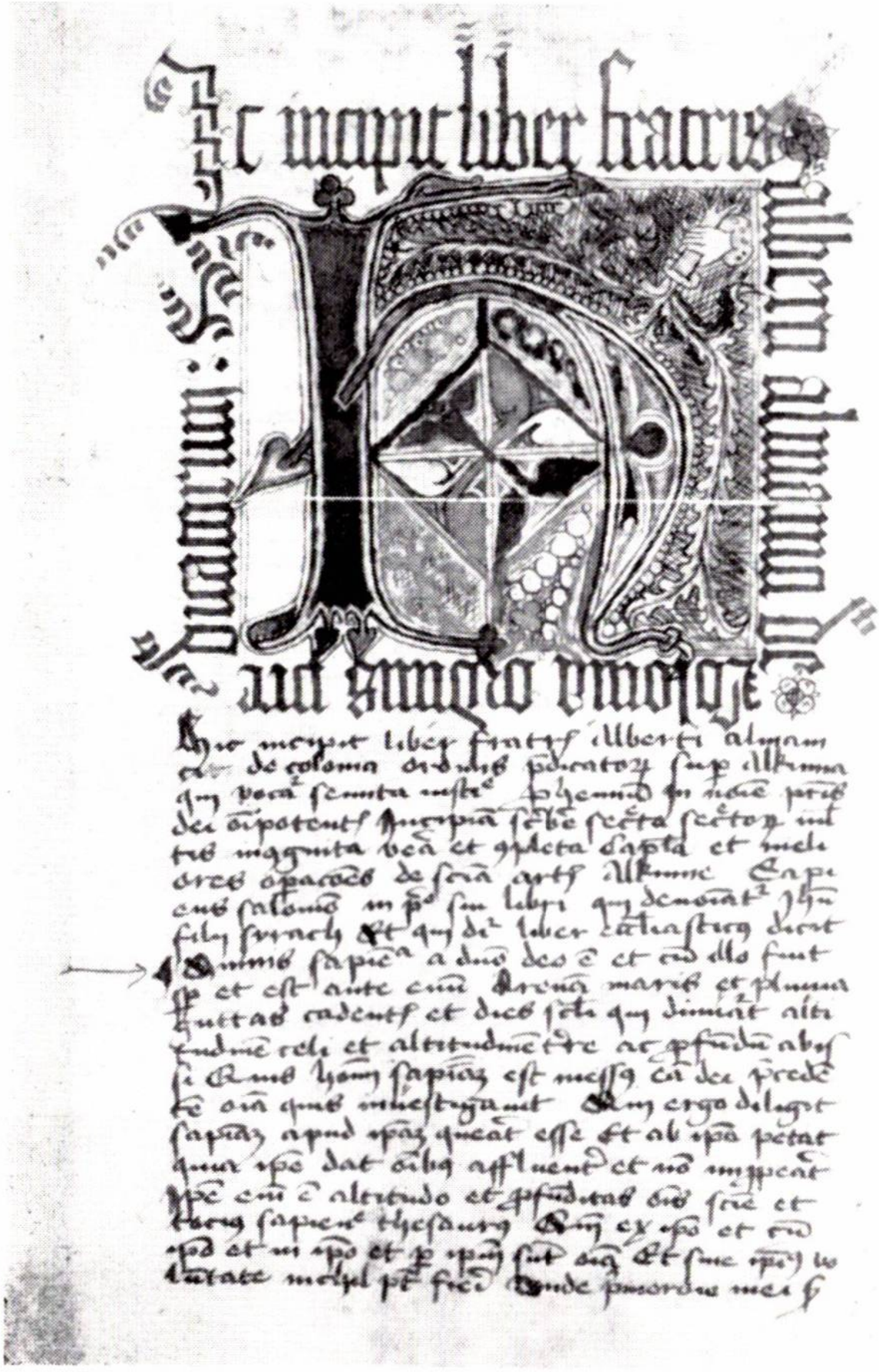
[155] *canna,* a reed-pipe; a small vessel.



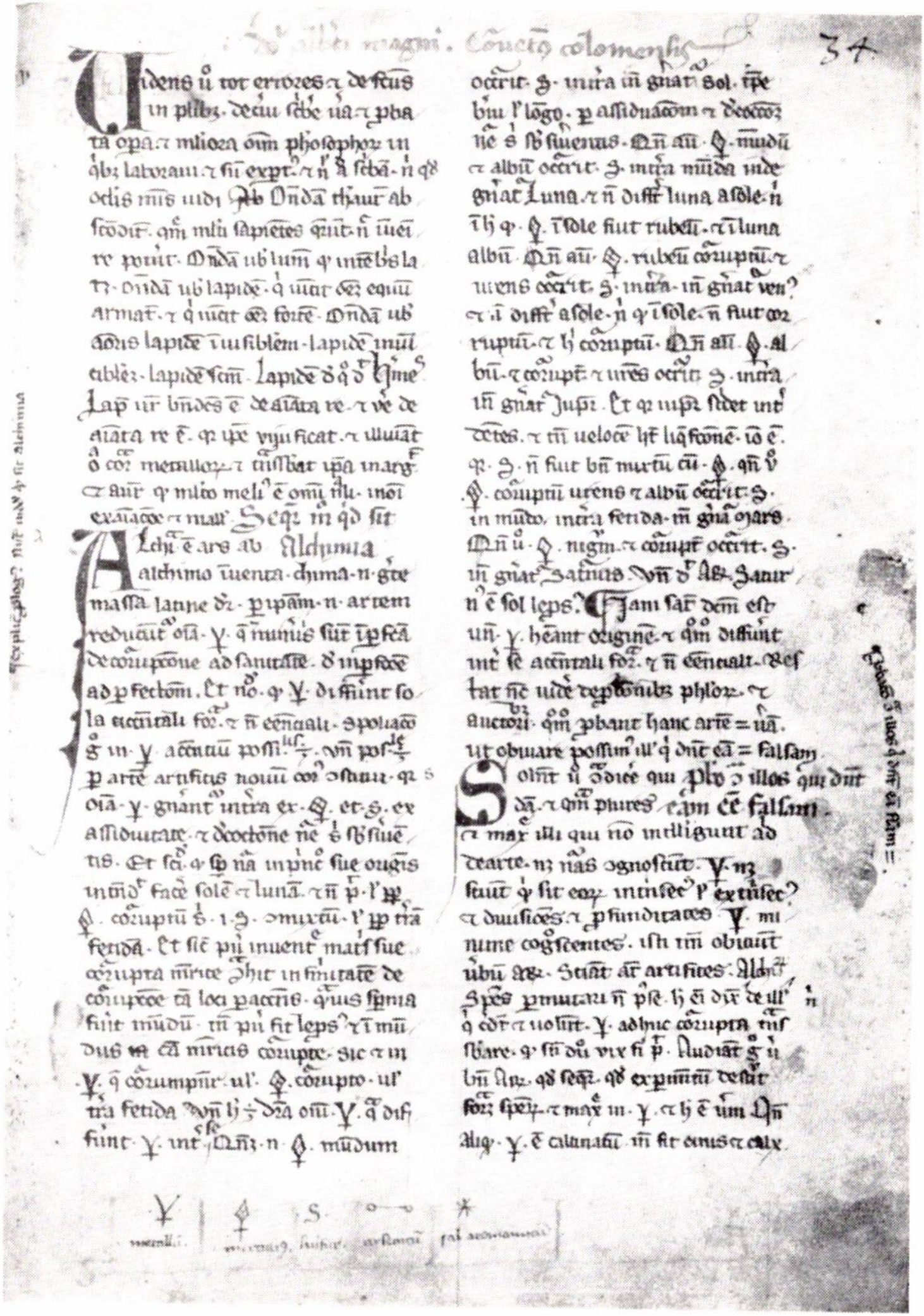
Biblioteca Apostolica Vaticana, Palatine MS 978, fol. 33.



