Gold

Price 25 Cents.

INSTRUCTIONS

FOR COLLECTING, TESTING, MELTING AND ASSAYING

GOLD,

WITH A DESCRIPTION OF THE PROCESS FOR DISTINGUISHING NATIVE GOLD FROM THE WORTHLESS ORES WHICH ARE FOUND IN THE SAME LOCALITY, AND THE CHEMICAL TESTS AND NECESSARY APPARATUS TO BE USED FOR TESTING GOLD, SILVER, PLATINA AND MERCURY;

ILLUSTRATED WITH 30 WOOD ENGRAVINGS,

AND ARRANGED FOR THE USE OF PERSONS WHO ARE ABOUT TO VISIT

THE GOLD REGION OF CALIFORNIA.

By EDWARD N. KENT, Practical Chemist,
No 116 JOHN-STREET, NEW-YORK.

☞ The whole of the Apparatus described in this work may be obtained as above, at the prices mentioned in the Catalogue at the end.

Published by the Author.

NEW-YORK:
EDWARD N. KENT, PRACTICAL CHEMIST,
No. 116 John-street.

1849.

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PREFACE.

During the present intense excitement relative to the immense amount of gold found in California, I have had frequent and anxious inquiries for the necessary apparatus and instructions desirable, to ensure success in searching for gold, platina and mercury. This, together with a knowledge that the greater proportion, in fact, nearly all of the persons who are fitting out for the gold region, are unacquainted with chemistry, and there being no single work containing the necessary information in a small space, has induced me to publish this little work.

As the book is intended for this purpose only, and for immediate use, it has necessarily been written in great haste, and consequently without that care which should be used in the publication of a work on any scientific subject; but being, as before stated, not for the use of students, but simply as a hand-book for gold seekers, I put it before them, trusting that they will attach the proper inference to my motives in its publication, and derive a benefit from its perusal.

EDWARD N. KENT.

INSTRUCTIONS

FOR

COLLECTING, TESTING, MELTING AND ASSAYING GOLD.

CHAPTER I.

ANALYSIS OF NATIVE GOLD FOUND IN CALIFORNIA —ITS EXTERNAL APPEARANCE—SITUATIONS IN WHICH IT IS FOUND—PROCESS AND APPARATUS FOR WASHING THE GOLD—CARE NECESSARY TO DISTINGUISH THE REAL GOLD FROM THE WORTHLESS ORES FOUND IN THE SAME LOCALITY—SOURCES FROM WHICH SPECIMENS HAVE BEEN OBTAINED.

HAVING lately analyzed three specimens of ore from California, all of which were supposed by the possessors to contain gold, and finding but one of them that proved to contain it, I am convinced that the native gold is found in the same localities as some worthless ores, having a yellow colour, and which are often collected or bought under the impression that the latter are valuable.

The object of this work is, therefore, to give such plain and simple instructions for distinguishing the real gold from the spurious, that the most humble individual may be able to protect himself

from the imposition of knaves, and prevent a waste of time and labour, in saving only such minerals as are really valuable. I shall, therefore, confine myself to such directions as will be suitable for persons who are supposed to be entirely unacquainted with chemistry.

The native gold found in California occurs in small, regular, flattened grains or spangles, which show by their ovoid shape and smooth edges, that this is their original form, and that they are not broken off from a greater mass. It is found mixed with the sands of the plains and rivers, and when washed from dirt is of a dull orange colour, and on analysis proves to consist almost entirely of pure gold, with a small quantity of silver. It is found most plentifully at low water, and after storms or temporary floods.

In the present state of affairs in California, the operator should be furnished with a few wooden bowls, holding from one to two gallons. A portion of the earth containing the metallic spangles is to be put into one of the bowls, filling it from one quarter to one third full. It is then to be mixed up with water, by stirring with a stick, and while the earthy matter is still suspended in the liquid, it is to be poured off, the gold, from its greater weight, having previously settled to the bottom. This process of washing is to be continued repeatedly, upon the same portion, until the water flows off clear, and the gold is left in shining spangles at the bottom. This is to be taken out and

carefully preserved in a well-corked vial, and then a new portion of earth treated as before.

