A SURVEY OF GREEK ALCHEMY

		PAGE
§ 1.	Introduction	109
§ 2.	The Papyri	110
§ 3.	The Manuscripts	111
§ 4.	The Texts	114
§ 5.	Substances used by Alchemists	123
§ 6.	Imitation of Silver	124
§ 7.	Imitation of Gold	127
§ 8.	Alchemical Apparatus and its use	130
	Bibliography	138

§ 1. *Introduction.*

In the Greek writings of the first millennium of the Christian era we find our earliest evidence of that remarkable body of doctrine known as Alchemy. Arising perhaps in the traditional knowledge of the Egyptian priesthood, it flourished as a living science and creed for seventeen centuries. The earliest alchemical works that have survived are all written in Greek, and the extant Greek alchemical writings run to more than eighty thousand words. The bulk of these documents is evidence of the attraction which the science possessed for the philosophers of the Byzantine age. Alchemy was then no mere by-way of thought, but one of the major departments of knowledge.

The alchemical writings have affinities with other contemporary works. It is, therefore, well to decide on the meaning we shall attach to the word *Alchemy* before discussing its methods and origin. In the forms ἀλχεμία, ἀλχημία, etc. the word first appears *subsequent* to the date at which the most important Greek alchemical texts were composed. These texts themselves usually refer to their subject as ' The Work,' ' The divine and sacred Art,' ' The making of gold,' and but rarely use the much-discussed word χημία, χυμεία, etc., which has since entered our vocabulary as *Chemistry*.

Alchemy and Chemistry were, of course, distinguished from each other only at a late date. The derivation of chemistry from alchemy should not lead us to assume that the alchemy of Greek times could correctly be called chemistry. Certain substances may have been investigated for specific purposes, but we know of no early investigation in that scientific spirit which is to be distinguished from practical crafts such as metallurgy or dyeing. Alchemy is distinguished from metallurgy, not by a scientific spirit, but rather by its specialisation on a particular metallurgical problem and its exaltation of that problem to a matter of more than material significance. The conception of rigidly defined chemical individuality could not be in existence in the early days of alchemy. On the old theory all matter was made up of mixtures in varying proportions of the four elements, air, fire, earth and water. The alteration of

the properties of a metal was thus not a task which presented itself as in conflict with any established theoretical principle. Yet although alchemy, looked at from the point of view of a practical craft, may be regarded as a department of metallurgy, it had from its first appearance a supernatural element associated with it.

The lack of interest in the general properties of matter is noteworthy. All the practical instructions or recipes deal with the production of gold, silver and purple, or in one or two instances precious stones. The texts make it clear that numerous chemical phenomena must have been discovered in the course of the alchemical processes, which include multifarious fusions, sublimations and distillations. Yet the alchemists found none of these phenomena interesting enough to mention. No one who had used sulphur, for example, could fail to remark the curious phenomena which attend its fusion and the subsequent heating of the liquid. Now while sulphur is mentioned hundreds of times there is no allusion to any of its characteristic properties except its action on metals. This is in such strong contrast to the spirit of the Greek science of classical times that we must conclude that the alchemists were not interested in natural phenomena other than those which might help them to attain their object. Nevertheless, we should err were we to regard them as mere gold-seekers, for the semi-religious and mystical tone, especially of the later works, consorts ill with the spirit of the seeker of riches.

This religious atmosphere is present in almost all the alchemical texts and serves to distinguish them from purely technical treatises. Certain of the earliest alchemical works were, probably, at one time wholly practical in content but even these seem to have been provided with a supernatural setting in order to make them more acceptable to a later public. The religious element in Greek alchemical works links them to Egypt rather than to Greece. The deeply religious nature of the Egyptian seems to make itself apparent here. We shall not find in alchemy any beginnings of a science, but rather an attempted interpretation of secrets of the past by men who believed that they might restore or rediscover lost or concealed knowledge, once possessed by the priests of Egypt, or by ancient philosophers. At no time does the alchemist employ a scientific procedure. He does not survey the theory and practice of his art and build up a method therefrom, nor does he ever base his practice on his theoretical beliefs concerning the nature of matter and its interactions. He is for ever concerned in finding out what the ancient authors meant. The reverence paid to the legendary figures of ancient science, such as Democritus, Ostanes and Hermes, and consequently to the authors who wrote in their names, paralysed research along new lines. Under the Arabs rose the second wave of alchemical progress, leading in a short time to chemical discoveries greater and more numerous than any made by the Greeks.

§ 2. *The Papyri.*

We derive our knowledge of Greek alchemy from a large number of mediaeval manuscripts and from a few papyri of earlier date.

Three papyri in Leyden are the most ancient known which treat of the subjects of alchemy or metallurgy. They are of about the third century A.D., and form part of a collection probably emanating from a tomb.[1] One contains magical incantations of a fairly early gnostic character. In the same papyrus is a list of 37 names of plants, minerals, etc., together with their mystical or sacred names. This synonymy is of interest in view of the alchemical practice of giving many names to the same substance. Two fragmentary metallurgical recipes occur also in this papyrus, affirming by their position the association of metallurgy with magic and gnostic mysticism. A second papyrus contains names of a few substances used in connexion with the writing of magical formulae.

The third alchemical papyrus at Leyden is more important for our purpose. It contains 101 recipes, all of a character bearing upon alchemy. Sixty-five of these are metallurgical. They are concerned chiefly with the making of gold and *asemos*. Fifteen are concerned with writing in letters of gold and silver. Eleven are recipes for dyeing stuffs. Ten are extracts from the Materia Medica of Dioscorides concerning minerals used in the recipes. This is, therefore, one of the earliest portions of a text of Dioscorides that we possess.[2] Some of the metallurgical recipes are of great interest as resembling those given by such authors as the alchemical writer 'Democritus.'

The Leyden papyri have been dated to the third century by Reuvens and Leemans, on the evidence afforded by the character of the script, and by their format. The authors cited in them are 'Democritus,' Phimenas, Anaxilaus and 'Aphrikianos.' The dating of 'Democritus' is uncertain, but probably he is to be placed in the first century A.D. (see p. 114). Phimenas may perhaps be identified with Pammenes, but even so he affords little help in dating. The age of Anaxilaus is also doubtful. Aphrikianos, however, is very probably Julius Sextus Africanus, who lived at the beginning of the third century A.D. This would be in agreement with the dating arrived at from the other sources mentioned.

Of somewhat less alchemical interest than the Leyden papyrus, though important on other grounds, is the papyrus of Stockholm, of about the same date and character as those at Leyden. It contains 152 recipes, 9 concerned with metals, 73 with precious stones and 70 with dyeing. Its date is probably the same as that of the Leyden papyri.

§ 3. *The Manuscripts.*

There is a great body of Greek alchemical manuscripts, chiefly of the sixteenth century or later. A few early manuscripts are known. The later, with the exception of those containing the few texts referred to in § 4(*d*), are all more or less accurate copies of these. The similarity of earlier and later manuscripts shows that Byzantine alchemy was quite static.

The early manuscripts of primary importance are three in number. A

[1] This collection was acquired by the Chevalier d'Anastasi, Swedish vice-consul in Egypt at the beginning of the nineteenth century, and was purchased by the Dutch Government in 1828.

[2] See C. Singer, 'Herbal in Antiquity,' *J.H.S.*, xlvii. p. 22.

fine MS. at Venice (Marcianus 299) is of the tenth or eleventh century. A manuscript at Paris which we shall call *the first Paris MS.* (Paris. gr. 2325) is of the thirteenth century. Another Paris MS. which we shall call *the second Paris MS.* is of the fifteenth century (Paris. gr. 2327). It is a fuller copy of the

FIG. 1.—THE SERPENT 'OUROBOROS' WAS A SYMBOL DENOTING AT ONCE THE UNITY OF MATTER, AND THE 'CIRCULATORY' TYPE OF ALCHEMICAL PROCESS PRACTISED IN CERTAIN TYPES OF ALCHEMICAL APPARATUS. (MS. PARIS, GR. 2327, F. 196.)

first Paris MS. These three MSS. contain almost all the surviving alchemical writings which date from the first eight or nine centuries of the Christian era.

Of a different character are several late Greek MSS., the texts of which cannot have been written earlier than A.D. 1000, nor perhaps later than A.D. 1300. The methods and spirit of these are allied to mediaeval Western rather than to early Greek alchemy. They are therefore more conveniently

studied in connexion with the alchemy of the Middle Ages. Among these are a recently discovered Codex at Holkham Hall (Holkhamicus 290) and a still more recently discovered and as yet unpublished Codex at the Vatican (Vat. gr. 1134).

The Greek alchemical MSS. of the British Isles, France, Italy, Madrid and Athens have been adequately described and catalogued. Those of Central Europe have not yet been systematically treated. In the libraries of Leyden, Vienna, Munich, Wolfenbüttel, Breslau and Altenburg there are Greek alchemical manuscripts, which, however, do not seem to contain anything of importance not found in the three primary MSS. at Venice and Paris.

Of the secondary MSS. a useful study has been made by Kopp. The contents of the primary MSS. have been transcribed by Berthelot, Ideler, Ruelle and others. The edition of Berthelot contains, in great confusion, the major part of the known Greek alchemical texts. His transcription is based, for the most part, on the second Paris MS., collated with several secondary MSS. Berthelot has translated most of the texts, but his interpretation is necessarily strongly coloured by his views of the nature of the alchemical processes, and these views are not accepted by all students.

§ 4. *The Texts.*

The older Greek alchemical texts are the work of some forty or more authors whose period of activity is datable within fairly wide limits. These authors fall naturally into five groups, of which we shall here be concerned only with the first three. Many of the names given are mere pseudonyms.

(*a*) *The earliest alchemical authors*, who wrote at dates in no case certainly known, but not later than the second half of the third century of the Christian era nor earlier than the first century. These include : [3]

Democritus	Eugenius	Pammenes
Isis	Comarius	Chymes
Iamblichus	Cleopatra	Pibechius
Moses	Maria	Petasius
Ostanes	Hermes	
" Chruth "	Agathodaemon	

(*b*) *The alchemical authors of the third and fourth centuries :*

Africanus	Heliodorus	Pelagius
Zosimus	Synesius	Olympiodorus

(*c*) *The later commentators.* These flourished between the sixth and thirteenth centuries. They include :

Philosophus Christianus	Pappus	Psellus
Stephanus	Theophrastus	Cosmas
Heraclius	Hierotheus	Nicephorus Blemmydes
Justinianus	Archelaus	
Philosophus Anonymus	Salmanas	

[3] No attempt is here made to distinguish between genuine authors and those to whom texts have been falsely attributed.

(*d*) The recently catalogued MSS. of Italy, Spain and Athens have revealed a number of late texts, the translators or authors of which may be dated as later than A.D. 1000. Their works, as yet unpublished, appear to belong to Western alchemy rather than to the Alexandrian and Byzantine traditions. Nevertheless, no evidence has yet been adduced that they exhibit Arabian influence except through their Western originals. These late authors include:

'Ρίναλδων Τελανοβέβιλα (βηλανόβα) (Arnaldus de Villanova)
'Αμπέρτος θεοκτόνικος (Albertus Teutonicus)
Comes de Santa Flore
Luciatus

(*e*) *A very late list*, contained in a MS. at Athens copied in 1804, refers to Dioscorides, Theodorus Magistrianus and Jacobus Cabidarius as alchemists. The date of this manuscript is a witness to the remarkable persistence of the alchemical tradition in the Near East.