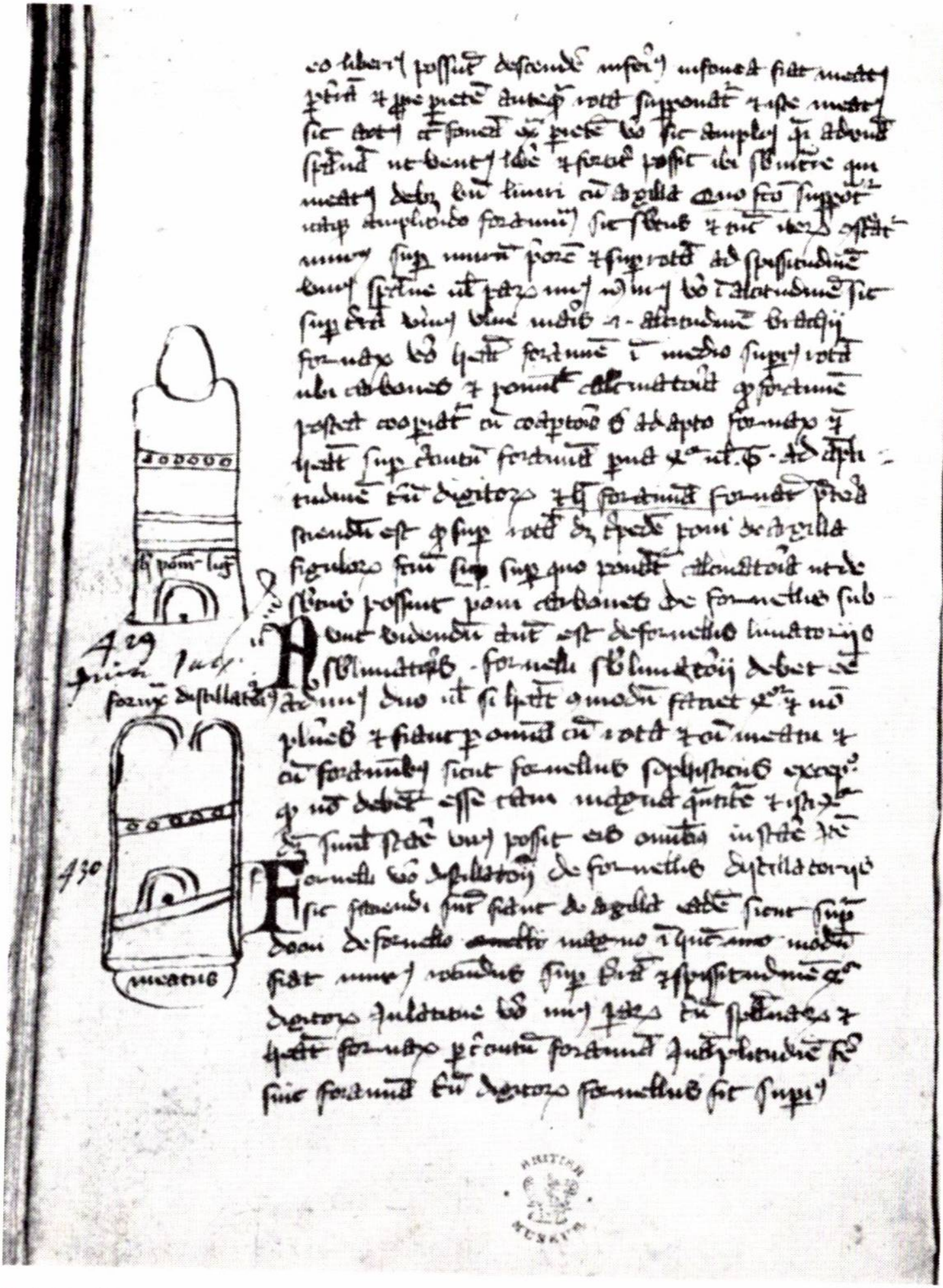
British Museum, Sloane MS 323, fol. 61v.



Biblioteca Apostolica Vaticana, Palatine MS 1330, fol. 56r.



Biblioteca Apostolica Vaticana, Palatine MS 978, fol. 34. The use of symbols for metals.



British Museum, Sloane MS 323, fol. 68r. Marginal drawings of furnaces.

¶ lutū furnoy q° sit

& argilla figulor optime mixta, et add̄ harenā parū, et sterc̄
conterē, quo facto fac murū sicut dixi sup̄ stercum ī alti-
tudine duor pedum uel parū min̄, et ad spissitudinē spāne
unī et permitte siccari, et tūc habeas rotā factā de argilla fi-
gulor valde bonā que ign̄ forte possit sustinē, que sit per-
forata lx^ta uel xl^ta foraminib uel pluribus sm̄ q̄ntitatē rote
ī quib foraminib possis ponē digitū minimū. et foramina
sint superi magis lata q̄ superi ut lapilli et carbones re-
manentes ī foraminib liberi possint descendē. Inferi uero
ī terra fiat medietas inter terrā et parietē ante q̄ rota sup̄ ponat̄
et iste sit arcus contra focum. Extra illū parietē ampli⁹
quasi per unā spānā ut possit intrare. que intus debet linire
cum argilla. Quo facto superpona rota. Murus uero sit p
altitudine super rotā unius cubiti. Fiunt uero habere foramen ī
medio sup̄ rotā per quod carbones imponant. Superi habeat
foramen ubi vasa calcinatoria imponant̄ quod foramen coope-
retur poster cum cooperitorio sibi apto. Fiunt q̄ habere per
circuitū foramina parvula quatuor uel sex uel plura ī am-
plitudine trium digitor. Et hec est fac^a fabrica. Preterea sciendū
est q̄ super rotā ponēdus est tripodis de argilla figulor fac-
tus super quod vasa calcinatoria ponant, et ut de sub̄ ponat̄
carbones sicut patet ī figura.

¶ furnū sublimatorū q° sit

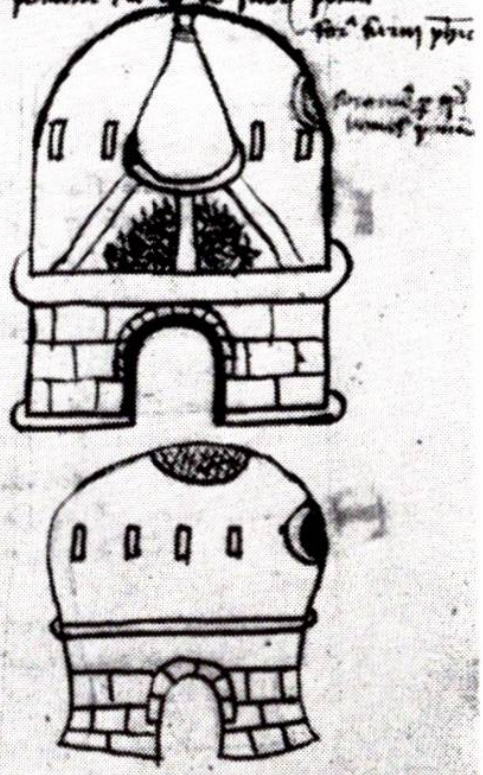
De furnellis sublimatoribus

Nunc videndū est de furnellis sub-
limatoribus qui ad min̄ debet esse
duo uel q^tor. et fiant per ord̄ ēē
crete et mediū et foraminib sic
fiunt phiales, excepto q̄ nō debent
esse tante quantitatis, et esse debent
simul stare, ut unus ign̄ possit alios
supplē et ministrare.