Gold very often exists in such small grains that it is almost invisible when mixed with the earthy matters, and doubtless large quantities are now overlooked and lost, from inability to obtain it by washing only. These fine particles may be obtained as follows: The earth is mixed up with water as before, but is allowed to settle a little longer before decanting off the water, for fear of losing the small particles. The time allowed for settling, before pouring off the water at each washing, must be regulated according to the relative density of the earthy matters, and of the gold to be separated; for instance, after mixing the earth well with the water, it may be left to settle for a half minute, then poured off; mixed again with water, settled for half a minute, and again poured off, and so on repeatedly till the residue is clean, although it may still contain grains of sand. If, on examination of the residue with a small pocket microscope, (Fig. 1,)

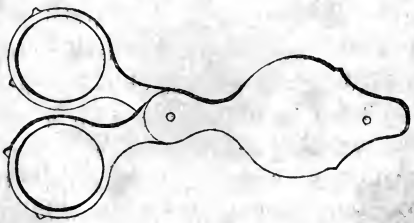

Fig. 1.

it is found to consist principally of gold, this shows that the earthy matters and sand having been washed away so cleanly, that some metallic par-

ticles may have been washed away with them. In order to prove this, some of the last washings of the next operation should be saved in a bowl, allowed to settle, and then examined with the microscope. If these washings contain gold, a longer time, say three quarters of a minute, to a minute or more, must be allowed for settling at each washing, so as to allow the gold to subside before the water is poured off. It is impossible to give the exact time that the mixture should be allowed to settle before it is poured off, as this depends entirely upon circumstances. This, however, can with a little care be so arranged that no gold will be lost, because this metal is heavier than all other bodies except platina, and will consequently settle first when mixed with lighter bodies.

When the gold is plentiful, and found in such large grains as to be visible to the naked eye, and the small particles are not present, this extreme care in washing may be dispensed with, because the large grains require no further treatment after being washed clean; but where the gold is in such a minute state of division as to be invisible without the aid of the microscope, it must be obtained from the residue by the process called amalgamation, or by melting in a crucible with a suitable flux; but as these operations require some instruction in the use of chemical apparatus, I shall defer the description of them for the present, and devote the whole of the third chapter to that important subject.

The most simple, and probably the best method of washing gold to separate it from earthy matters is practised in some parts of Europe, as follows: The washing is performed in a wooden bowl or dish, formed like a very flat cone, (Fig. 2,) and which is from 15 to 18 inches in diameter, and 3 or 4 inches deep. It requires some skill in order to perform this operation to advantage. The dish filled with about 20 pounds of the earth or sand containing gold, is carried into a river, if possible, where the operator stands above his knees in water, protected with india rubber boots, which come up to the thighs. The dish is plunged into the stream, and the mixture stirred up with the hand; the dish is dexterously whirled in such a manner, that at each gyration it is inclined at different angles, so as to allow the matters suspended in the water to flow out, while the gold remains at the bottom, in the angle of the cone. The washing is to be repeated till the gold is left clean; it is then transferred into a small iron dish and dried.

Fig. 2.

If the above shaped bowls cannot be obtained, those sold at the wooden ware stores must be purchased. But those with conical bottoms are much better, as they retain the gold in a small space. Vessels of wood are preferred to metal, as the slight roughness of the interior prevents the little particles of gold from sliding out, and being buoyant, they can be left at rest on the surface of the water, when necessary, without danger of sinking.

Two of the spurious samples which I have analyzed, somewhat resemble gold in external appearance. They are in small bright pieces, not uniform in shape, and of a light yellow colour, more brilliant than pure gold, but containing principally copper and arsenic, with traces of zinc and iron. This ore seems to be found in California in large quantities, and from the fact of its metallic appearance and yellow colour, it is difficult for one unacquainted with such matters to distinguish it from pure gold, without resorting to chemical tests.

Another sample required but a slight examination to prove that it was iron pyrites.* A part of it is in pieces of irregular size and shape, and some is in well formed cubical crystals. It is very brittle, breaking easily under the hammer, and strikes fire with steel. On the outside of the mineral the colour is dark brown, inside it is bronze yellow. These characters are sufficient to identify this ore without a chemical examination.

One of the samples containing copper, and also the iron pyrites, were handed to me for examination by the editor of one of our city papers, who informed me that he received them from a person who bought them in the vicinity of the California mines.

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* Iron Pyrites, which is a bisulphuret of iron, contains 45 pr. ct. of iron, and 54 of sulphur. It is used in the arts for making sulphur, sulphuric acid, and sulphate of iron. The residue of some of these processes, is an oxide of iron called colcothar in commerce.

The other sample, containing copper, was handed to me by a person who said that he received it from one of the soldiers of Col. Stevenson's regiment.