(a) *The earliest alchemical authors* are sharply divided into two schools, to which we add an indefinite appendage or third school:

(i) *The followers of Democritus.*—These carry out their alchemical work by superficial colourings of metals and by the preparation of alloys by fusion. The Democritan school includes Isis, Iamblichus, Moses, Ostanes and Eugenius.

(ii) *The school typified by Maria and Comarius.*—These employ complex apparatus for distillation and sublimation. The Marian school includes also Hermes and Cleopatra. Agathodaemon, of whose works fragments only survive, probably also belongs here. To this school Western alchemy and, indirectly, modern chemistry owe some debt. This is acknowledged in the common modern laboratory device known as the *bain-marie*, and in the design of our distillation apparatus. The title *balneum mariae* seems to occur first in the works of Arnald of Villanova (fourteenth century).

(iii) *Fragments.* There remain a number of authors of unquestioned early date whose works are lost or survive only in too fragmentary a state for us to determine their affinities. To this group must be relegated Pammenes, Chymes, Pibechios and Petasius.

(i) *The followers of Democritus.*

Democritus (Pseudo-Democritus).—The mention of this author in one of the Leyden Papyri places him before *c.* A.D. 250, the *terminus ad quem* of that document. Later commentators refer to him as a remote and legendary figure. This is doubtless the result of the pseudonym of the writer of the existing treatises. The reference of Pliny to the *Chirocmeta* of Democritus shows that a collection of recipes for some kind of marvellous manipulations, attributed to that philosopher but doubtless the work of a much later author, was in existence in the first century A.D.

The term Χειρόκμητα in the sense of ' artificial substances ' is applicable to the *Physica*

et Mystica, the most important work of the alchemist Democritus. It is in this sense that the adjective χειρόκμητος is used by Aristotle (*Meteor.*, 2. 1. 6).

It is, then, possible that this Democritan work of Pliny is identical with the alchemical *Physica et Mystica Democriti* which we possess or with the older portions of it. The *Physica et Mystica* contains no Christian references. Its magical portion, which is almost certainly later than the practical portion, is not flavoured with the complex Gnostic beliefs which abound in works of the second and third centuries. Moreover, the comparative simplicity of the methods of the *Physica et Mystica* suggest that it is considerably older than those authors that mention it. It is, then, probable that this work at least of Democritus is of the first century of the Christian era.

Democritus was regarded as a father of alchemy by his successors. He appears as the earliest exponent of the school of alchemical thought which has given its teachings to the world in the form of short and definite recipes. The obscurity of these is due rather to our ignorance of the nature of the constituents than to deliberate concealment or to a mystical or symbolic terminology. The methods advocated by Democritus and his followers include the preparation of alloys and the superficial coloration of metals; while the processes of distillation and the prolonged action of the vapours of arsenic, mercury and sulphur, much practised by the school of alchemical thought, of which the earliest exponents were Mary, Comarius and Cleopatra, were either unknown to them or considered valueless for preparing gold.

The works attributed to Democritus are:

(α) Φυσικὰ καὶ μυστικά. (B. II. p. 41. 1–49. 22.)[4]
(β) Δημοκρίτου βίβλος ε′ προσφωνηθεῖσα Λευκίππῳ. (B. II. pp. 53–56.)

A Syriac version of the *Physica et Mystica* exists and was probably a means of transmitting the knowledge of Greek alchemical processes to the Moslem world.

Isis.—The character of the mythology of the interesting text bearing the name of Isis assigns it to the earlier period of Gnostic beliefs. The text exists in two forms differing in the mythological part but identical in their alchemical content. The alchemical matter is consistent with a date near to Democritus. This text also probably dates from the first century. The title of the work is:

Ἶσις προφῆτις τῷ υἱῷ αὐτῆς. (B. II. pp. 28–33.)

Iamblichus.—That this author is not identical with the well-known writer Iamblichus may be inferred from a consideration of his style and thought. The alchemical matter is somewhat more advanced in type than that of Democritus, the influence of whose work is noticeable. An attribution to the second or third century seems reasonable.

(α) Ἰαμβλίχου καταβαφή. (B. II. 285.)
(β) Ἰαμβλίχου ποίησις. (B. II. 286.)
(γ) Χρυσοῦ ποίησις. (B. II. 287.)
(δ) Χρυσοῦ δίπλωσις. (B. II. 287.)

Moses.—The opening passage of the considerable work (β) attributed to this author is a somewhat altered version of Exodus xxxi. 2–5. This suggests an attribution to the Hebrew prophet, though it is to be remembered that Moses was a personal name affected by the Byzantines. The alchemical matter is similar to that contained in the preceding texts, and the works were probably written at some period of the first or second centuries.

(α) Μωσέως δίπλωσις. (B. II. p. 38, 13–29, 4.)
(β) Εὐποία καὶ εὐτυχία τοῦ κτισαμένου καὶ ἐπιτυχία καμάτου καὶ μακροχρονία βίου. (B. IV. p. 300–315.)

Ostanes.—The name was probably suggested by that of the Persian under whom Democritus of Abdera is said by Diogenes Laertius and others to have studied. An Ostanes

[4] B. here and later M. Berthelot: *Collection des anciens alchimistes grecs* (Paris, 1888).

is mentioned by Zosimus as an author of some antiquity, but there is no proof that he had the author of this treatise in mind. The character of the work is such that it may be of the first two centuries of the Christian era.

'Οστάνου φιλοσόφου πρὸς Πετασίον περὶ τῆς ἱερᾶς ταύτης καὶ θείας τέχνης. (B. II. 261.)

EUGENIUS.—The name is attached to a recipe of the Democritan type.

Εὐγενίου δίπλωσις. (B. II. 39.)

(ii) *The School typified by Maria and Comarius.*

MARIA, also called Mary the Jewess, must be one of the earliest alchemical authors. In the third century she was known to Zosimus, who identified her with Mary, sister of Moses. The works in her name can hardly be later than the first century A.D. Unfortunately they survive only in quotations. Her Jewish origin is confirmed by the quotation (B. II. 103)

Μὴ θέλε ψαύειν χειροῖν· οὐκ εἶ γένους 'Αβραμιαίου . . .

Her works are freely quoted by Zosimus and other authors. She appears from these to have been quite the most remarkable of the ancient alchemists. She appears in these quotations as the originator of the major part of the processes used by the Greek alchemists. The elaborate 'kerotakis' apparatus (p. 132 ff.), the hot-ash bath, the dung-bed and the water-bath (*bain-marie*) are all apparently her inventions or discoveries, while it appears likely that she perfected the apparatus for distillation of liquids (p. 136) in a form so efficient as to have suffered little alteration in two millennia. Her practical character distinguishes her very notably from all other alchemists. She describes apparatus in detail, even to the method of constructing the copper tubes required from sheet metal. She appears to have used almost every type of alchemical method, but perhaps to have paid most attention to the use of alloys of copper and lead. The latter metal she refers to as 'our lead' as distinguished from 'common lead,' and it may well be antimony or some metallic sulphide to which she refers. Democritus and Maria must hold the first place as practical alchemists.

The work of the other alchemists is in all probability merely the performance of variations of the processes invented by these authors.

COMARIUS is perhaps the earliest of all our authors. The mythical and symbolic matter, of which his fragmentary treatise is largely composed, is, when freed from later additions, fully consonant with a first-century Egyptian origin.[5]

Κομαρίου φιλοσόφου ἀρχιερέως διδάσκοντος
τὴν Κλεοπάτραν τὴν θείαν καὶ ἱερὰν τέχνην
τοῦ λίθου τῆς φιλοσοφίας. (B. II. 289.)

CLEOPATRA.—Three treatises survive. The *Chrysopoeia* consists only of a page of symbols and drawings reproduced on p. 117. The title of the treatise mentioned under Comarius, and also internal evidence of Cleopatra's treatise, indicate a first-century date. The symbols and drawings of figures are probably the earliest drawings that we have of chemical apparatus. 'A dialogue of Cleopatra and the philosophers' exists in a mutilated form; it is probably of the same date as the above treatises, but cannot be attributed to Cleopatra.

(α) 'Εκ τῶν Κλεοπάτρας περὶ μέτρων καὶ σταθμῶν. (Hultsch: *Metrologicorum scriptorum reliquiae*. Lipsiae, 1864, I. 253.)
(β) Κλεοπάτρης χρυσοποία. (Figures only, no text.) (B.I. 132.)
(γ) Διάλογος φιλοσόφων καὶ Κλεοπάτρας. (B. II. 290. Included under the same title with the dialogue of Comarius and Cleopatra.)

HERMES.—The name is attached to three fragments. These are unrelated in style

[5] von Hammer Jensen: *Die älteste Alchimie*. Copenhagen, 1921.

and matter to the mystical works bearing the name of Hermes Trismegistus, but are conceivably derived from some of the priestly works attributed to Hermes-Thoth and mentioned by Clement of Alexandria. Many other fragments are scattered through the works of Zosimus and later commentators.

(α) Ἑρμοῦ τρισμεγίστου ὄργανον. (B. II. p. 23, 8–17.)
(β) Αἴνιγμα (Ἐὰν μὴ - ἔσται). (B. II. 115, 10.)
(γ) Αἴνιγμα τοῦ φιλοσοφικοῦ λίθου. (B. II. 267, 16–268, 2.)

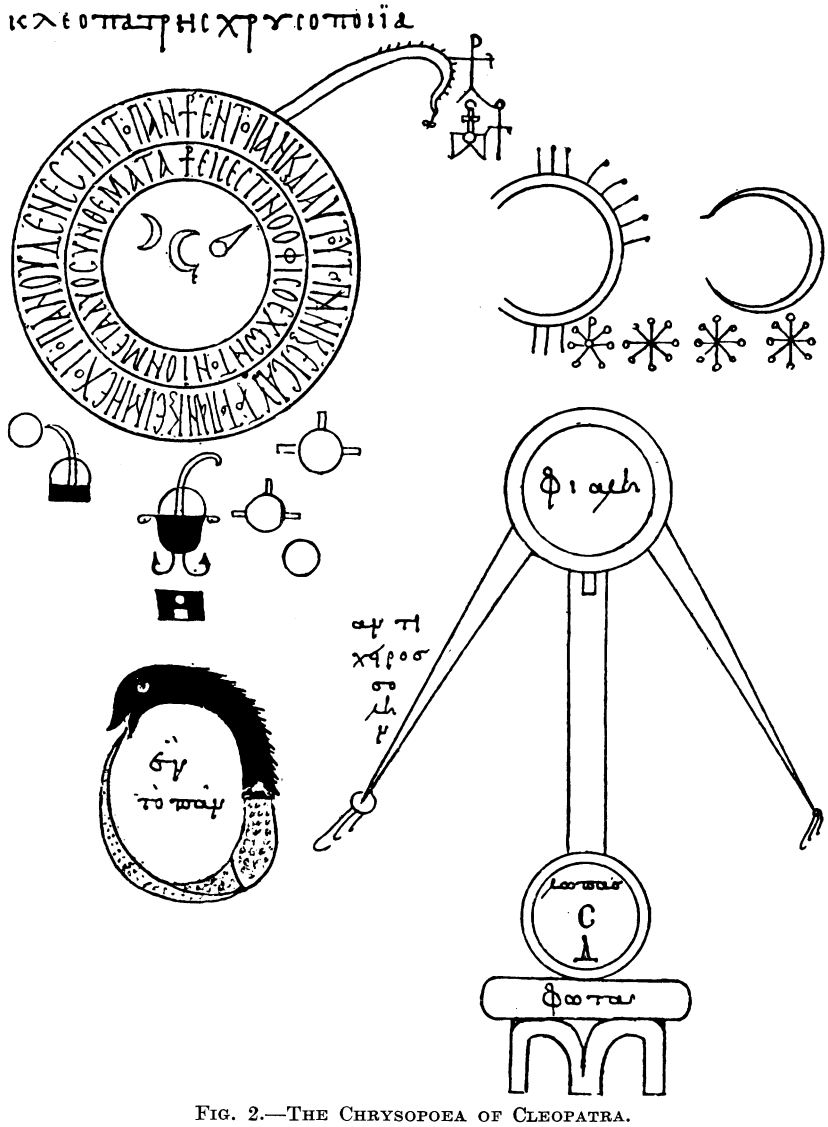

FIG. 2.—THE CHRYSOPOEA OF CLEOPATRA.