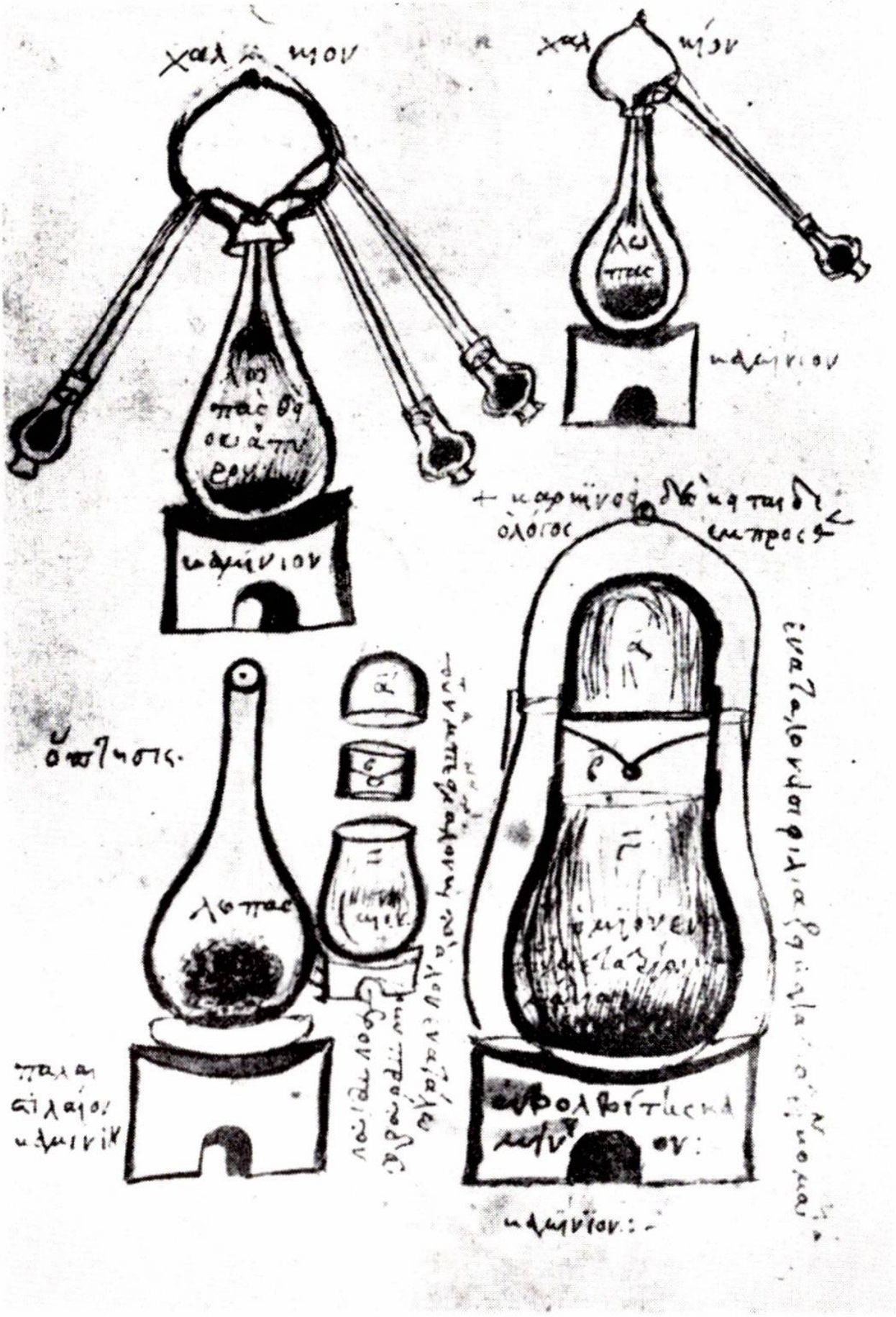
¶ furnū distillatorū q° sit

De furnellis distillatoribus

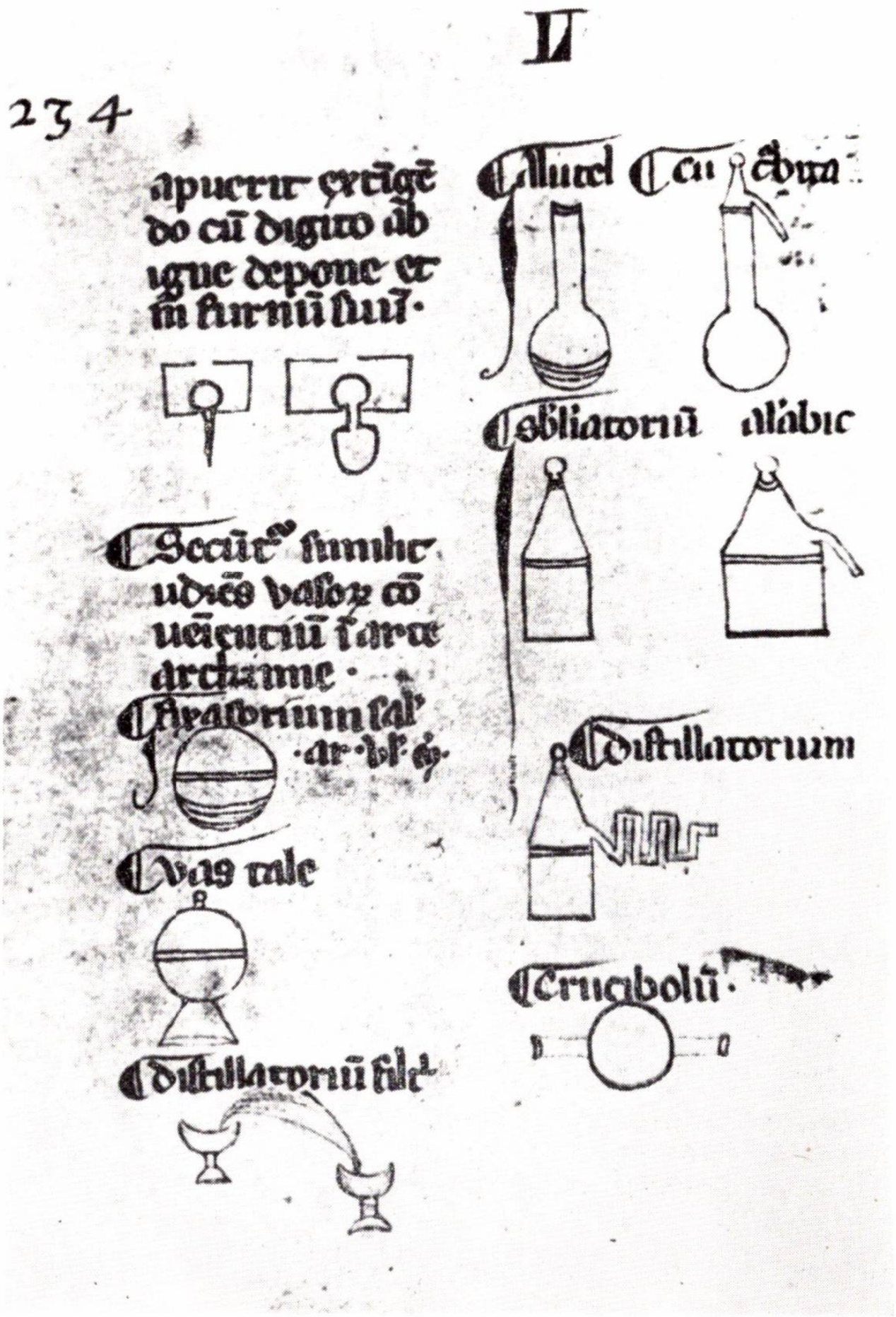
Furnelli distillatorij sic fabricādi sūt
fiant de eadem argilla sicut sup̄ dixi
de furnello phico ī hūc modū. Fiat
min̄ rotundus sup̄ terrā ad spissitudi-
nē quatuor digitor, in latitudine
nō trium palmar uel min̄, et habeat
ī circuitu foramina q^tuor uel plura ad
latitudinē trium digitor. furnus uero



Bologna, Biblioteca Universitaria, MS 104, fol. 174v. Text drawings of furnaces.



Florence, Medicea-Laurenziana, Greek MS 86-16, fol. 85^{v}. Drawings of alembic and digestion vessels. Reproduced from Giovanni Carbonelli, *Sulle Fonti Storiche della Chimica e dell'Alchimia in Italia*, p. 109. Top left: alembic with three pipes; top right: alembic with one pipe; bottom left: a digestion vessel; bottom right: apparatus used to whiten mercury or to sublime arsenic; detail of this vessel in three sections.



Bologna, Biblioteca Universitaria, MS 184, Liber Ebubacre, fol. 234. Alchemical apparatus. Reproduced from Giovanni Carbonelli, *Sulle Fonti* ... , p. 110. Left column: indefinite form; vessel for fusion of sal ammoniac or mercury; iron vessel, with cover, for fusion; a filter set-up. Right column: an aludel; cucurbite; sublimatory; alembic, distillatory, crucible.

type of sublimation of mercury the separation of its earth will result and there will be a change in its fluidity. On the other hand, it is natural that superfluous earth very often is mixed with things with which it has no affinity,[156] hence its sublimation has thus to be repeated more often. Examples of these are the calx of eggshells and of white marble, and finely ground glass, and every kind of prepared salt. From these latter, it [the earth] is cleansed, from others it is not, unless the bodies are [in a state of] perfection; however, they are rather more corrupt, because all such things have sulphureity which, ascending with it in sublimation, corrupts the work. Because of this, if you sublimate from tin or lead you will note that after the sublimation it is contaminated with blackness. Therefore, sublimation is better accomplished with those things with which it does not agree [in nature]. However, sublimation, in general, would be more readily accomplished with those things with which it [the substance to be sublimated] agrees [in nature] if it were not for the sulphureity [in any of the components] with which it does not agree [in nature].[157] A method of removing moisture is to mix and grind with calxes—with which the sublimation should be done—until the metal can no longer be detected, and then the moisture is removed by slow heating. As [the moisture] of [the mixture] recedes, the moisture of the mercury will recede

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[156] Albertus Magnus "introduced the word affinity to designate the cause of the sublimation of the metals with sulphur." (F. P. Venable, *History of Chemistry,* New York, 1922, p. 24.) This is the only occurrence of the word *affinitas* in the text of the Borgnet edition. See also above, chap. 14, n. 89.

[157] *Et propter hoc si sublimas a stanno vel plumbo, post sublimationem ipsum conspicies nigredine infectum: ergo melior est sublimatio per ea cum quibus non convenit: melius autem esset cum eis cum quibus convenit, si sulphureitatem non convenit.* This is a knotty sentence to untangle. The writer seems to be saying that: sublimation would be more easily effected with a mixture or compound of substances of a like nature, if it were not for the sulphureity which is of a contrary nature.

with it, as I shall teach you in the following sublimations of spirits.

31

WHAT IS CALCINATION AND IN HOW MANY WAYS CAN IT BE DONE?

Calcination of any kind is the pulverizing of substances by fire to remove the moisture uniting the parts. Bodies diminished of their own perfection are calcined.

There are also different kinds of calcinations. Bodies are calcined so that the sulphureity corrupting and defiling them may be removed. In fact, each sulphureity may be burned from the substance with which it is combined, but which without calcination cannot be removed. Soft bodies are, indeed, particularly hardened by it, but they [also] take an impression more clearly and harden more readily.[158] Spirits are calcined the better to fix them and bring them more quickly into solution. Every kind of calcined body is more fixed, and more easily sublimed than the uncalcined; hence, soft bodies can be easily calcined through fire; hard bodies need very strong fire [to be calcined], as I shall teach you at the end [of this book].

ADDITION. Silver[159] may be calcined thus: take an ounce of purest Silver, or more if you wish, and from this make plates thin as the [finger] nails of the hand. Add a third part of common salt, from the preparation commonly prepared and calcined, and a fourth part of sublimated mercury, making a powder of said mercury and salt by grinding. Afterwards cement the plates together in the sublimatory, by placing first a layer of the powder, then a second layer

[158] This probably refers to some kind of stamping test; the susceptibility for the impression being related to the hardness of the body.

[159] That is, Luna.

of the sheets, and follow layer by layer; then sublime with a slow fire until all the moisture of the mixture evaporates. Close well the opening and increase the fire through the natural day; take care not to remove the vessel from the fire immediately, but let it cool [for] three hours. Do not open the vessel until it is cold, because the spirits will evaporate. When the vessel is cold, take out the sublimed mercury, clear as a crystal, and set [it] aside; then take out the silver that remains half-calcined with the common salt. If possible, crush the salt and the half-calcined Silver at once above the *porphyry*.[160] If it cannot be ground, put it into a glass *cassola*[161] and separate the whole salt with fervent waters,[162] until you perceive no salty taste; dry the remaining calx in the bottom of a *paropsis*,[163] and calcine once again with new salt and mercury sublimed five or six times. Alternate the calcining and washing of the Silver calx until you detect no salty taste. Your calcined Silver will then be the whitest and cleanest [kind], like the rays of the stars, so that if you melt part of the said calx with borax, or with good sal nitrum or sal alkali, you will find your Silver converted to white gold.

32

WHAT IS COAGULATION AND WHY IS IT USED?

Coagulation is the reduction of liquid substances to a solid mass by deprivation of their vapors. It was devised to harden mercury and purify medicinal solutions of moisture mixed in them. Mercury is coagulated by its

[160] A purple stone found in Egypt; often used by alchemists instead of marble.

[161] A kind of saucepan with a handle.

[162] Perhaps alcohol was used here to precipitate the salt. "Fervent water" might also mean boiling water.

[163] A small dish.

frequent precipitation with violence to the dryness of the fire.[164] The dryness of the fire removes the moisture. This is accomplished in a long narrow vessel.