The emblem in the left hand top corner encloses the aphorisms: Ἓν τὸ πᾶν καὶ δι' αὐτοῦ τὸ πᾶν καὶ εἰς αὐτὸ τὸ πᾶν καὶ εἰ μὴ ἔχοι τὸ πᾶν οὐδέν ἐστιν τὸ πᾶν: and: Εἷς ἐστιν ὁ ὄφις ὁ ἔχων τὸν ἰὸν μετὰ δύο συνθέματα. On the right of this emblem are symbols of which the meaning is doubtful. Below these is a still with two condensing arms (cf. Fig. 8) and on the left the serpent Ouroboros with the inscription: ἓν τὸ πᾶν. Above the serpent are sketches illustrating a piece of apparatus of the *kerotakis* type, used for the fixation of metals.

AGATHODAEMON.—A deity of that name was worshipped in Greece and Egypt in connexion with wine, and later figured in Gnostic hymns and inscriptions (cp. Isis and Hermes). There was a geographer Agathodaemon, but there is no reason to suppose a connexion with these texts. Olympiodorus (early fifth century) doubted whether Agathodaemon were 'an ancient philosopher in Egypt or a mystic angel, or a good genius (ἀγαθὸν δαίμονα) of the Egyptians.'

Internal evidence suggests the first two centuries of the Christian era as a date for his texts:

(α) An aphorism without title (Μετὰ τὴν - ξάνθωσις). (B. II. 115, 7.)
(β) Ἀγαθοδαίμων εἰς τὸν χρησμόν: Ὀρφέως συναγωγὴ καὶ ὑπόμνημα. (B. II. 268, 3–271, 25.)

(iii) *Fragments.*

CHRUTH.—A MS. (Paris. gr. 2314) contains an unedited text entitled Ἔβρεσις ἐκ τῆς χυματικῆς βίβλου τῆς χρυσοποιήας (*sic*) τῆς χρύθ καὶ τοῦ ὀρφέως (*sic*) καὶ κλεοπάτρας. The text is late (probably ninth century), and the name χρύθ may be a copyist's error. The name is placed here on account of its association with Cleopatra.

JOHANNES.—'Philosophus Anonymus' (p. 122) refers to 'Johannes the arch-priest of the "Tuthia" in Evagia . . .' as the oldest of the alchemical writers with the sole exception of Hermes. Another list which places Johannes earlier than Democritus dates from the seventh century.

The character of the work attributed to Johannes makes it certain that its author was not earlier than the fifth century. It may be that this work is falsely attributed to a real Johannes of the first century. The application of the title itself to this work seems to be an error on the part of Berthelot as editor.

The work attributed to him is entitled:

Ἰωάννου Ἀρχιερέως τοῦ ἐν Ἐβειγίᾳ περὶ τῆς θείας τέχνης. (B. II. 263 and 130, 4.)

PAMMENES may be the Egyptian Phimenas of Sais to whom a recipe in the Leyden Papyrus X is attributed. He is mentioned by Olympiodorus (fifth century). None of his works survives.

CHYMES is mentioned as an ancient author by Zosimus, and a few quotations from his works are found in the treatise of Olympiodorus, and in certain works of Zosimus. He is associated by the latter with Mary the Jewess and may well date from the same early period.

PIBECHIOS.—The name has a mythological significance, being equivalent to Apollo Bechis (Pliny, XXX. 2). He is mentioned, together with Mary, Chymes, Democritus, Agathodaemon, in a treatise attributed to Zosimus. He might therefore be placed in the first or second century. The attribution of this particular treatise to Zosimus is, however, doubtful.

PETESIS or PETASIUS.—The name Petesis (Egyptian = Gift of Isis; in Greek, Isidoros) is perhaps that of a real person. The treatise of Olympiodorus (*c.* 400) is addressed 'to Petasius, king of Armenia.' The latter title has, however, probably been added at a later period. This treatise, moreover, mentions 'Petasius the philosopher' in such a way as to make it unlikely that he is the person to whom the treatise is addressed. A Petesis is mentioned by Zosimus as a contemporary of Hermes. The quotations from his works show him to have been of the school of Comarius and Mary.

(b) *Alchemical authors of the third and fourth century.*

The work of Zosimus, like that of a few authors to be classed with him, is distinguished from that of the earliest authors by its character as commentary. Zosimus is probably

a practical author as well as a commentator, but very little of his work, if any, is truly original. The other commentators of the fourth and fifth centuries are even less practical in type, but are perhaps less barren than those of the sixth century and later.

AFRICANUS.—The first alchemical author who can be dated with any degree of accuracy is Africanus. He is almost certainly identical with Julius Sextus Africanus who died in A.D. 232. Scanty remains of his alchemical writings survive in quotations in the works of Zosimus and Olympiodorus. They are not unlike those of Zosimus.

ZOSIMUS.—Suidas mentions that Zosimus and Theosebeia wrote a work *Cheirokmeta* (cp. Pliny on Democritus), a Chemical Encyclopaedia in 28 books. Of this certain existing works of Zosimus are fragments. The Syriac version of Zosimus seems to preserve a large portion of this work.

This most important of the Greek alchemists certainly belongs to the third century. He cites Democritus, and most of the early authors, and also Africanus, who died in A.D. 232. He is himself cited by Olympiodorus (beginning of fifth century). He mentions the Serapeum (destroyed A.D. 390) as still in being. His allegorical writings are consistent with the third century. A date of about 300 A.D. is probable. He is not identical with Zosimus the historian.

Zosimus produced several works on alchemy and also a collection of some of the alchemical works extant in his time. A part of this collection survives. Zosimus is heir to the ideas of Mary and Cleopatra. He had some tincture of the experimental spirit, and appears to have added something of his own to the tradition he had received. His remarkable ' visions ' do not readily receive a physical interpretation, and it is possible that these and some of the work of his followers are mystically symbolic and not primarily practical in meaning.

The following are attributed to him :

(α) Ζωσίμου τοῦ θείου περὶ ἀρετῆς (πρᾶξις α′). (B. II. 107.)
(β) Ζώσιμος λέγει περὶ τῆς ἀσβέστου. (B. II. 113.)
Ζώσιμος πρᾶξις β′. (B. II. 115.)
(γ) Ποίημα τοῦ αὐτοῦ Ζωσίμου πρᾶξις γ′. (B. II. 117.)
(δ) Ζωσίμου τοῦ θείου περὶ ἀρετῆς καὶ ἑρμηνείας. (B. II. 118.)
(ε) Περὶ τῆς ἐξατμίσεως ὕδατος θείου. (B. II. 138.)
(ζ) Περὶ τοῦ αὐτοῦ θείου ὕδατος. (B. II. 141.)
(η) Περὶ τοῦ θείου ὕδατος (in some MSS.). Ζωσίμου τοῦ Πανοπολίτου γνήσια ὑπομνήματα περὶ τοῦ θείου ὕδατος. (B. II. 143.)
(θ) Παραινέσεις συστατικαὶ τῶν ἐγχειρούντων τὴν τέχνην. (B. II. 144.)
(ι) Ζωσίμου τοῦ Πανοπολίτου γνησία γραφὴ περὶ τῆς ἱερᾶς καὶ θείας τέχνης, τῆς τοῦ χρυσοῦ καὶ ἀργυροῦ ποιήσεως κατ' ἐπιτομὴν κεφαλαιώδη. (B. II. 145.)
(κ) Βίβλος ἀληθὴς Σοφὲ Αἰγυπτίου καὶ θείου Ἑβραίων κυρίου τῶν δυνάμεων Σαβαώθ. Ζωσίμου Θηβαίου μυστικὴ βίβλος. (B. II. 211 and 213.)
(λ) Ζωσίμου πρὸς Θεόδωρον κεφάλαια. (B. II. 215.)
(μ) No title. Inc. :—καὶ ὅτι τοὺς χρησίμους λόγους . . . (B. II. 219, 1.)
(ν) Ὑδραργύρου ποίησις. (B. II. 220.)
(ξ) Ζωσίμου περὶ ὀργάνων καὶ καμίνων. (B. II. 224.)
(ο) Τοῦ αὐτοῦ Ζωσίμου περὶ ὀργάνων καὶ καμίνων γνησία ὑπομνήματα περὶ τοῦ ὦ στοιχείου. (B. II. 228.)
(π) Περὶ τοῦ τριβίκου καὶ τοῦ σωλῆνος. (B. II. 236.)
(ρ) Τὸ πρῶτον βιβλίον τῆς τελευτείας ἀποχῆς Ζωσίμου Θηβαίου . . . (B. II. 239.)
(ς) Ἑρμηνεία περὶ πάντων ἁπλῶς καὶ περὶ τῶν φώτων. (B. II. 247.)
(τ) No title. Inc. :—δύναμις, μετὰ δὲ τὴν ἐργασίαν . . . (B. II. 248, 11.)
(υ) Περὶ λευκώσεως. (B. II. 211.)
(φ) Ἑρμηνεία περὶ τῶν φώτων. (B. II. 249.)
(χ) Περὶ αἰθάλων. (B. II. 250, 13.)

The following works may belong to the remains of the Encyclopaedia of Zosimus and Theosebeia:

(α) Περὶ τῶν ὑποστάτων καὶ τὰ δ′ σωμάτων κατὰ τὸν Δημόκριτον τὸν εἰπόντα. (B. II. 148.)
(β) Περὶ διαφορᾶς χαλκοῦ κεκαυμένου. (B. II. 153.)
(γ) Περὶ τοῦ ὅτι πάντων τῶν ὑγρῶν τὸ θεῖον ὕδωρ καλοῦσιν· καὶ τοῦτο συνθετόν ἐστιν καὶ οὐχ ἁπλοῦν. (B. II. 154.)
(δ) Περὶ τοῦ ἐν παντὶ καιρῷ ἀρκτέον τὸ ἔργον. (B. II. 156.)
(ε) Περὶ τῆς κατὰ πλάτος ἐκδόσεως τὸ ἔργον. (B. II. 159.)
(ϛ) Περὶ τοῦ τί ἐστιν κατὰ τὴν τέχνην, οὐσία καὶ ἀνουσία. (B. II. 167.)
(η) Περὶ τοῦ ὅτι πάντα περὶ μιᾶς βαφῆς ἡ τέχνη λελάληκεν. (B. II. 169.)
(θ) Περὶ τοῦ τροφὴν εἶναι τὰ δ′ σώματα τῶν βαφῶν, εἰσίν. (B. II. 170.)
(ι) Περὶ τοῦ χρηστέον στυπτηριᾷ στρογγυλῇ ἀντίλογος. (B. II. 171.)
(κ) Περὶ θειῶν. (B. II. 174, 11.)
(λ) Περὶ σταθμῶν. (B. II. 177.)
(μ) Περὶ καύσεως σωμάτων. (B. II. 179.)
(ν) Περὶ σταθμοῦ ξανθώσεως. (B. II. 181.)
(ξ) Περὶ θειοῦ ἄθικτου ὕδατος. (B. II. 184.)
(ο) Περὶ σκευασίας[6] ὠχρας. (B. II. 186.)
(π) Περὶ οἰκονομίας τοῦ τῆς μαγνησίας σώματος. (B. II. 188.)
(ρ) Περὶ σώματος μαγνησίας καὶ οἰκονομίας ⟨αὐτοῦ⟩. (B. II. 191.)
(ϛ) Περὶ τοῦ λιθοῦ τῆς φιλοσοφίας. (B. II. 198.)
(τ) Περὶ ἀφορμῶν συνθέσεως. (B. II. 204.)
(υ) Περὶ ξηρίου. (B. II. 205.)
(φ) Περὶ ἰοῦ. (B. II. 205.)
(χ) Περὶ αἰτίων. (B. II. 206.)
(ψ) Without title. Inc.:—Ὑδραργύρου πῦρ πυρὶ κρατοῦντες . . . (B. II. 206, 8.)
(ω) Without title. Inc.:—Οὗτος ὁ χαλκάνθρωπος ὃν ὁρᾷς . . . (B. II. 207, 1.)
(αα) Καδμιάς πλύσις. (B. II. 207.)
(ββ) Περὶ βαφῆς. (B. II. 207.)
(γγ) Περὶ ξανθώσεως. (B. II. 208.)
(δδ) Τὸ ἀέριον ὕδωρ. (B. II. 209.)
(εε) Περὶ λευκώσεως. (B. II. 211.)

HELIODORUS.—His work is addressed to Theodosius, presumably Theodosius I (379–395). It is an alchemical poem and bears no evidence of being the work of a practising alchemist.

Title: Ἡλιοδώρου φιλοσόφου πρὸς Θεοδόσιον τὸν μέγαν βασιλέα περὶ τῆς τῶν φιλοσόφων μυστικῆς τέχνης διὰ στίχων ἰάμβων. (Goldschmidt: *Heliodori carmina quattuor.* 'Religionsgeschichtliche Versuche und Vorarbeiten,' XIX. 2. Giessen. 1923.)

SYNESIUS is not the famous bishop of that name, since he writes prior to the destruction of the temple of Serapis at Alexandria (A.D. 390). His one work is:

Συνεσίου φιλοσόφου πρὸς Δίοσκορον εἰς τὴν βίβλον Δημοκρίτου, ὡς ἐν σχολίοις. (B. II. 56.)

PELAGIUS.—This author mentions Zosimus (*c.* A.D. 300) and is mentioned by Olympiodorus (*c.* A.D. 425). He is thus about A.D. 370. He wrote:

Πελαγίου φιλοσόφου περὶ τῆς φείας ταύτης καὶ ἱερᾶς τέχνης. (B. II. 253.)

OLYMPIODORUS wrote in A.D. 425 a history of his times. Thus his lengthy alchemical work may perhaps be *c.* 400–425.

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[6] Or σημασίας.

Ὀλυμπιοδώρου τοῦ φιλοσόφου Ἀλεξανδρέως εἰς τὸ κατ' ἐνέργειαν Ζωσίμου ὅσα ἀπὸ Ἑρμοῦ καὶ τῶν φιλοσόφων ἦσαν εἰρημένα. (B. II. 69.)

(c) *The Commentators.*

The remaining writers on alchemy are merely commentators, and few, if any, exhibit anything original. Disputes as to the meaning of the phrases of the ancient authors occupy much of their space. The development of elaborate analogies such as that between alchemy and music also interests them. Rhapsodical passages acclaiming the marvellous transformations brought about by the art appear, while the alchemical content remains completely static. Only when Western or Arabic alchemy came to the Greek world did a new type of alchemical work appear. Up to the tenth century the alchemical works written in Greek had made no advance on those of Zosimus. The knowledge of work which was done by the Arabs in the ninth and tenth centuries did not reach the Byzantine Greeks until a date entirely beyond our period.

The earliest commentators are sometimes interesting, but the later are a wilderness of futile subtlety.

PHILOSOPHUS CHRISTIANUS.—This name is attached to a very considerable treatise. The 'Sergius' to whom it is dedicated may be Sergius Resainensis, who lived in Alexandria in the early sixth century. This date is compatible with the general character of his work, which is undoubtedly a compilation of which probably only the first item is original. In certain MSS. works are attributed to this philosopher which are elsewhere ascribed to Zosimus. It seems likely that Philosophus Christianus incorporated the compilation of Zosimus into his own work.

The following works, with the name of Christianus attached, are elsewhere attributed to no other author:

(α) Τοῦ Χριστιανοῦ περὶ εὐσταθείας τοῦ χρυσοῦ. (B. II. 395.)
(β) Τοῦ αὐτοῦ Χριστιανοῦ περὶ τοῦ θείου ὕδατος. (B. II. 399.)
(γ) Τίς ἡ τῶν ἀρχάιων διαφωνία. (B. II. 400.)
(δ) Τίς ἡ καθόλου τοῦ ὕδατος οἰκονομία. (B. II. 401.)
(ε) Ἡ τοῦ μυθικοῦ ὕδατος ποίησις. (B. II. 402.)
(ϛ) Ἀντίθεσις λέγουσα ὅτι τὸ θεῖον ὕδωρ ἕν ἐστι τῷ εἴδει καὶ ἡ λύσις αὐτῆς. (B. II. 405.)
(η) Ἄλλη ἀπορία. Τὸ ἓν ἀβύσσαιον ὕδωρ ἐν τῷ ἀριθμῷ δεικνύειν ἐθέλουσα ἡ τούτου ἐπίλυσις. (B. II. 407.)
(θ) Τοῦ χριστιανοῦ σύνοψις. τίς ἡ αἰτία τῆς προκειμένης συγγραφῆς. (B. II. 409.)
(ι) Ὅτι τετραχῶς τῆς ὕλης διαιρουμένης, διάφοροι ἀπογίνονται τῶν ποιήσεων αἱ τάξεις. (B. II. 409.)
(κ) Πόσαι εἰσὶν αἱ κατ' εἶδος καὶ γένος Διαφοραὶ τῶν ποιήσεων. (B. II. 410.)
(λ) Πῶς δεῖ νοεῖν αὐτὰς καὶ σχήμασι γεωμετρικοῖς. (B. II. 414.)
(μ) Τίς ἡ ἐν ἀποκρύφοις τῶν παλαιῶν ἐκδιδομένη τάξις. (B. II. 415.)

STEPHANUS is dated by his connexion with Heraclius 610–641. His alchemical works are entitled:

(α) Στεφάνου Ἀλεξανδρέως οἰκουμενικοῦ φιλοσόφου καὶ διδασκάλου τῆς μεγάλης καὶ ἱερᾶς ταύτης τέχνης περὶ χρυσοποίας. πρᾶξις πρώτη το ἐννάτη (9 texts). (Ideler, II. 199.) The letter Τοῦ αὐτοῦ Στεφάνου ἐπιστολὴ πρός Θεόδωρον is inserted in the first work after the second part (πρᾶξις δευτέρα). (Ideler, II. 208.)

(β) Στεφάνου τοῦ παμμεγίστου φιλοσόφου καὶ οἰκουμενικοῦ διδασκάλου πρὸς Ἡράκλειον τὸν μέγαν βασιλέα διδασκαλία περὶ τῆς ἱερᾶς καὶ μεγάλης ἐπιστήμης τῆς χρυσοποιΐας. (Ideler, II. 243.)

HERACLIUS and JUSTINIANUS.—The treatises attributed to Heraclius have disappeared.[7] A portion of a treatise attributed to Ἰουστινιάνος βασιλεύς remains, but is undoubtedly the work of some other person.

PHILOSOPHUS ANONYMUS.—This author cites Stephanus, who is undoubtedly of the seventh century. He must be dated as of the seventh or eighth century.

(α) Ἀνεπιγράφου φιλοσόφου περὶ θείου ὕδατος τῆς λευκώσεως. (B. II. 421.)
(β) Τοῦ αὐτοῦ Ἀνεπιγράφου φιλοσόφου κατὰ ἀκολουθίαν χρήσεως ἐμφαῖνον τὸ τῆς χρυσοποιΐας συνεπτυγμένον συν Θεῷ. (B. II. 424.)
(γ) Ἀνεπιγράφου φιλοσόφου περὶ τῆς θείας καὶ ἱερᾶς τεχνῆς τῶν φιλοσόφων. (B. II. 433.)

PAPPUS is probably of the seventh or eighth century, as is shown by his mention of Stephanus, and is represented by the fragment:

Πάππου φιλοσόφου ⟨ὅρκος⟩. (B. II. 27.)

THEOPHRASTUS, HIEROTHEUS, ARCHELAUS.—These three writers of alchemical verse are apparently of the eighth to ninth century, being cited by no earlier author, and resembling Stephanus and his followers in their declamatory style.

Θεοφράστου φιλοσόφου περὶ τῆς αὐτῆς θείας τέχνης διὰ στίχων ἰάμβων. (Ideler, II. 328. Goldschmidt, *ibid.* 34.)
Ἱεροθέου φιλοσόφου περὶ τῆς αὐτῆς θείας καὶ ἱερᾶς τέχνης διὰ στίχων. (Ideler, II. 336. Goldschmidt, *ibid.* 42.)
Ἀρχελάου φιλοσόφου περὶ τῆς αὐτῆς ἱερᾶς τέχνης διὰ στίχων ἰάμβων. (Ideler, II. 343. Goldschmidt, *ibid.* 50.)

SALMANAS from his style and language appears to be of the ninth to tenth century and wrote a work Μέθοδος δι' ἧς ἀποτελεῖται ἡ σφαιροειδὴς χάλαζα κατασκευασθεῖσα παρὰ τοῦ ἐν τεχνουργίᾳ περιβοήτου Ἄραβος τοῦ Σαλμανᾶ. (B. II. 864.)

PSELLUS.—The famous Michael Psellus (1018–1078) wrote two alchemical works of no originality and of no special interest for our theme. They were, however, of importance as a means of spreading alchemical ideas in Western Europe.

(α) Τοῦ Ψελλοῦ πρὸς τὸν πατριάρχην κυριότατον Μιχαήλ· περὶ τοῦ ὅπως ποιητέον χρυσόν. (Parisinus, gr. 2328, f. 10; 3027, f. 52.)
(β) Τοῦ μακαρίου καὶ πανσόφου Ψελλοῦ ἐπιστολὴ πρὸς τὸν ἁγιώτατον πατριάρχην τὸν Ξιφιλίνον περὶ χρυσοποιΐας. (Parisinus gr. 2327, f. 1 and other MSS.) (*Cat. MSS. Alch. Gr.*, Vol. VI.)