33

WHAT IS FIXATION AND IN HOW MANY WAYS ARE BODIES FIXED?

Fixation[165] is the appropriate tempering of a volatile substance in fire. It was devised so that every coloring, and every alteration is perpetuated in another and is not changed: for bodies, whose perfection has been diminished[166] through calcination, are fixed when they are freed from corrupting and volatile sulphureity. Sulphur and arsenicum are fixed in two ways: one method is the repetition of their sublimation from one state to another,[167] or until they achieve stability. Spirits are also fixed in another way, either with the solutions of metals or with oil of tartar,[168] as I shall say below.

Addition. Take sublimed mercury, an equal amount of sal ammoniac, and sublime seven times, or until melted, [then] let the stone remain at the bottom; crush it and expose to damp air so it will become a liquid. Soak metallic arsenicum in this water, dissolve in distilled vinegar, and

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[164] In Aristotle's concept of the four elements both fire and earth were dry (earth = cold and dry; fire = hot and dry) but fire represented dryness preëminently.

[165] Fixation to the alchemist meant the stabilizing of a substance by removing impure vapors by heat or by converting them into another form.

[166] See above, chap. 30.

[167] *super illa in aliis,* from the nonsublimed to the sublimed state.

[168] Stillman says (*op. cit.,* p. 293), in speaking of the recipes of alchemists, "The preparation of a concentrated and purified syrup (oleum) of potassium carbonate from the ignition of tartarum (argol from wine) is given with elaborate detail." See above, chap. 23.

distill seven times, or congeal, and dissolve, and a stone will result.

Metallic arsenicum[169] is made by melting one part of arsenicum with two parts of white soap. Another [procedure] is given in Geber's [*Liber*] *Fornacum*:[170] where you may read [it], if you wish.

Either sublime mercury, or sulphur, or prepared arsenicum, or several of these, at the same time, along with sal tartarum or saltpeter, or sal ammoniac. Do this many times until they remain fixed, then extract [them] with warm water.

34

WHAT IS SOLUTION AND IN HOW MANY WAYS IS IT DONE?

Solution is the resolution of any calcined substance into water. It was devised so that the intrinsic qualities of substances might become extrinsic and vice versa, and so that they might be made suitable for distilling; thus they are freed from every contamination. Solution is achieved either by heat and moisture or by cold and moisture, as I shall teach in the following [chapters].

ADDITION. Some [substances] dissolve after being calcined with an equal weight of sulphur, with water or the juice of limes,[171] in a closed crucible.[172]

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[169] "Although the Greeks and the Romans used a substance which they called 'arsenic' this was not the metal itself. The so-called 'arsenic' of the ancients consisted of the poisonous sulphides, orpiment and sandarac, mined with heavy loss of life by slave labor. No one knows who first isolated the metal, but this honor is sometimes accredited to Albert the Great . . . who obtained it by heating the orpiment with soap." (M. E. Weeks, *Discovery of the Elements,* p. 10.)

[170] See above, chap. 18, n. 106.

[171] *succo limonum.*

[172] *crucibulo.*

35

WHAT IS DISTILLATION AND HOW IS IT DONE?

Distillation[173] is the rising of the vapors of a liquid in its own container. There are different methods: with and without fire, that with fire is of two kinds; one, through rising vapors, as with an alembic;[174] the other through a descensory,[175] as with a pipe, and through fire superimposed on vessels.

The general purpose of distillation is [the] purification of a liquid from its dregs. We can see that the distillate is rendered purer [than the original liquid]. The special purpose of pure water is the imbibition of spirits and clean medicines, so that we can have a pure solution when we need one, for the dregs that can contaminate our medicines and purified spirits will have been removed. Distillation was invented to extract, through a descensory, an oil pure in its nature, whenever we cannot [evidently] have an oil combustible in its nature, as is true of petroleum. However, distillation, through filtration, is devised solely to obtain a clear liquid.

ADDITION. Mercury is sublimed thus: take an ounce of dry vitriol and one of previously calcined common salt, pul-

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[173] Distillation is a very ancient process. Among the earliest descriptions of the process is that of Dioscorides Pedanus, a Greek physician of the first century, who described the distillation of mercury from cinnabar. The substance to be distilled was put into a vessel the mouth of which was covered by a wet cloth to condense the vapors. Later the cloth was wrung out to collect the distillate. (Stillman, *op. cit.*, pp. 70-71.)

[174] Alembic vessels had two parts: the lower, shaped like a gourd; the upper, which received the steam condensate, had a beak fitted to the neck of a receiver. This vessel is today replaced by the retort. The word comes, of course, from the Arabic, *al-inbiq;* Dioscorides Pedanus called his distilling apparatus an *embic.*

[175] *per descensum.*

verize, mix, and [in turn] add to this time and time again, one ounce of mercury. Grind well together by sprinkling with some of the partly distilled vinegar, so that it may be better fortified; [or even better] use a little *aqua fortis*,[176] which will be even stronger, then place it in the sublimatory. If this be made of glass, [place it] in the midst of ashes and let it be luted with Cretan earth pulverized with flour mixed with egg albumin. If the sublimatory be of earth, lute it with potter's clay and quicklime, moistened with horse dung and salt water [according to] the best papyrus [manuscript], and place it above the coals.

36

WHAT IS CERATION AND HOW IS IT DONE?

Ceration[177] is the softening of dry and nonfusible substances. It is clear that this process was invented to mollify a body with a view to change (or inceration) and thus permit penetration of other substances, for a body deprived of liquefaction permits no penetration. Some think that ceration should be done with liquids and liquid oils, but that is an error; for in no substance is the whole moisture found better than in sulphur and arsenicum. By this method [sulphur and arsenicum] their sublimation may be multiplied a great many times because of the softened substance, to the point where, finding moisture in them, they attain a good fusion; on the other hand, this cannot be accomplished without perfectly cleansing them of all corruption. But it seems better to me that their oils should first be fixed by oil of tartar and with these oils every ceration can suitably be made. Concerning these things this will suffice.

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[176] Possibly *nitric acid*.

[177] Ceration, a word now obsolete, is the softening of a hard substance or reducing it to a waxlike state.

ADDITION. Ceration is necessary in all elixirs whether of spirits, of stones, or of bodies; in this all philosophers agree. It is done in this way: a body is [said to be] cerated when it appears as soft as wax and floats above the water. Dissolve [the elixir] in a phial[178] placed in dung, then distill once, and remove the dregs, which are somewhat blackened, then harden in a small furnace. The signs of transmutation are: if a little of the congealed elixir melts when placed in a crucible above a fire, it is good: if it does not, go back over the process.

37

HOW IS MERCURY PREPARED AND WHITENED LIKE SNOW?

Take a pound of mercury, crush on a stone thus: take the calx of eggshells, or of white marble, or of green copper, and put on a stone; pour over enough strong vinegar to make a paste; add a little mercury, rub until it disappears, and once again add a little mercury and rub as before [or rub] all together until no mercury is seen.[179] Make the paste into small lozenges[180] and place in a vessel until [no mercury] is seen. Make lozenges of this, and put on [a container], made in the form of a *scutella*,[181] and dry in the furnace with moderate heat, lest the mercury volatilize by overheating. Take one pound of mercury and one of the calx, a measure of [sal] ammoniac, so that there is always as much calx as mercury, and grind until the mercury disappears. When well dried, [grind] with vinegar until

[178] *phiala;* Gr. φιάχη, a broad, flat, shallow cup or bowl. Today, a small glass bottle (vial).

[179] When mercury is triturated with powders, such as chalk or eggshells, it is formed into very minute globules.

[180] *tunc facies ex hoc frustula ad modum pastillarum.*

[181] A salver, tray for vessels.

the mercury cannot be seen. A sign of perfect grinding is to moisten it with a little saliva, smear it on a silver coin,[182] and [observe whether] the mercury will fail to cling to it. If it does, then it is not well rubbed. When it is satisfactory, grind it very finely and evenly, and place in the sublimatory, completely covered.

When you put the medicine [in a vessel], do not fail to brush its surface [level] with a feather. Close the container with potter's clay, smeared well in the joints to prevent leaks, and place on the sublimation furnace and apply a slow fire through half a day until the moisture evaporates. Test with a plate until it is no longer moist; then, when dry, close well with potter's clay and apply a stronger fire, and finally the greatest heat. When night comes allow [the vessel] to cool. Open [it] in the morning and [note that] what has not reacted appears in the upper part of the aludel;[183] the other part [lies], like snow, on the dregs, pulverizable around the lower walls of the vessel, and sometimes on the upper part. Collect and save this. Now, as before, grind the unreacted part with the dregs, and sublime until all is reacted and is pulverizable. Do not add the least liquid to it, because it will regain its vivacity, and your labor will be in vain. Then, take one part of prepared salt, as I have taught, well purified and dry, add to it one-half part of sublimed mercury, mix together with the hand, and put into a sublimation vessel; level off, close and sublime as described above. In the morning take out what is sublimed, collect and test [it]. If anything remains in the dregs, note this: quickly take the salt from the dregs and put it above coals; if it fumes, sublime, as before, [for] a second day; afterwards diligently collect all the sublimate.

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[182] *denarius.*

[183] A pear-shaped pot open at both ends so that the neck can be fitted into the bottom of a similarly shaped second pot; used as a condensing tube in a sublimatory.

On the third day sublime with new salt, and continue as before, and you will find it whiter than snow. Then test to see if anything remains in the dregs; [if] so, sublime until all is recovered. Then, once again, take new salt and do as before, four or more times up to fixation, and set aside.

ADDITION. Also, it is best calcined from talc.[184] Master Joide Meun[185] in his great work adds green copper; this, however, is contrary to Geber who, in his chapter on sublimation of mercury, says that it should be sublimed with those substances which have no sulphureity, and so on.