COSMAS.—Probably *c.* A.D. 1000 as shown by the use of the barbarous terms σαλόνιτρον, τζαπαρίκον, ῥασούχθη. His work is entitled Ἑρμηνεία τῆς ἐπιστήμης τῆς χρυσοποιΐας ἱερομονάχου τοῦ Κοσμᾶ.

NICEPHORUS BLEMMYDES.—A writer of the thirteenth century and inhabitant of Constantinople. Despite its late date his work does not display the characters of Western or Arabic alchemy, but is derived from the work of Democritus and his school. It is entitled:

Νικηφόρου τοῦ Βλεμμύδου περὶ χρυσοποιΐας. (B. II. 452.)

ANONYMOUS WORKS.—In addition to the works which bear an author's name there

[7] These treatises are catalogued by Miller as existing in the MS. Ψ 13 of the Escurial. Though mentioned in the list of contents (copied from the old list of M. 299) they are not to be found in the MS. itself. (E. Miller: *Catalogue des Manuscrits grecs de l'Escurial*, 1848.) (See *Cat. MSS. Alch. Grecs*, Vol. V.)

are a number of anonymous treatises and fragments. Of these a few are of interest. Certain MSS. contain the *Lexicon of Gold-making*, Λεξικὸν κατὰ στοιχεῖον τῆς Χρυσοποιΐας (B. II, 4), a dictionary of alchemical terminology. It is not very informative. Occasional items such as

'Ανδροδάμας ἐστὶ πυρίτης καὶ ἀρσένικον.

are of value, but some of the substances are defined on the system of *obscurum per obscurius*, and other definitions involve contradictory statements. Thus the term *Magnesia* is explained three times in an entirely different way. A part of this Lexicon has clearly been compiled at a late date and unintelligently, but it contains a residue of valuable information.

A list of alchemical symbols contained in certain MSS. is of great value. The MSS. as a rule employ symbols in place of the names of the substances employed. The list of these covering several folios and reproduced by Berthelot (Intr. 104–120) has been of use in interpreting the MSS.

§ 5. *Substances used by Alchemists.*

The Greek alchemists employed a considerable variety of substances in their operations. Some can be identified. The first essential ingredients of their operations are the metals, gold, silver, copper, mercury, iron, tin and lead. These were termed σώματα or true bodies, in contradistinction to ἀσώματα, substances other than metals. In addition to the substances that we know as the metallic elements, the σώματα included a number with metallic lustre formed for the most part of mixtures or alloys of true metals. Among these were the following :

ἄσημον.	Asemon.	A lustrous alloy of varied composition, silver, copper, tin, lead and mercury being frequent ingredients.
χρυσοκόραλλος.	Chrysocorallos.	Apparently a superfine gold or substance more fine than ordinary gold. Its composition is not known, but it may have been a fine red gold-copper alloy.
κλαυδιανός.	Claudianos.	A copper-lead alloy.
ἤλεκτρον.	Electrum.	A gold silver alloy.
μολυβδόχαλκον.	Molybdochalkon.	A copper lead alloy, or perhaps a metallic sulphide.
ὠρείχαλκον.	Orichalkon.	A form of brass containing copper, zinc, and perhaps arsenic.
σιδηρόχαλκον.	Siderochalkon.	Presumably an alloy of copper and iron.

Besides the metals and their alloys the alchemists had at their disposal a great number of native minerals. Many of these may be identified, such as :

ἀλάβαστρος.	Alabaster.	Possibly also a preparation having the appearance of alabaster.
στυπτηρία.	Alum.	Not always identical with modern alum and possibly used as a term for arsenic.
ἀνδροδάμας.	Androdamas.	Possibly arsenical pyrites.
στίμμι.	Antimony sulphide.	
ἀργυρίτης.	Argyrite.	Perhaps native silver sulphide or argentiferous galena.
ἀρσενικόν.	Arsenic.	Certainly orpiment, yellow arsenic sulphide.
ἀρσενικὸν ξανθόν.	Yellow arsenic.	Orpiment, as distinguished from white arsenic.
κύανος.	Blue.	Probably azurite, native hydrated copper carbonate, but possibly native hydrated copper sulphate.

ἅλμυρία, ἅλμη.	Brine.	Perhaps also used figuratively for other liquids.
καδμεία.	Cadmia.	A product deposited in smelters' flues, chiefly consisting of the oxides of zinc, copper and arsenic.
ψιμύθιον.	Ceruse.	White lead, but also perhaps other white substances such as arsenic trioxide.
χάλκανθος.	Chalkanthos.	Impure copper and iron sulphates derived from the oxidation of pyrites.
χαλκῖτις.	Chalkitis.	Probably the same as Chalkanthos.
χρυσόκολλα.	Chrysocolla.	Apparently malachite, but also used in other senses in these texts.
κιννάβαρις.	Cinnabar.	Native mercury sulphide, but the word is also used of realgar and perhaps red lead, which are all similar in colour, and were imperfectly distinguished one from another.
γῆ.	Earth.	Earths of various kinds are used, Chian earth being perhaps the commonest.
ἰός.	Ios.	The term has the meaning of 'rust' or 'calx,' and also the sense of the Latin 'virus.' The use of the word is often difficult to follow.
λιθάργυρος.	Litharge.	This translation is doubtfully correct. The sense in which the alchemists use the word is that of 'silver-producing stone,' and it is doubtful whether lead oxide is ever intended.
ἄσβεστος.	Lime.	
τίτανος.	Limestone or chalk.	
μάρμαρον.	Marble.	The word is used as a generic term for preparations resembling marble in appearance, as well as for marble itself.
μαγνησία.	Magnesia.	Not the modern magnesia, but usually an alloy of the four base metals, copper, iron, lead and tin: the sense of the word appears to be very wide.
μίλτος.	Minium.	A term used for red lead, realgar and cinnabar.
μίσυ.	Misy.	Basic iron sulphate.
νίτρον.	Natron.	Native soda.
ὤχρα.	Ochre.	Perhaps has the additional meanings of realgar and cinnabar.
πυρίτης.	Pyrites.	The term probably includes iron and copper pyrites, galena and mispickel.
σανδαράχη.	Realgar.	The modern Sandarac is a resin.
ἅλς.	Salt.	
σῶρι.	Sori.	Similar in nature to misy.
θεῖον.	Sulphur.	The term includes not only the element sulphur, but also similar substances such as arsenic sulphide. The term has not, however, the wide meaning it acquired in mediaeval times.

A host of less important and often more obscure materials were used. These include honey, gum, milk, bile, urine and vegetable products. A complete list extends to some five hundred items.

§ 6. *Imitation of Silver.*

Many alchemical recipes are concerned with the making of silver and of the alloy ἄσημον. This was expected to have the brilliant metallic surface

and general appearance of silver. Such recipes are found mainly in the earlier texts, in particular in the *Physica et Mystica* of Democritus, and in the Papyri of Leyden and Stockholm. The methods employed in the preparation of silver or asemos fall into two groups.

(*a*) Processes for the whitening of copper by means of arsenic.
(*b*) Recipes for the melting together of such metals as would give a hard and white alloy with a silvery lustre.

(*a*) The usual method of whitening copper was to coat it with some preparation of arsenic and then to heat gently. A superficial layer of copper arsenide is thus produced. It is white and lustrous, tarnishing to a yellow tint, much as with silver. One recipe indicates the boiling of copper with an arsenical solution which would whiten the copper in the manner still used in the familiar 'Reinsch test' for arsenic.[8] These recipes can be used in the laboratory to produce a whitish metallic substance, with some resemblance to silver. One recipe attributed to Democritus runs as follows:

Λαβὼν ἀρσένικον σχιστὸν,[9] ποίησον πέταλα·[10] βάλλε εἰς τεῦχος στρογγύλον καὶ καῦσον· ὀπηνίκα δὲ διαγελάσῃ,[11] ἐπιβαλὼν γάλα ⟨πάλαι⟩ ἐξουρικὸς τὸ μηκέτι ῥέψαντι· ὀπηνίκα δὲ παγῇ, ἄρον καὶ λείωσον[12] μετὰ στυπτηρίας ἐξηποριθείσης οὔρῳ δαμάλεως ἡμέρας ζ′ καὶ ἀναξηράνας εἰς ἥλιον, λείου πάλιν ἅλμην, τοῦ αὐτοῦ ἁλὸς ἄνθος ἐπίβαλλε, ⟨ἔχε⟩ ἡμέρας ζ′, καὶ γίνεται, καὶ λαβὼν ἀναξήραινε πάλιν εἰς ἥλιον, τοῦτο βάλλε εἰς τεῦχος, ἔψει ἐλαίῳ κικίνῳ ἢ ῥαφανίνῳ[13] ἕως ξανθὸν ⟨γίγνηται⟩, τούτῳ ἐπίβαλλε[14] χαλκὸν, καὶ λευκανθήσεται. Τοῦτο δὲ αὐτὸ ποιεῖ καὶ ἡ σανδαράχη . . . (B. II. 54.)

This recipe is typical and neither more nor less lucid than most. A mixture of arsenical substances and organic matter is prepared and projected on copper. The dilution of the arsenic with inert substances ensures slow volatilisation and therefore protracted action on the metal, while the presence of organic matter protects the copper from oxidation and reduces the arsenic compounds to the elementary condition in which they are most active. The reaction of the arsenic and copper produces a layer of the white and lustrous copper arsenide. In certain other recipes the copper appears to have been melted with the arsenic compounds producing a solid white alloy.

(*b*) The other method of preparing silver was the making of an alloy, white in colour and fairly hard, by fusing together various metals or their

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[8] It is quite possible that this recipe may owe its success to the presence of silver or mercury in the mixture used.

[9] Probably arsenic trioxide.

[10] Metallic leaves or foil, presumably of copper.

[11] διαγελάσῃ. The sense of διαγελάω here seems very doubtful. The word recurs in other recipes.

[12] λείωσον 'temper' or 'soak.' The word has the sense of treating a solid with a liquid.

[13] These oils are probably not actual 'castor' and 'radish' oils (*v.* note 24).

[14] The sense of the word in Greek alchemy seems to be simply 'place upon,' or, as the later alchemists said, 'project.'

compounds. The recipes indicate the preparation of the following alloys or metals.

(i) Tin. Purified by methods similar to some in use at the present day, tin is said to yield ἄσημον, a lustrous metal resembling silver, to which, indeed, pure tin has some likeness.

FIG. 3.—THESE DRAWINGS ILLUSTRATE TYPES OF APPARATUS FOR DISTILLATION AND SUBLIMATION CLOSELY RESEMBLING THAT USED IN CHEMICAL WORK UP TO THE CLOSE OF THE EIGHTEENTH CENTURY. (MS. PARIS, GR. 2327, F. 81.)

(ii) A lead–silver alloy seems in one case to be indicated.

(iii) A copper–zinc–tin alloy with some arsenic. This is identical with some modern speculum metals which are white and exceedingly lustrous.

(iv) Copper with about 1 per cent. of arsenic and a small amount of silver. This would almost certainly be white and lustrous.

(v) Copper–lead–iron–arsenic alloy. This would be white, but as the quantity of lead and arsenic does not appear its properties are doubtful.

(vi) Copper–iron–lead–silver alloy. Certainly white, since only 36 per cent. of copper is used.

(vii) Tin with traces of copper and mercury. Probably the copper would harden the tin and the mercury would improve its lustre.

(viii) Copper–zinc alloy with traces of arsenic and other metals. Since only 40 per cent. of copper is present, this alloy will be white.

(ix) Copper–silver alloy (50 per cent.). This is harder and slightly less lustrous than pure silver.

These alloys are prepared by methods which seem unnecessarily complicated to us. The complication is due in part, at least, to the fact that the alchemist had no means of judging the purity of his materials or of finding out the composition of a satisfactory product. Small differences of composition often profoundly modify the colour and other properties of an alloy, and a chance success has often been attributed to the use of some inert ingredient. The retention of such ingredients leads to the adoption of these complicated mixtures. The making of alloys is not easy even to-day, for, during fusion, volatilisation or oxidation removes such metals as zinc, arsenic, lead and mercury to an extent which cannot be certainly predicted. Thus slight variations in the conditions of fusion often alter considerably the appearance of the product.

§ 7. *Imitation of Gold.*

The preparation of a gold-like substance was the main object of practical alchemy. The problem was far more difficult than for silver. For a metal to pass as gold it had to withstand the fairly reliable tests then available.

First of these was the test of the touchstone. The gold was rubbed on a hard black stone and its quality judged from the colour and extent of the streak produced. To pass this test a metal would have to resemble gold in colour and in hardness.

Second was the test by fire. This rules out alloys of base metals, but a slight oxidation at a high temperature was evidently not considered incompatible with gold. Modern jewellers' gold will not stand prolonged heating without change, since it always contains copper. Much native gold is also contaminated with copper, and this would help to minimise the failure of the artificially produced gold to satisfy the conditions of the fire test.

Third was the density test. The high density of gold cannot be imitated by any alloy of baser metals, but although density measurements to detect impurities in gold had been used by Archimedes in his famous experiment, it seems unlikely that it was generally applied in the early days of alchemy.

Thus for an alchemist to believe that he had prepared gold, he would have had to make a metal, closely resembling gold in colour and hardness, of high density, and little affected by atmospheric action.

The recipes for making gold fall into three well-marked classes:

(*a*) Manufacture of alloys analogous to brass.
(*b*) Preparation of debased gold.
(*c*) Superficial treatment of metals.

All three methods are in present use in the preparation of artificial jewellery.

(a) *Manufacture of alloys analogous to brass.*

Brass-like alloys, including some of the alloys of copper, tin and zinc, used to-day under the names of *ormolu*, *oroide*, *Mannheim gold*, etc., were certainly prepared by the Greek alchemists. The problem of making these was difficult, because zinc, which gives the yellow colour to brass-like alloys, was unknown as a metal to the Greek alchemists. The alloys which contained zinc were made by them through the medium of cadmia, an impure zinc oxide found as a deposit in the flues of smelting furnaces. This cadmia was of inconstant composition, varying with the nature of the ore from which it was derived. Such variation makes successful results hard to reproduce, since small changes in the proportion of zinc have a considerable effect on the colour of the resulting alloys. Moreover, the volatility of the zinc yielded by the cadmia would be an additional source of difficulty.

Many alloys thus produced do not admit of certain identification; the following, however, appear to have been made by these recipes.

(i) Complex copper–tin–lead–iron alloys. These are yellow if the proportion of copper be sufficient.
(ii) Copper amalgam. The amalgam containing 13 per cent. mercury is used for artificial jewellery at the present date.
(iii) Copper–zinc alloys containing traces of other metals. These have a good golden colour when about 20 per cent. of zinc is present, and are known at the present time as *Dutch metal*, *Mannheim gold*, *pinchbeck*, etc.
(iv) Copper–silver–lead alloys.
(v) Copper–tin–lead alloys.

As an example of this type of recipe I quote the following, which is less complicated than many:

Democritus *Physica et Mystica*. (B. II. 44.)

Τὸ κλαυδιανὸν[15] λαβών, ποίει μάρμαρον[16] καὶ οἰκονόμει ὡς ἔθος, ἕως ξανθὸν γένηται. Ξάνθωσον οὖν· οὐ τὸν λίθον λέγω ἀλλὰ τὸ τοῦ λίθου χρήσιμον· ξανθώσεις[17] δὲ μετὰ στυπτηρίας ἐκσηπτωθείσης θείῳ, ἢ ἀρσενίκῳ, ἢ σανδαράχῃ, ἢ τιτάνῳ, ἢ ὡς ἐπινοεῖς. Καὶ ἐὰν ἐπιβάλλῃς ἀργύρῳ, ποιεῖς χρυσόν· ἐὰν δὲ χρυσῷ, ποιεῖς χρυσοκογχύλιον· ἡ γὰρ φύσις τὴν φύσιν νικῶσα κρατεῖ.

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[15] Copper-lead alloy or perhaps a bronze containing lead.

[16] A marble-like white preparation.

[17] The nature of the yellowing is not very clear. Most of the substances used are arsenical: στυπτηρία is evidently used in the sense of 'arsenic' by some of the alchemists.

The 'gold' made by this process was a copper–silver–lead alloy possibly containing arsenic also. No modern information is available concerning such alloys, but there is a strong probability that they would be yellow.

(b) *Preparation of debased gold.*

The second type of recipe for making gold employs a considerable quantity of the metal. Such methods are called by the Greek alchemists διπλωσις, *i.e.* a doubling of the weight of gold. They depend mostly on the fact that, while silver gives a greenish and copper a reddish colour to gold, the admixture of both copper and silver hardly alters the tint of true gold. The alchemist did not regard himself as in any way falsifying gold, but rather believed that the gold acted as a seed which, nourished by the copper and silver, grew at their expense until the whole mass became gold.

Such alloys are fairly easy to make, but need a considerable outlay of gold. They were thus less sought after by alchemists than alloys formed with a larger proportion of the less costly base metals.

The recipes describe the preparation of alloys of the following types, some of which are to-day legalised on the Continent just as are 18-carat gold and other gold–copper alloys in this country.

(i) Gold–copper alloys with small quantities of other metals, notably zinc and arsenic. This corresponds to our modern 14–18-carat gold, possibly made somewhat lighter in colour by the presence of zinc.

(ii) Gold–copper–silver alloys, similar to the above but reproducing the colour of pure gold more closely.

(iii) Alloys containing much copper and some silver and gold. The yellow colour of these derives chiefly from the copper, and the addition of precious metal prevents the alloy from tarnishing readily.

The following example of these methods may be given (B. II. 39):

Χαλκοῦ κεκαυμένου μέρη τρία· χρυσοῦ μέρος α'. Χώνευσον καὶ ἐπίβαλε ἀρσενικόν· καῦσον,[18] καὶ εὑρήσεις θρυπτόν. Εἶτα λείωσον ὄξει ἡμέρας ζ' ἐν ἡλίῳ· εἶτα ξηράνας, χώνευσον ἄργυρον καὶ γελάσαν·[19] τι (?) ἔκβαλε ἐκ τούτου τοῦ συνθέματος, καὶ εὑρήσεις τὸν ἄργυρον ὡς ἤλεκτρον.[20] Τοῦτο ἴσῳ σύμμιξον χρυσόν, καὶ ἔξεις ὄβρυζον καλόν.

The final product would be roughly gold 60 per cent., copper 20 per cent., silver 20 per cent., although the silver might form a greater proportion of the alloy than this. The colour of such an alloy would very closely resemble that of pure gold. The word ὄβρυζον may mean 'Gold judged good by the touchstone,' the original meaning of ὄβρυζα being 'a touchstone.'

[18] Probably most of the arsenic is volatilised and a very base gold copper alloy is produced.

[19] Berthelot reads γελάσαντι (see note 11).

[20] The product would not be true electrum, but the yellow copper–silver alloy improved in appearance by the gold.

(c) *Superficial treatment of metals.*

The third type of recipe used for the making of gold operated on the metal superficially. These superficial treatments were hardly regarded as a true making of gold, and as a rule the word καταβαφή and not ποίησις is used to describe them. These methods also find their counterpart in modern practices. Then as now three chief methods of colouring metals were employed.

(i) Coating the metal with a tinted lacquer composed of gums, etc., as brass is treated to-day.

(ii) Tinting the metal with solutions which form a thin superficial layer of sulphides.

(iii) Treating debased gold by removing the base metal from the surface by corrosive substances such as the sulphur trioxide derived from the calcination of the sulphates of iron and copper known as μίσυ and σῶρι. This leaves a layer of fairly pure gold on the surface. At the present day, nitric acid is used instead of the sulphates.

The following appears to be a recipe for a process of the third type: Democritus, *Physica et Mystica* (B. II. 46).

Χρυσόκολλαν τὴν τῶν Μακεδόνων τὴν ἰῷ χαλκοῦ παρεμφέρουσαν οἰκονόμει λειῶν οὔρῳ δαμάλεως ἕως ἐκστραφῇ ἡ γὰρ φύσις ἔσω κρύπτεται. Ἐὰν οὖν ἐκστραφῇ κατάβαψον αὐτὴν εἰς ἔλαιον κίκινον πολλάκις πυρῶν καὶ βάπτων· εἶτα δὸς ὀπτᾶσθαι σὺν στυπτηρίᾳ προλειώσας μίσυι, ἢ θείῳ ἀπύρῳ ποίει ξανθὸν καὶ ἐπίβαπτε πᾶν σῶμα χρυσοῦ.

Apparently base gold or gold-like alloys 'σῶμα χρυσοῦ' are to be treated with misy, alum, sulphur, etc. which attack base metal, but leave gold unaffected.

The following recipe appears to deal with the tinting of a metal by means of a layer of lacquer, coloured by various plant juices, to be applied to the surface of polished metal. (B. II. 48.)

Δέξαι κρόκον κιλίκιον· ἄνες ἅμα ἄνθη τοῦ κρόκου τῷ προταγέντι χυλῷ τῆς ἀμπέλου, ποίει ζωμὸν ὡς ἔθος· βάπτε ἄργυρον ἐκ πετάλων ἕως ἀρέσῃ τὸ χρῶμα· ἐὰν δὲ χάλκεον τὸ πέταλον ἔσται, βέλτιον. προκάθαιρε δὲ τὸν χαλκὸν ὡς ἔθος. Εἶτα βαλὼν ἀριστολοχίας βοτάνης μέρη β', καὶ κρόκου καὶ ἐλυδρίου[21] τὸ διπλοῦν, ποίει πάχος κηρωτῆς καὶ χρίσας τὸ πέταλον, ἀπεργάζου τῇ πρώτῃ ἀγωγῇ καὶ θαυμάσεις.

§ 8. *Alchemical Apparatus and its use.*

Lines such as have been indicated give a reasonable explanation of those recipes which contain definite instructions for the making or colouring of a metal. Only a small part of Greek alchemical texts, however, consist of such recipes, which are, in fact, confined to the Democritan school of alchemical practice. Long sections of the other alchemists' works deal with the prepar-

[21] Mentioned as a yellow dye-stuff (Lagercrantz: *P. Holm*, p. 191).

ation of the divine or sulphurous water, θεῖον ὕδωρ, the use and nature of which is obscure. There was controversy among the alchemists themselves as to its nature. Some held it to be mercury. In one or two descriptions it seems to be a solution of a polysulphide of calcium made by the action of sulphur and arsenic sulphide on lime. A third school treat it as a generic term for all liquids useful in the work. The issue is clouded by the homonymy practised by the alchemists, who give many names to the substances most important in their art.

I quote a typical passage dealing with this divine water:

Zosimus: Περὶ θείου ὕδατος. (B. II. 184.)