A better way to sublime mercury is given by Rhases[186] in his book of *Divination*, the twenty-third [chapter] of the seventieth [book]. Crush well one part of rock salt, [and] one of Egyptian atramentum; then place above them a quantity of quicksilver equal to the others and crush all of it well. Place [the substance] at the bottom of a pergamen aludel,[187] and above this put roasted rock salt, to which a medicine may be added after it is dried, because no fluid remains in it. [Now] light a small fire under it, then in-

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[184] *talco*. Talc is a magnesium silicate.

[185] Jean de Meun (1280–1365), French poet, satirist, translator of Boethius and others, and master of the literary and scientific knowledge of his time, has had many apochryphal writings in alchemy attributed to him. (See Sarton, *op. cit.*, II, 929.) He lived, of course, at a later time than Albertus Magnus, hence this paragraph represents another late addition to the text of the *Alchimia*. Cf. above, chap. 18, n. 106.

[186] Abu-Bakr Muhammad ibn Zakarīyā al-Rāzi (commonly, Rasis, Rhazes), a Persian physician who lived in the late ninth and early tenth centuries. He was the author of numerous medical works several of which were translated into Latin in the twelfth century. As with Aristotle, Djaber, and Avicenna, many treatises on alchemical matters written in the twelfth and early thirteenth centuries were ascribed to Rasis. According to Steele (*op. cit.*, p. 10), the *De aluminibus et salibus* of Rasis was translated into Latin by Gerard of Cremona (1114?–1187) from a text altered and interpolated by Moorish alchemists. See also Thorndike, *op. cit.*, I, 667-669; II, 751-808 *passim*.

[187] Pertaining to Pergamum (Pergamon), chief city of ancient Mysia in Asia Minor. Under the Attalid dynasty in the third century it was the capital city and a notable literary and art center.

crease the fire until the quicksilver is sublimated; then collect, grind well, and sublime it. Let the aludel head be broad in the first part, then successively smaller and narrower in the next part down to a palm's width. It [the mercury compound] will then sublime in crystals under the shield head of the aludel. That [substance formed] above the shield will not be made a stone, but will be a white powder. Do this seven times. If it becomes solid above the fire, and makes a burning slab,[188] this will be well, and if not, repeat the sublimation with atramentum and salt, so that it will be confined above the head: for, in fact, it may flow (or cling) and make a white slab and be pure silver.

If you sublime mercury more often, you should, each time, diminish a fifth part of the dregs. If you sublime with vitriol and salt, as above, they should be roasted.

The clay used for closing the cracks may be [made] from ashes, potter's clay, and common salt dissolved in urine. Some persons [use] egg albumin and quicklime.

38

HOW IS SULPHUR DISSOLVED, WHITENED, AND FIXED?

First, boil sulphur in strong acid for a whole day. Let it first be well ground, and remove the supernatant scum. Afterwards allow to dry, grind it, and add as much of the prepared alum as I have taught, and put into the vessel for sublimation for mercury, knowing that less fire is to be applied than [in the case] of mercury; turn down the fire and slowly sublime for a whole day. Take [it] out in the morning and you will find it sublimed and black; sublime a second time and it will be white; sublime a third time, with salt added, and it will be very white; again sublime

[188] *tabulam ignitam*. The term is not susceptible of modern interpretation, since the substances used were impure.

a third and a fourth time up to the fixation point and set aside.

ADDITION. It is sublimated like arsenicum but needs more vigorous and longer boiling.

39

HOW IS AURIPIGMENTUM WHITENED?

You should grind auripigmentum and boil it one day in vinegar, and another in urine. Then add to it a like amount of black iron powder,[189] mix well, then sublime, doing everything as I taught concerning sulphur, and it will become white.

ADDITION. Auripigmentum is called yellow arsenicum. Auripigmentum is prepared from vinegar and salt until it rises clear; there is no better way of purifying it. Rhases says the same elsewhere: salt is best of all for this preparation.

40

HOW IS ARSENICUM WHITENED?

Arsenicum is of the same nature as auripigmentum, but it is not necessary to boil it. Therefore, grind well and soak up[190] with strong vinegar[191] (Roger[192] says with distilled

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[189] *fuligine ferri.*

[190] *imbibe.*

[191] *aceto forti.*

[192] Doubtless refers to the great Franciscan theologian and philosopher Friar Roger Bacon (1214–1292), a younger contemporary of Albertus Magnus. Bacon was traditionally thought to be a practitioner of alchemy and magic and a great number of treatises on these subjects were, as with other well-known clerics, falsely attributed to him. Among his numerous authenticated writings the greatest are: *Opus Maius, Opus Minus,* and *Opus Tertium* dealing with physics, mechanics, chemistry, and other sciences. See Thorndike, *op. cit.,* II, 616–691; and Sarton, *op. cit.,* II, pt. ii, 959. See also below, chap. 53, n. 222.

vinegar, as you will see, when he speaks of the calcination of bodies) [193] two or three times, or four, and dry as many times. Then it can be reserved as a powder which will be suitable for calcining bodies. But if you wish to sublimate, grind well by itself and add to it the same amount of black iron powder. Sublimate seven times or more, following all [that] I have taught concerning mercury, and it will be whiter than snow.

41

HOW IS SAL AMMONIAC PREPARED?

Sublime the sal ammoniac thus: crush it well with a certain amount of common salt, carefully prepared without any fluid; sublime over a low flame for three hours, then over a high flame for a day. Remove [from the flame] in the morning and reserve the sublimate; do it all as I have taught for mercury. With these[194] dregs, sublime two or three times, save, and [set aside].

ADDITION. With a prepared solution of common salt soften the sal ammoniac, then dry and repeat the softening and drying several times until the sal ammoniac will take up a quantity of salt equal to itself; then use this. When the sal ammoniac has been dissolved in vinegar and distilled through a filter and dried in the sun, add [to it] an equal amount of burned salt and let [them] be ground together in a closed vessel [195] and [placed] in hot ashes. The [sal ammoniac] will then be sublimed without any other imbibition and it will be sufficiently prepared for every use. This is proved if it melts without fumes over a red-hot plate. These [ideas] are Roger Bacon's.

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[193] *corporum*.

[194] Parenthetically in the text: (*alibi novis*), elsewhere, new.

[195] *in cluteo*. Perhaps an error in spelling: *cludo* (*claudo*) derived from *occludo;* that is, "in a closed [vessel]."

Some persons sublime with rock salt, but this salt should be very well dried before a fire and should be very well ground up with sal ammoniac.

Others sublime with common salt and prepared talc ground together with a layer of the prepared common salt, and placed in a circle of the sublimatory, and sublimed well four or five times.

Sal ammoniac prepared according to Rhases: take the crystallized sal ammoniac, crush well with sea foam[196] and sal nitrum, sublime it (place it in the bottom of a pergamen aludel, and above a layer of roasted salt). Take the sublimed substance and boil it in pipes[197] with water [in order] to dissolve it. Distill or dissolve it in a bladder or cat's bladder[198] above the water, then distill it and then work from this.

It is difficult to dissolve fixed sal ammoniac. Therefore, imbibe it in vinegar and place [the aludel] in dung, for [in this way it] will indeed be dissolved and then distill it. Take care that you do not take all the water, but only as much as you have put on the spirit you wish to dissolve.

42

FROM WHAT SUBSTANCES IS FIRE MADE?

Since the principle of sublimation of spirits has been presented, it remains now to investigate the substance of fire. I assert, therefore, that fire should be made of coals for two reasons: first, because it is less work to lay coals than wood; second, because wood gives much more smoke and, because of the smoke, the work cannot be observed well.

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[196] *spumae maris.* That is, salt water from the sea.

[197] The alembic often had one or more pipes.

[198] *kisti fellis.* Gr. σάκκος, = sack, bag; Lat. *feles,* cat. The bladder is here used as a dialyzing membrane.

Vessels are broken by the heat of the fire, as happens oftener when the clay is not good or they [the vessels] are not well-baked. And when they break to pieces, white smoke at once appears, which may easily be seen over a fire that is made from coals; hence when the vessels smoke let them be taken from the fire at once or else the sublimation will be lost. Take care that this does not happen.

Note that the upper vessel, namely an aludel, should be glazed, but this is not necessary for the lower [one]. It is customary also to harden the medicine that cannot be sublimed, on a scutella. This is not to be doubted, but it [the medicine] should be ground a second time and mixed with a little more of the dregs and it will be sublimed thoroughly.

43

ON THE FIXATION OF SPIRITS, AN ADDED CHAPTER [199]

The fixation of sulphur. Pulverize it and tie [it] up in a linen cloth, and boil in water with quicklime. First, half-fill the vessel with the calx, then add ordinary water at the top; do this so that the bag[200] does not touch the bottom of the vessel, but stands in the middle; that is, by tying well at the top and bottom, and by placing in it a small stone so that it [the bag] hangs down. Let the liquid boil for twenty-four hours, or about that, replacing with fresh hot water when the first liquid has boiled off; then draw off the sulphur, and boil in sweet water[201] so that it may be purged from the calx and then it will be finished.

The strongest water for fixing every spirit.[202] First, rectify the solution of the hidden white stone, namely, four pounds

[199] *caput additum* appears also in the Jammy edition.

[200] *sacculus*. A small bag used for filtering wine.

[201] *aqua dulci*. Probably refers to soft water rather than sugar water.

[202] *aqua fortissima*. Since the identity of "the hidden white stone" cannot be determined, it is difficult to name the "strongest water."

with one pound of calx of eggshells, by covering with earth and distilling; and do this often. Then in [to] this liquid, to wit: in one pound and a half, place two ounces of common salt prepared as in the second step, two ounces of the best prepared sal alkali, and one ounce of sal ammoniac sublimed four times, and one ounce of feather albumin, coagulated after its preparation. All these salts may be dissolved in this liquid, and with it, when it is fixed, all spirits, in a double cucurbite,[203] the vessel of which has been well luted. Thus says Arnold.[204]

Yet, much distillation, reduction of dregs, sublimation of salts, as well as solutions, are brought about with these salts and the resolution in the water distilled from it. This is done with spirits and without double vessels. Sometimes the spirits will be fixed in the seventh sublimation with the solution in the bottom of the cucurbite, by virtue of the salts, as a plate sustaining heat. Sometimes, in the fourth sublimation, a fourth part of the solution will be fixed, and it is then time to add the rest for completing the fixation of spirits.

Some persons say that sublimed mercury placed upon a tin or iron plate in a storage bin,[205] is turned at once into a liquid which is more easily fixed through solutions and congelations. Liquid removed from the white of an egg[206] and then purified with the calx of an eggshell, alum of Yemen, and sal ammoniac—an equal pound of each—is the best fixative [agent] of the spirits, superior to all liquids, as follows below.

Mercury will also be fixed in this way. Crush the sublimated mercury in a mortar with tartar and crude common salt; then sublimate, and again crush and sublimate. Continue this up to ten times or more, renewing, in each grind-

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[203] A vessel shaped like a gourd used with or forming part of an alembic.
[204] Refers to Arnold of Villanova; see above, chap. 22, n. 130.
[205] *cellarium*.
[206] *albuminibus ovorum*.

ing, the salt and tartar, and then the mercury will be fixed.

Mercury is also fixed in a double cucurbite in one day, with oil of tartar poured over it, by submitting it to a slow fire for the first two hours, afterwards continuing to build it up for a day, until no vapor rises. Then, this may be proved by uncovering the cucurbite or by opening the aperture or by putting in a hazel twig[207] to detect if there is still liquid at the bottom. If it is hardened, then it will be fixed; but if it is not, build up the fire for three [more] hours, then permit to cool; remove, grind, moisten, and repeat the cooking seven times.

Liquid mercury. Take some sal ammoniac and equal parts of sea foam, grind well, immerse in a single cucurbite and put quicksilver above, and what remains from this brush off, and distill with a low fire. A white liquid, which will be distilled at first, is useless. Afterwards, for a short time, increase the vigor of the fire and liquid quicksilver will be distilled, whether or not it has been worked or sublimed at the beginning. All fixed salts will fix mercury, just as sal ammoniac can fix by subliming it until the mercury melts.

Mercury is fixed with sal alkali and the calx of bodies, or with both, and this [is done] by a temperate fire, in a suitable vessel, because a moderate fire is conducive to a conservation of moisture for melting, but [an] excessive or too active fire is a hindrance or impediment to fusion.

Mercury can be fixed by sublimating between two well-sealed scutellae by turning and placing alternately the lower scutella over the upper [scutella], then the upper over the lower for fourteen or fifteen times, and then it will be fixed. Some persons say that this should be done in an iron vessel, and that this method is by the order of fire.

If you wish to make fixed sublimated spirits, dissolve the calx of the bodies with the liquid of sal ammoniac, and from this liquid imbibe them, because they shall have been fixed,

[207] *corylus*. From the hazel tree.

for by reason of the calx the spirits are fixed, as [Roger] Bacon says.

Fixation of sal ammoniac. Make a paste of quicklime with the white of egg, and do it in two crucibles. Put in sal ammoniac broken into pieces, then surround [it] with the above-mentioned paste, then dry. Afterwards, make another coating of the clay of wisdom,[208] dry and bury in warm ashes for two days and nights, and it will be fixed. Then, dissolve in warm water and, if you wish, filter and congeal, and it [the sal ammoniac] will be pure.[209]

44

THE REVELATION AND TEACHING OF THE SECRETS OF THIS ART BEGIN HERE

Now I have already taught you how to collect various flowers full of the fine fragrances, redolent with health and beauty, and the glory of this world: this is the flower of flowers, the rose of roses, and the lily of the valley. Rejoice therefore, O Youth, in thy adolescence and gather the flowers, since I have introduced you into the garden of Paradise; make from these a wreath for your head, that you may rejoice and enjoy the delights of this world.

I have disclosed to you the meaning, now I will help you to understand the secrets of this art, and what was hidden for such a long time, I shall now bring to light.

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[208] *luto sapientiae*. This substance, known as the "clay of wisdom," was used to seal the cracks in vessels before they were heated. In his *Liber de mineralibus* Albertus Magnus says (IV, vii, 93): ". . . et conglutinature in loco contactum et tenaci luto, quod *sapientiae lutum* vocant alchimici."

[209] The recipes in this chapter are somewhat difficult to interpret in the light of present-day knowledge. They emphasize the importance of sulphur, mercury, and sal ammoniac to the alchemist and his constant striving to purify his products. Since many of the manuscripts contain "additions" of later copyists, it is possible that this chapter was an insertion made to bring the text up to date. There is a great deal of repetition of previously discussed recipes.

Previously, I taught you how to sublimate and to collect the flowers of these substances, therefore, now I shall teach you how to plant them so that they may bear much fruit, and their fruit may last forever. I shall teach you how to fix the powders sublimed, that they may remain in the fire, be combined and mixed with bodies, and [I shall show you that this may be done] in two ways.

45

THE FIXATION OF POWDERS, SO THAT THEY CAN MIX WITH BODIES, IS TAUGHT HERE

Take as much [powders] of these as you wish, one pound or two without anything else, and place in the vessel of fixation, and shape off the opening with good clay, not glazed, of the glassmakers, one digit thick, and close the cracks with good clay, namely, clay of wisdom. When this is done, put [it] upon a sublimation furnace, and apply fire for a whole day. Now if done in summer, the amount of heat is as of sublimed mercury after mid-day; however, if it is done in the morning, turn the upper layer underneath, alternate two times at least, then open and see in this way if the powder is fixed; place a little of it over the coals: if it smokes, it is not yet fixed, but if it does not smoke, then it is fixed, and this is the sign of every spirit. If, however, it is not fixed, return to the furnace, closing the vessel as before, and apply fire for five days or until at length you hear a sound in the vessel like falling stones, as very often happens, when it is dried up too much. (Another direction says that it may be tested over a burning plate to see if it melts or flows, or fails to give off smoke.)

A second way [to fix powders] is with the imbibition of oil of tartar. However, you can do it this way: take sublimed arsenicum or sulphur or auripigmentum, and crush over the

stone with oil of tartar, until all becomes liquid. Then place in a glass phial in ashes, which have been sifted through a fine sieve, and place the vessel with the ashes over a distillation furnace, and apply the fire at first very slowly as [is done] in masticating, lest the vessel be broken. After heating the glass, increase the fire; then dry the medicine in an open vessel, if you wish, but it is better [to do it] in a closed one. Place above it an alembic which collects the water distilled from it, because [this distillate] is useful for many things. When the medicine is dry, the vessel has to be broken, since you cannot empty it otherwise, and you will find the powders hardened like stone. This has to be well ground as before with the distilled oil [of tartar]. Using the same procedure, again break the glass, remove, grind well, place in another ampulla, and set [it] in a warm dung pit for seven days, and then it will be dissolved into a liquid. Then place the vessel in warm ashes and heat with a slow fire, then you will have the spirits fixed; and the color will remain firm and lasting. And of this powder, add one part to fifty parts of calcined Iron or Copper, and this will be good for every malleation and testing.

46

HOW ARE SPIRITS DISSOLVED IN WATER BY ONE METHOD?

Spirits are dissolved by two methods. One way I have already taught with oil of tartar. But after the seventh congelation, [the spirits] should be placed upon a slanting marble stone in a very damp storage bin, so that whatever dissolves will flow down steadily into the glass vessel.

Spirits are dissolved in water in another way; namely, by a solution of sal ammoniac. It is done thus: place it, or whatever other prepared salt you wish, on a stone or a pit for dis-

solving, or in a glass storage bin and at once it will dissolve; crush the sublimated powder to be dissolved in this liquid. Note that after the mercury has been sublimated, it should never be mixed with any liquid except common salt water, or sal ammoniac, or oil of tartar. Rub the powder and liquid seven times, and dry the same number of times; afterwards place the rubbed powder upon the stone, and without doubt it will quickly become a liquid, then keep this for distilling. Calcined bodies are dissolved in the same way as spirits; that is, the flower of copper, and the flower of atramentum are to be treated as were the spirits, and each by itself is to be distilled.

Additions. Again (refer to the beginning of the chapter on this), salt is necessary for every solution.

Rhases. The oil of the eagle[210] is made thus: take one pound of sal ammoniac, and grind upon the stone with enough urine to make a paste. Then, first, place [upon the stone] a layer of common lime; second, [a layer] of sal ammoniac; third, one of calx. Upon the salt place a small quantity of calx of eggshells, and place [the mixture] on the fire for melting. When it has melted take it from the fire, place upon a stone, and dissolve the oil within four days, and then put into a glass vessel and set aside. Some persons make a paste of sal ammoniac, white of an egg, and the calx, and roll this into a ball, cover with clay, dry, and fix in a fire. Quicksilver, however, never dissolves until either good salt, dried and ground, or sal alkali, is placed over it and [the procedure] repeated seven times. Afterwards vivify in warm water, and then dissolve it. Unless you proceed in this manner no solution is effected.

Rhases. Take the dissolved sal ammoniac, sublimed three or four times, moisten sublimated mercury with it, a little at a time, and after imbibition, let dry in the sun or over a low fire. Then close the mouth of the vessel well and place in the

[210] *oleum aquilae.*

dung for seven days; if [it is] not dissolved at the end of this time, renew the dung and continue until the liquid is clear.