Καλεῖται ὕδωρ θεῖον δι' ἅλμης, διὰ ὕδατος θαλασσίου, διὰ οὔρου ἀφθόρου, δι' ὄξους, δι' ὀξάλμης, δι' ἐλαίου κικίνου, ῥεφανίκου, βαλσάμου, γάλακτος γυναικὸς ἀρρενοτόκου, καὶ γάλακτος βοὸς μελαίνης, καὶ δι' οὔρου δαμάλεως, καὶ προβάτου θηλείας· τινὲς οὔρου ὀνείου· ἄλλοι καὶ ὕδατος ἀσβέστου, καὶ μαρμάρου, καὶ φέκλης, καὶ θείου, καὶ ἀρσενίκου, καὶ σανδαράχης, καὶ νίτρου, καὶ στυπτηρίας σχιστῆς, καὶ γάλακτος πάλιν ὀνείου, καὶ αἰγείου, καὶ κυνίνου, καὶ ὕδατος σποδοκράμβης, καὶ ἄλλων ὑδάτων ἀπὸ σποδοῦ γινομένων· ἄλλοι καὶ μέλιτος, καὶ ὀξυμέλιτος, καὶ ὄξους, καὶ νίτρου, καὶ ὕδατος ἀερίου, καὶ Νείλου, καὶ ἄρκτου, καὶ οἴνου ἀμηναίου, καὶ ῥοϊτοῦ, καὶ μορίτου, καὶ σικερίτου καὶ ζύθου· καὶ ἵνα μὴ τὰ πάντα ἀναγινώσκω διὰ παντὸς ὑγροῦ.

From such a passage as this, which is typical of many others, it is well-nigh impossible to deduce anything concerning the nature of this 'divine water.' It may mean that the 'divine water' is given all these names, or perhaps, as the other passages hint, that the 'divine water' is a term for all liquids used in 'the work.' The recipes which employ the 'divine water' seem to indicate that it had the power of dissolving or disintegrating the substances used in the art, and that it had also the property of colouring metals. It was evidently also a volatile substance, or at any rate one which produced a gas or vapour which attacked metals. Both mercury and solutions of easily hydrolysed sulphides have this power in some degree, and it is fairly certain that sometimes at least the term refers to these.

The Marian school is especially concerned with this 'divine water,' which takes an unimportant part in the Democritan school. The Marian school, of which Zosimus is the most important representative, sets out methods of operation which, while obscure, are yet consistent. The prime material operated on is not as a rule disclosed, but when revealed appears as copper or the alloy of the four base metals known as the τετρασόμια. This is treated in a peculiar form of apparatus, the invention of Mary, which to some extent resembled the modern reflux extractor (Figs. 4, 6), by exposure to the vapour and condensed liquid derived from boiling 'divine water,' mercury, sulphur or arsenic sulphides. It must be remembered that these substances may be used, in accordance with alchemical custom, as covering names for some analogous substances the nature of which the authors wished to conceal from all but the initiated. The condensed liquid, together with any fused or dissolved products of its interaction with the copper, dropped back into the lower part of the apparatus and was

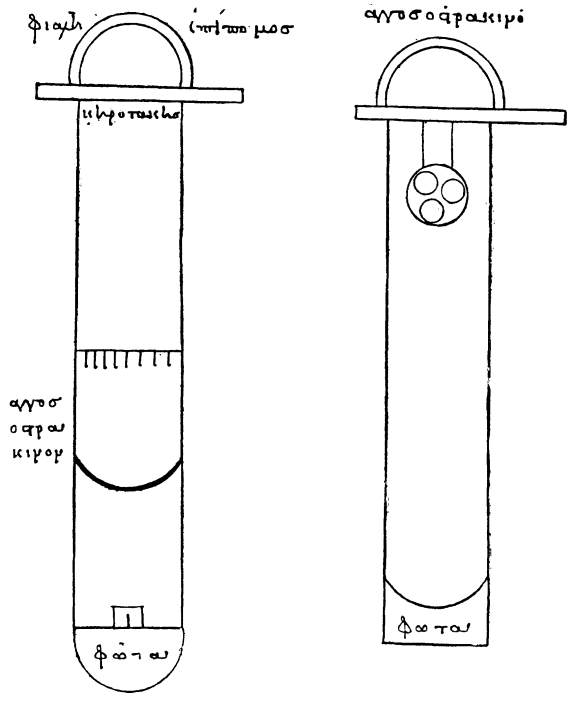

FIG. 4.—THE LONG FORM OF *KEROTAKIS* APPARATUS, AS SHOWN IN MARCIANUS 299. A RECONSTRUCTION OF THE LEFT-HAND PIECE OF APPARATUS APPEARS IN FIG. 5.

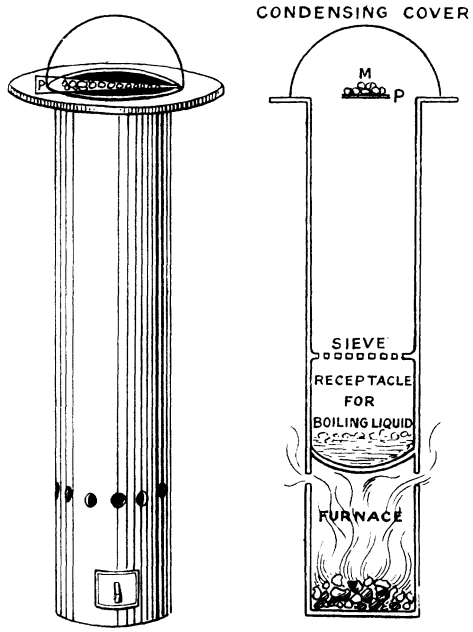

FIG. 5.—CONJECTURAL RESTORATION OF THE LONG TYPE OF *KEROTAKIS* APPARATUS.

there volatilised afresh. We are told that this process led progressively and continuously to a blackening, whitening and yellow coloration of the contents of the apparatus. Then followed a process called ' iosis,' of the nature of which no reasonable explanation can be given, though the alchemists regarded it as of high importance.[22]

The apparatus used is illustrated by several sketches in the MSS., of which two are reproduced here (Figs. 4, 6), but the theories which have been put forward to explain the use of the apparatus, and, indeed, the whole process outlined above, are not satisfactory. Two views of it appear from the chemical standpoint to represent possible methods of procedure.

The first is based on the fact that the alloy of copper and mercury containing 13 per cent. of mercury is of a golden tint. It is occasionally used at the present time for artificial gold. This alloy is not easy to prepare by the direct mixture of mercury with melted copper, for the high temperature of the latter volatilises the mercury. Nor does the direct action of mercury on copper produce it, for a mixture of unchanged copper and the silvery amalgam of copper containing much more mercury than 13 per cent. is produced.

The process used by the alchemist was probably the following :—Mercury was placed in the lower part of an apparatus such as Fig. 4 or 6,[23] and copper or an alloy containing much copper on the κηροτακίς or ' palette ' (P) in the upper part. The mercury being heated from below, boiled and condensed on the cups (φιάλη) and on the copper, which was disintegrated and finally dissolved. Impurities (oxides, etc.) remained on the κηροτακίς or on the sieve-like diaphragm below, while a pure copper amalgam collected in the lower part of the apparatus (ἄγγος ὀστράκινον), into which the droppings from the kerotakis fell. The copper blackened during the process as a result of oxidation. The white amalgam formed contained much more mercury than the yellow gold-like amalgam which was required; and continued and steady heating caused the mercury to be volatilised from this and to escape by leakage or by diffusion through the porous earthenware until the required alloy was produced.

Evidence is to be found in the texts to support this view of the process, but it was not the only purpose for which the apparatus was employed, for it was probably used as a sublimation apparatus of the type of the aludel, and also for the treatment of metals with sulphur. The process of making copper amalgam of suitable composition must have been far from easy, and indeed the alchemists who employ the κηροτακίς give the impression of dealing with a

[22] The meaning ' violet coloration ' seems improbable. A. J. Hopkins, *Chemical News*, Vol. 85, p. 49, upholds the view that this process was the formation of a purple bronze similar to the Japanese *shaku-do*. This theory, though explaining the meaning of ' iosis ' in a reasonable manner, seems inconsistent with the processes that precede this operation. Conceivably ' iosis ' may be the final removal of the *ios* or tarnish formed on the surface of the metal.

[23] The figures are copies of those in the MS. of St. Mark, folios 112, 193, 196; Figs. 4 and 6 represent the same type of apparatus, the globular lower portion of Fig. 4 being probably some form of heating apparatus. Several other sketches are reproduced in Berthelot's *Introduction à l'étude de la Chimie des Anciens et du Moyen-âge*. Figs. 5 and 7 represent reconstructions of the apparatus of Figs. 4 and 6, based on the figures contained in the MSS. and the descriptions in the text.

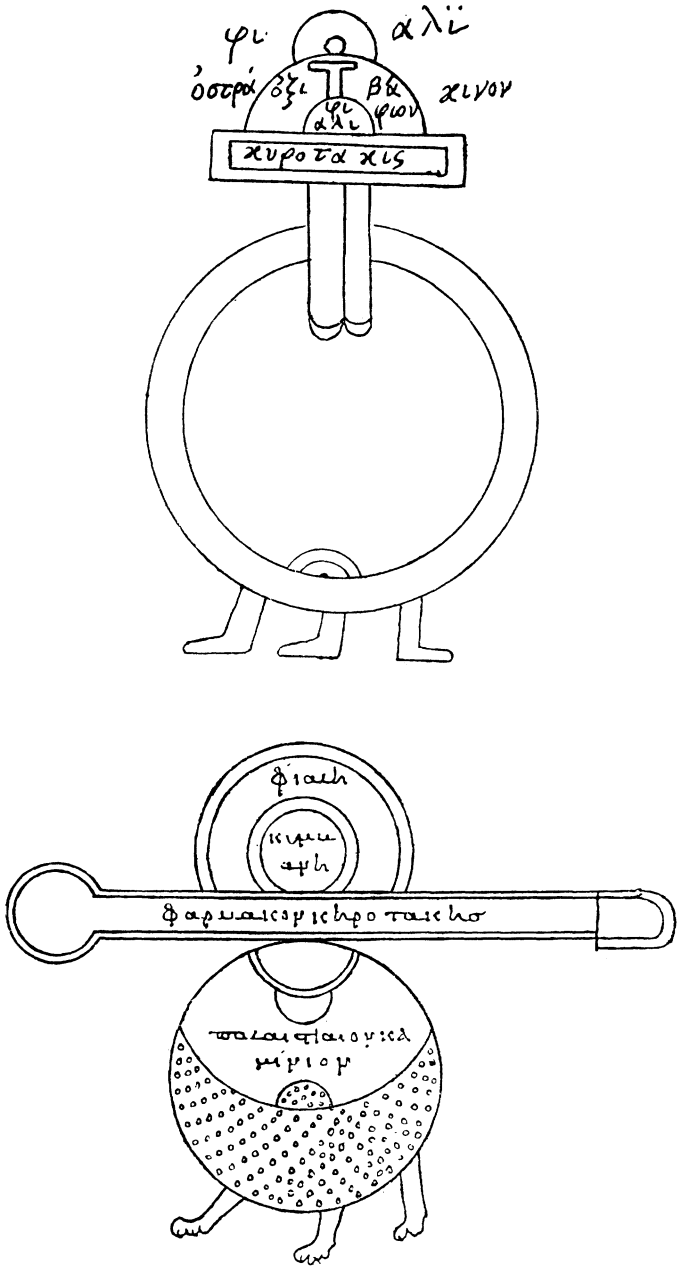

FIG. 6.—TWO TYPES OF THE MORE COMPLEX *KEROTAKIS* APPARATUS FROM THE MS. MARC. 299. CONJECTURAL RECONSTRUCTIONS ARE GIVEN IN FIG. 7.

most difficult problem. The author is aware of no other chemical process which is consistent with the descriptions, and could at the same time give the *continuous* blackening, whitening and yellowing which is so strongly emphasised by all the authors. The explanation given above is at least consistent with the two great maxims which run through so much of the alchemical literature.