Oil for softening.[211] Take sal ammoniac, an equal part of common salt, and two parts of non-extinguished quicklime with a small amount of pig's grease, and place in a glass vessel and distill over a slow fire. When the distillation is complete, repeat even a third time. And this resulting white oil is the elixir for softening and for sweetening and melting the calx of metals and everything that is used for the whitening process, but this need not be spoken of here.

Liquid mercury is made by using one ounce of mercury with two ounces of *aqua fortis,*[212] made with two parts of alum of Yemen, and another part of saltpeter. Otherwise, it is made thus: congeal sublimated mercury by melting it seven or eight times with tin boiling above it;[213] each time covering the crucible lest any fumes escape, and cause [the substance] to turn black, or an oily color. Then, grind well on the marble with a little liquid sal ammoniac and place in the dung. When it is in solution, it can be distilled either through a filter or distillatory. This water, with Silver calx, sublimated arsenicum, and white oil of the philosophers, is used to make the Elixir.

Solution of sulphur. Take one pound of cleaned white *amizadir*[214] (sublimated), the amount of white sublimated vinegar, which may be equal to five parts of sulphur, [and] let it be put in a mud [bath], which is changed every third day.

Rhases. You can find this [discussed] at length in Aris-

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[211] This oil may have consisted of soap and unreacted pig's grease.

[212] Perhaps this is nitric acid. Sulphuric acid coming from the alum could have reacted with the saltpeter.

[213] Mercury amalgamated with tin formed a solid.

[214] Variant of *almicadir* (Ar.), sal ammoniac; this word appears in Milan, Bibl. Trivulziana Codex 245, see Carbonelli, *op. cit.,* p. 194, n. 838, sect. xv.

totle's *De Perfectione,*[215] in the chapter on the separation of sulphur. Grind, sift, and place in a cucurbite, one part of amizadir, three parts of sea foam, two of salt, and one part of urine, adding sufficient quicksilver; then hold lightly over a large fire. When the liquid becomes clear, remove it and set aside what is necessary. It is always essential to take it up and to change the mud every four days, until what you seek becomes visible. But I think that Rhases spoke of making the solution of bodies [needed] for a greater work: therefore note.

Mercury distilled a second or third time by alum of Yemen or rock alum, will dissolve by itself when placed upon a marble [slab] in a dewy or damp place; and even better, I believe, if it is put with crude material.

47

HOW ARE SPIRITS MADE INTO A RED LIQUID?

Now we must see how spirits are reddened. Take the red liquid distilled from atramentum and with it absorb the (fixed) spirits which you wish to redden. [Do this] by grinding seven times, absorbing and roasting, and then place for dissolving upon the stone. A very red liquid results.

ADDITION. The red liquid saved should not be distilled through a distillatory, unless its color is fixed by fire, otherwise it will distill white.

48

HOW CAN WATER BE DISTILLED IN A TWOFOLD MANNER?

The distillation is done thus: place water which you wish to distill in a distillation vessel, and place the vessel in ashes,

[215] See above, chap. 22, n. 130.

as above; and this may be done with heat and dryness.[216] If, however, you wish to distill with heat and moisture, place water [in a vessel] in which ashes had been placed, or else in a cauldron over a distillation furnace; in the liquid put hay with the glass above; make it firm so that it will not lean to one side, but will stand erect.[217] Take care not to put a cold glass in hot water or vice versa, since it might break and your work would be lost. Also, note that when you wish to remove the vessel you should permit it to be cooled with water when the distillation is completed. Take care in distilling lest the liquid boil during the distillation; and reserve all solutions obtained according to this instruction and [to that] on distillation. Keep in mind all that the instruction and formulary have shown.

Addition. Solution of bodies: take a calx of Gold or Silver, and an equal amount of sublimated sal ammoniac and grind together on the stone. Then sublimate the sal ammoniac from the solid calx, repeating the grinding and sublimating seven times; then place the mixture upon the stone for solution. Some, however, before they sublimate immerse the substance and grind it with borax water, and they repeat this seven times.

Bringing bodies into solution. Grind calcinated bodies with an equal amount of sal ammoniac and the calx of eggshells; then put into a glass phial over a moderate fire, until all becomes one lump. Cool, break the phial, then pulverize and put the powder in a place to dissolve. Thus sublimated spirits can be dissolved above a marble stone or in a dung [bath] which has been renewed frequently. But if you wish to re-

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[216] *caliditate et sinceritate*. (In Jammy and Borgnet editions.) The word *siccitate*, dryness, gives a better reading, for the phrase is then "heat and dryness," in contrast to the next line: *caliditate et humiditate*.

[217] The first method was carried on by means of a hot-ash bath, thereby freeing the volatile oils or sublimating the salt. The second method was distillation. The hay prevented the vessel from touching the bottom of the heated vessel and served as a support.

duce it to its own substance, congeal with a slow fire and melt with *attincar*.[218] Gold calcinated with salt can be dissolved into a red liquid by very astringent vinegar.

49

ON THE DISTILLATION OF OIL

The distillation which is done through a descensory [by means] of a pipe is thus: take an earthen vessel of the shape [of a pipe] and place in it ashes, or roots, or wood, or stone, from which you wish to distill the oil, and make a pit [or ditch] in the earth. Place the vessel in it, the hollowed-out part underneath, and over it the vessel with the pipe, and seal it lest it leak, and permit to dry. Then block up the lower vessel with earth; afterwards apply slow fire for an hour, increase it from hour to hour, until you have completed half a day. Allow to cool, and reserve the distilled liquid and oil.

50

ON THE COAGULATION OF ALL SOLUTIONS

Coagulation of all solutions is accomplished with heat and dryness. Put the liquid which you wish to dry in a glass vessel with a narrow neck, and place it in ashes over a slow fire, and it will coagulate within six hours into a white or red sheet.

51

HOW CAN GOLD AND SILVER BE CALCINED?

The calcination of all metals must now be noted. First, take the calcination of Gold and Silver. Place the filings of either

[218] A kind of nitrum; (Ar.) *al-tinkar* (Steele, *op. cit.*, p. 43).

one you wish in vinegar for nine days. Then remove and, when dried, crush into dry powder; afterwards add water [and] sal ammoniac, crushing and drying six times. Then place over a stone, as I have taught for dissolving, and distill and put aside; and from this liquid take the powder for the solution.

Note this, however, that you should use liquids of Gold for making red solutions and [liquids] of Silver for white [ones].

52

ON THE CUCURBITE

The cucurbite is a vessel which should be able to stand in a cauldron so that it can not move, in water up to the sealed joint.[219] It should not touch the bottom, for it will crack. When the water diminishes, pour in more warm, not cold water, lest the vessel break.

53

HOW CAN OTHER METALS BE CALCINED?

Take plates and heat them, afterwards you may rub them with salt water, because the salt eats up all the impure moisture in the bodies, and select the earthen vessel prepared for this. Fill the plates, place on a tripod in the furnace for calcination, put coals under it, and make a strong fire and have the furnace closed. When the plates glow, lower the fire so they will not melt but permit [them] to stay at such heat until [they are] entirely consumed by the fire. Take out in the morning, scrape and preserve what is cal-

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[219] *ad juncturam firmatum.*

cinated; what remains, moisten again with salt water and continue until [all] is calcinated.

Additions. The calcination of Gold and Silver[220] is done through amalgamation of either, with equal parts of mercury and common salt, by placing over a slow fire and continually stirring until the mercury volatilizes. Wash [the residue] with lukewarm water, and distill through a filter, and you will find your substance reduced to a calx. Another [method of] calcination of Gold and Silver and of other substances may be found in Aristotle's *De Perfecto magisterio.*[221]

Likewise, the double calcination of Gold and Silver is found in Brother Roger Bacon's book, entitled, "A method of compounding medicine through equalization of the elements," [222] in the chapter on "the calcination of bodies," where he discusses the calcinations of the various bodies.

Calcination of gold. Liquefy it, make of it thin sheets, fill an iron crucible, cover, and let it melt with common salt, or partly prepared [sal] ammoniac and acid of pomegranates,[223] because it will be crushed to powder by the sharpness of the salt and acid. Then place in a baker's oven for a day and night, and draw off the yellow-red calx to which there is no equal.

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[220] "One of the methods of purifying or perfecting silver from lead was repeated calcination, quenching in sal ammoniac or vinegar, distilling, and calcining again. Now, although it is ridiculous to suppose that calcining removed any of the impure sulphur, or the impure mercury, or the lead, leaving a purer product and more noble metal, and thus effecting its transmutation into silver, the process was probably founded upon chemical fact. Many lead ores are argentiferous, and hence much of the lead in use was also argentiferous." (J. C. Brown, *A History of Chemistry,* p. 178.)

[221] See above, chap. 22, n. 130.

[222] *Modo componendi medicinam per aequationem elementorum.* This title does not appear in the lists of Roger Bacon's authenticated writings. For a full bibliography of Bacon's works, see the appendix to A. G. Little's *Roger Bacon Essays on the Occasion of the Commemoration of the Seventh Centenary of His Birth* (Oxford, 1914). See above, chap. n. 192.

[223] *mali granati,* a pomegranate.

Calcination of silver. Melt it and make of it sheets; fill an iron crucible; then put into the crucible common salt, slightly ground, fill, cover, and melt—it soon melts by the beneficence of the salt—then crush. This, too, the salt helps to do. Put [it] into a baker's oven for a day and night, and draw off the Silver calx to which there is no equal.

Calcination of lead. Melt the lead, cover with a solution of common salt and the sourest of white vinegar, so that the salt may be partly prepared and dissolved. Then immerse the melted lead in this water forty times, and place (pulverized) in a new, crude clay-closed jar. Dry [it] in the oven for a day and a night, and in the morning take out the snow-like calx, heavy as salt.

Calcination of tin. Melt and immerse ten times in the liquid of common salt, made by dissolving it in the strongest white vinegar, mixed with two ounces of the honey of bees.[224] Then crush and place in a jar in a baker's oven for a day and night; then extract the tin calx.

Calcination of iron. Crush and imbibe with a solution of common salt, sorb-apple vinegar,[225] and pomegranates, in which the salt is dissolved, and dry ten times in ashes. Afterwards, regenerate by triturating with aqua fortis to the measure of five digits, then place under dung ten days and it will be dissolved. Then congeal the liquid for a day and it will be colored; then crush and put into a baker's oven for a day and night, and you will have a calx as red as blood. This is the calx of Solix [the Sun or Gold], which is called [Saffron iron].

Calcination of copper. Make copper plates, suspend them in a jar with chains, in which is strong vinegar, and place [the jar] in the dung for ten days. Withdraw the plates and scrape off the deposit from them, and repeat this until the plates are finished. Wash [the corroded plates] with vinegar,

[224] *mellis apum.*

[225] *aceto-sorbarum.*

rub gently, filter through a cloth, and throw away the dregs, which are its thickest part. Then let [the vinegar water] settle, and you will get the subtlety of green copper.

Calcination of quicksilver. [This method] will be found in the chapter on sublimation.[226]

54

HOW ARE COPPER PLATES CALCINED?

Cut Copper plates about as thick as a denarius, moisten with salt water and put in a row at the bottom of a crucible. After rolling and rerolling them on each side with arsenicum prepared with vinegar, then stack layer upon layer until the vessel is filled. Close with potter's clay to prevent leaking, allow to dry, and then place in the calcining furnace. Let it remain there for a full four hours, so that the entire small vessel will glow; but, take care lest by the intense heat the Copper should melt, and liquefy, as often happens. Afterwards, allow to cool, take [it] out and you will find total decomposition; grind [this] well in a mortar or on a stone. Then, rub the powder; set aside; and again smear well the residue that is not calcined and calcine further.

ADDITION. The cleansing of red copper[227] is done [in this

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[226] Footnote in the Borgnet edition reads: Vide supra §30. The reference is to the calcination of the common metals other than mercury. The general method of calcining was to react the melted metal with a substance to dissolve it; on further ignition it was converted to a dry powder. In the text "additions" amalgamation took place between mercury and gold, and between mercury and silver.

The "tin" here must have been an alloy. For example, Pliny confused tin with alloys of lead and tin. The calcination of iron presented no difficulty, but the copper was perhaps the alloy of brass.

[227] Copper was sometimes whitened in antiquity by alloying with arsenic. Similar directions have previously been given, in Chapters 24 and 53. Vitruvius, Dioscorides, Theophrastus, and the Elder Pliny describe how to make green copper and flowers of copper, but they probably did not know, or at least do not mention, the differences between them. Even in the

fashion]: as soon as it is roasted with auripigmentum placed in the middle of it, it is then washed until pure.[228] [Then] distill through the descensory until it is as white as silver; grind and use it; if it has not turned out this way, crush, wash, and distill until it achieves this result.

55

HOW IS THE CALX OF BODIES REDUCED TO A MASS? SEE ALSO IN GEBER'S LIBER FORNACUM

The reduction of the calx of bodies to a solid mass is done [in this manner]: take the calx of whatever metal you wish and rub well on a stone, afterwards wash with warm water two or three times, and discard the turbid part; when it washes clear that will be enough. Then crush very well the dried part and add a solution of alum of Yemen mixed with common salt water. Rub vigorously, saturating as many times [as before] with this water and drying [the mixture] until a calx, white and alive, is made. Thus will be removed from it all the accidents of sulphur, which it picked up in the earth. Afterwards crush once with alkali water, and when it is dried, place in a small vessel, such as a crucible, close well with potter's clay. Make a small hole in one part, so that the mass can come out when melted, then put [it] into a furnace, increase the fire by blowing vigorously, so that it will melt more quickly. When it has been melted, open the hole, and pour out the material into an iron pipe,[229] where the melt will be enclosed as poured out,[230] and you will see a white mass and you will rejoice. This mass may be

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Middle Ages knowledge had not progressed far enough to distinguish between these two green substances.

[228] *deinde abluatur donec fiat purum.*

[229] *canale ferreum.*

[230] *ubi sit sepum infusum.*

colored white or red, because it has been cleansed from all corruption. If, moreover, you wish to redden it, saturate the calx of the metals with the red water from the flowers of copper, whether made from atramentum or minium, and follow all that has been said above. Finally, [wash] with alkali water, and discard as I have taught. The mass will be red and you will rejoice.

Addition. Some dissolve [sal] nitrum and alum in vinegar, and with it they cleanse the calx of its blackness.

Others reduce Copper thus: take sal alkali, and sal nitrum, dissolve in the urine of boys and with this make a paste with the calx of Copper, and subject it to a slow fire until somewhat dry. Afterwards increase the fire until it is reduced; then ignite and quench in common oil four times, and you will have Copper similar to Silver or the fixed salt. The calx of Copper is made by cementing with common salt, until it can be ground and washed.

56

HERE BEGINS THE FIRST OF THE OPERATIONS

Take, in the name of the good God, one part of white mercury, a second part of sulphur, and a third part of arsenicum. Mix these all together [and] add one-half part of liquid silver, [and] put into a glass vessel and heat above strongly with a glowing iron until the glass melts and congeals. Then place in ashes above the fire, and congeal; when it is congealed, a fixed persevering brown color will develop throughout the coagulated mixture. Place therefore one part of this colored tincture over a hundred parts of iron ore or purified copper and it will always, without doubt, be good, and in every malleation and testing will endure forever.

Addition. Note this, that the colored substance should be

dissolved and mixed with the bodies for calcination and converted to liquid. When the liquid is mixed with water, [the bodies] will never be separated from each other, [in the same way] as a little red wine will tint a great amount of water.

I saw other tracts, where this chapter was omitted, and only the [material in the] following [chapter treated].

57

HOW CAN GOLD AND SILVER BE OBTAINED ACCORDING TO ALL THE ABOVE?

Take one part of sublimed and fixed mercury, another of fixed arsenicum, and a third of Silver calx. Triturate well above a stone and saturate with a solution of sal ammoniac. Do this three or four times, grinding, saturating, and roasting as above; set aside similarly for dissolving, and keep the solution. If it does not dissolve, grind more, and add a little sal ammoniac, and thus the whole will dissolve. When all has been dissolved, place [it] for distilling into warm water, and the entire [solution], as I have taught, will be distilled. Take care not to put into ashes for distilling, for it will harden for the most part, and it will have to be redissolved as at first. When the whole distillation is finished, put into a glass cucurbite, coagulate, and there will be a white substance, hard and clear as a form of crystal, liquefying above the fire as wax, a permeating and stable [substance]. Take of it one part to a hundred parts of any purified and calcined metal, and it will be good for all time. Take care not to touch with any unpurified metal, because the color will vanish after two or three testings.

Additions. Aristotle's book *De Perfectionis magisterio,*[231]

[231] See above, chap. 22, n. 130.

speaks of the sublimated and calcined mercury, which I think is the same as fixed, because it cannot be calcined unless it is first fixed; and unless it is calcined it cannot be dissolved. Near the end [of the experiment] some [writers] say that a certain white oil of philosophers should be added for the softening of this medicine. If fixed spirits cannot be penetrated,[232] add a similar amount that is not fixed, dissolve and coagulate and penetration[233] will take place, etc. Thus, also, if the calcined body cannot be reduced to a solid, add some of its own melt and it will be reduced. Divide the egg of the philosophers into four parts[234] of which each will have one nature, then bring together equally and proportionately, so that it has no inconsistency, and you will have achieved that which was proposed, the Lord willing.

This is a universal method. However, I will explain it to you in specific operations divided into four. Two of the methods work well and without corruption. When, therefore, you will have water from air and air from fire, then you will have fire from the earth. Dispose, therefore, of the airy substance through separation, and of the earthy substance through heat and moisture, until they come together and unite and do not differ nor divide. Then, you may add to it two effective virtues: namely, water and fire, and the

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[232] *ingredi.*

[233] *intrabit.*

[234] The "philosopher's stone" was a mythical stone, substance, or chemical which was supposed to cause the transmutation of base metals to gold or silver. It first appears in alchemical writings in the seventh century. "In the early centuries of alchemy, there was also developed a mass of symbolism which lost nothing of complexity and obscurity with the development of alchemy. Thus the egg, symbol of the round universe, or of eternity; the "egg of the philosophers" consisted, like the physical universe, of four components, white and yolk, a skin and shell. These four constituents again are sometimes said to typify the four metals which form the basis for transmutation, copper, tin, lead and iron." (Stillman, *op. cit.*, p. 170.)

work will be completed.[235] For if you mix water alone, Silver will be made; if you add fire, it will make it redden, the Lord willing.[236]

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[235] In this chapter the writer gives the final recipes for preparing gold and silver and treats again of the four elements: earth, water, fire, and air. This Aristotelian doctrine of the composition of matter was generally accepted until the time of Paracelsus, 1493–1541 (Theophrastus Bombastus von Hohenheim) who, in his writings on medicine and chemistry, profoundly influenced the work of his contemporaries and succeeding generations. Paracelsus introduced the doctrine that all matter is composed of three principles: salt, sulphur, and mercury.

The treatise here concludes with the notion that matter could assume different forms, and that these forms could be removed. Perhaps the author wished here to emphasize the idea of the transmutation of metals.

[236] The ancient method of fractional distillation is illustrated on page 79 by a drawing from the Codex Oldanis di Milano, fol. 129^{v}. Modern ascending or descending chromatographic technics by filter paper are similar to the ancient separation of mixtures by cloth strips.

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