Μετὰ τὴν τοῦ χαλκοῦ ἐξίωσιν καὶ μέλανσιν καὶ ἐς ὕστερον λεύκωσιν, τότε ἔσται βεβαία ξάνθωσις. (Agathodaemon Αἴνιγμα) (B. II. 115.) *After the refinement of copper and its blackening and its later whitening, then will take place the solid yellowing.*

Ἐὰν μὴ τὰ σώματα ἀσωματώσῃς καὶ ἀσώματα σωματώσῃς οὐδὲν τὸ προσδοκώμενον ἔσται. (B. II. 115.) (Hermes.) '*If you do not disembody the bodies and embody the things without body, nothing which is expected will take place.*'

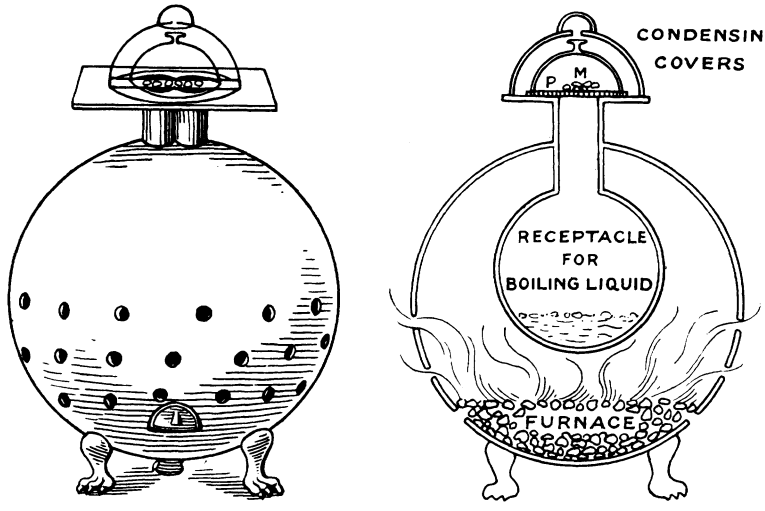

FIG. 7.—CONJECTURAL RESTORATION OF THE ROUND FORM OF *KEROTAKIS*, AS SHOWN IN FIG. 6.

The last is clear enough if we remember that σώματα has the meaning 'metallic bodies,' and ἀσώματα substances without metallic properties. Thus the meaning is, 'If you do not bring the metals to a non-metallic condition and then back to a metallic condition, nothing which is expected will take place.'

Consistent with the latter maxim is the method of treating metals with sulphur practised by the alchemist Mary. She employed the kerotakis type of apparatus for the treatment of metals with sulphur or with arsenic sulphide. The mode of procedure in such a case would be similar, the sulphur or arsenic sulphide being placed in the lower half of the receptacle. The metals on the kerotakis would be converted into sulphides which might dissolve in the melted condensed sulphur and be carried into the lower half of the apparatus. The black mixture of sulphides and unchanged sulphur collecting in this lower receptacle would then be the 'black lead' or scoria of Mary, which is said to collect in the 'Hades' or lower part of the apparatus. This 'black lead'

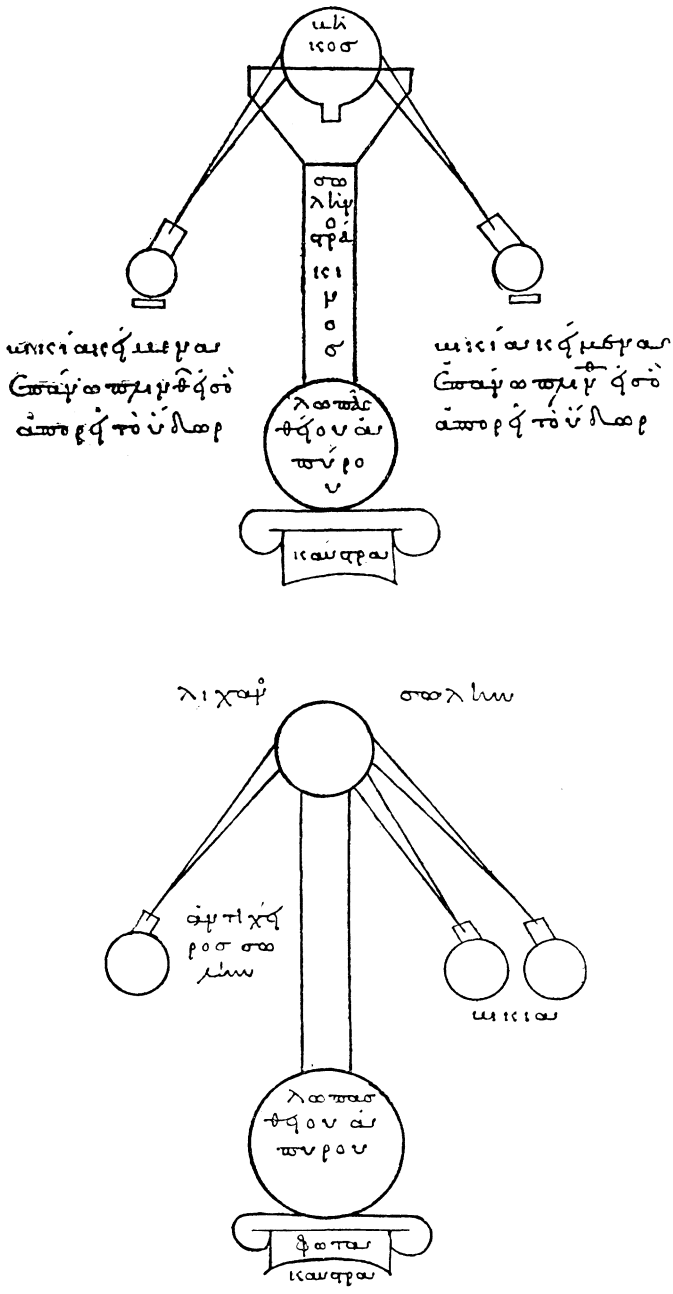

FIG. 8.—DISTILLATION APPARATUS (MS. MARC. 299).

when heated in air with ' oil of soda ' or other flux could be reduced by a pyritic smelt to an alloy of the metals originally placed on the kerotakis. The process is quite a possible one and consistent with the texts, but the object of such a complex method of preparing an alloy may seem obscure. It may be that the difficulties mentioned on p. 128 prevented the use of simple melting of the metals, or again the sulphur and arsenic retained in this process may have favourably influenced the colour of the product. Colours are observed on ' blister ' copper, as made to-day by a pyritic smelt which may have suggested the ' iosis ' or violet coloration already mentioned as a problem.

In addition to the kerotakis and the simple aludel for sublimation, the MSS. contain numerous sketches of distillation apparatus.

The eighth figure represents a drawing from the Codex Marcianus 299 and

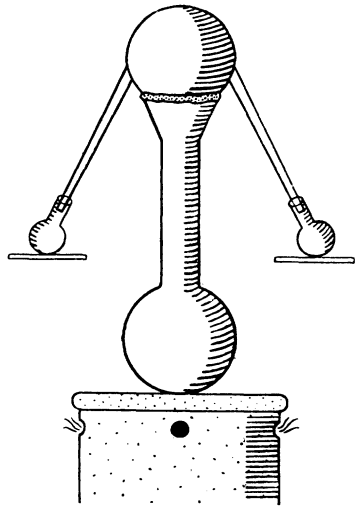

FIG. 9.—RECONSTRUCTION OF THE DISTILLATION APPARATUS OF FIG. 8.

a conjectural reconstruction. The drawing shows a type of apparatus used for distillation, which is very similar to that employed to-day. The globe marked βῆκος must have been luted into the funnel-shaped tube which surrounds it, but in all other respects the apparatus as figured appears to be practical and well designed. The value of the apparatus to the alchemists is not clear. They appear to have distilled sulphur from it and to have obtained liquids which they called ἔλαιον κίκινον and ῥαφάνινον, and to have used these in the colouring and treatment of metals. No liquid products except melted sulphur can be obtained by distilling sulphur, or any mixture of sulphur and a mineral substance. A theory has been propounded that these oils were in fact melted sulphur, but this liquid would solidify in a few minutes or seconds to a mass of monoclinic or plastic sulphur. Perhaps the word ' sulphur ' was used in a wider sense, or again sulphur may have been distilled with vegetable oils, so forming sulphur-substituted organic liquids which would have the effect of tinting metals by formation of a layer of sulphide as is described in

the Democritean recipes.[24] Doubtless mercury was also distilled from the apparatus, though there is no definite statement to this effect.

A reading of the work of the alchemists will often lead to a consideration of a totally different conception of alchemy to that which we have put forward. In many passages the practical element is replaced by mystical and religious matters, and it has been thought that some alchemists were not seeking to make gold at all or indeed any other substance. No one can read the works of Democritus or Mary without feeling that they are practical metallurgical efforts undertaken with a definite purpose, even though mystical and religious elements are present. But the texts of Comarius, the visions of Zosimus, and parts of the work of later authors suggest that these men were not really interested in making gold and were not in fact talking about real gold at all. The practical chemist examining these works feels like a builder who should try to get practical information from a work on Freemasonry.

Alchemy always contains some elements of the mystical and symbolic. The puzzle is that the practical content of alchemy, which is the treatment and manufacture of metals, affords no evident reason or justification for the mystical atmosphere with which the subject has always been surrounded. The mystical side of alchemy seems of an antiquity at least equal to that of the practical, nor does its obscurity make it less important for an understanding of the subject. The representation of metals by planetary symbols, the symbols of the philosophic egg, and of the serpent, and numerous references to Jewish, Egyptian and Gnostic beliefs all go to show that alchemy had a spiritual significance as well as a practical utility.

Gold has always been of importance in religious symbolism. The comparison of its burnished brilliance to the sun was no recondite step. Thus at an early date each of the other six metals was connected with one of the planets. The heavenly bodies thus gave a religious significance to the *somata*. With the metals equipped with the astrological qualities the alchemist passes from the Lesser to the Greater World, to the ' Great Work ' which is the aim of every mystical system.[25]

F. SHERWOOD TAYLOR.

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[24] The terms ' radish ' and ' castor ' oils may refer to the taste of the substance. A bad radish has the type of flavour which might be expected in a sulphur-treated oil. The flavour even of pure castor-oil is sufficiently unpleasant to justify its name being given to these oils.

[25] The writer would wish to express his deep indebtedness to Dr. Charles Singer and Mrs. D. W. Singer, both of whom have given him invaluable help at every stage in his investigations of the subject of Greek alchemy.

[26] This bibliography includes only such works on alchemy in general as are of special value to the student of Greek alchemy in particular.

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