The sample of real gold which I analyzed and found pure, was presented to me by one of the firm of a large commission house in this city, who assured me that they received it direct from a brother of one of the firm who resides in San Francisco; this sample being from a lot containing about $9,000 worth of gold.

Not having been in California personally, I am obliged to give the statements of other individuals (without, however, doubting their truth) as to the sources from which all of the above specimens were obtained.* But the analyses of all the samples I performed myself. Specimens of those which I have tested may be seen at No. 116 John-street, N. Y.

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* The following extract is from a letter, dated California, Sept. 9th, 1848, which appeared in the New-York Sun, Dec. 20th. As I noticed the letter just as these sheets were going to press, I concluded to publish it, as it is a singular confirmation of the statements I have made on the same subject:

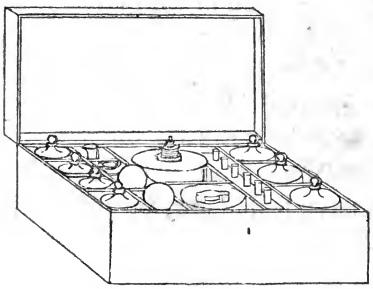
"I have in my possession upwards of sixty pounds of it *pure*, besides a great quantity which, for want of means, I am unable to separate from the mineralogical incrustations which enclose it.

"But there are also other substances to be found here which resemble gold, and which have deceived many who thought themselves rich in the possession of it. Copper and platina in great quantities have been dug up and thrown by unnoticed. From my tent, in which I am now writing, I can see at least two or three thousand dollars worth of these metals."

CHAPTER II.

APPARATUS AND TESTS NECESSARY FOR DISTINGUISHING PURE GOLD FROM THE SPURIOUS—TESTS FOR GOLD, SILVER, PLATINA AND MERCURY—PROBABLE PRESENCE OF PLATINA AND MERCURY IN CALIFORNIA—MINOR DIRECTIONS TO BE FOLLOWED TO PREVENT A POSSIBILITY OF FAILURE—FOUNDATION FOR THE STUDY OF CHEMISTRY.

Fig. 3.



THE chemical operation of testing a mineral is very simple, when the proper apparatus and tests are at hand, and for this purpose the author has prepared a large number of test chests, neatly fitted up and furnished with all the apparatus and reagents necessary for testing, gold, silver, copper, iron, platina and mercury, with a separate division in the chest for each article, and with a lock and key, as represented in Fig. 3.

The possessor of one of these chests can, by proper attention to the plain and simple directions given in this chapter, test, on the spot, any of the minerals he may find, and thus prevent the possibility of failure.

The Test Chest contains the following pure

CHEMICALS AND APPARATUS:

4 oz. Nitric Acid, in a glass stoppered bottle.
8 " Hydrochloric Acid, in 2 " "
1 " Protochloride of Tin, in a " "
1 " Protosulphate of Iron, " "
1 " Solution of Ammonia, " "
1 " Chloride of Ammonium, " "

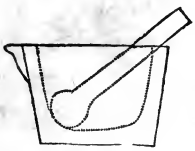
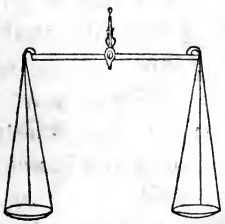


Fig. 4.

Small porcelain Mortar and Pestle, for pulverizing ores, &c. Fig. 4.



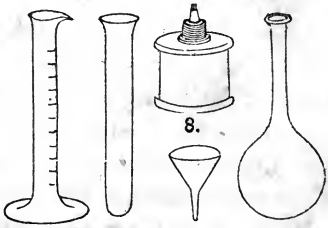


Fig. 5. 6. 7. 9. 10.

Scales, for weighing gold, and a set of Troy Weights, from 20 dwts. to 1 grain. Fig. 5.

Small graduated Measure, with divisions of one drachm into 60 minims. Fig. 6.

Six test Tubes, for testing solutions. Fig. 7.

Brass spirit Lamp, for travelling, with screw cap to prevent leaking. Fig. 8.

Glass Funnel, and 24 small filters to suit. Fig. 9.

Two small Flasks, for dissolving metals. Fig. 10.

The operation of testing *gold* is to be performed as follows: A small quantity of the metal, which need not be more than a few grains in weight, is to be put into one of the flasks. Nitric acid is then poured into the graduated measure till it is filled to the line marked 20; the acid is then poured into the flask, and a gentle heat is now to be applied to it by the aid of the spirit lamp. If the metal be gold it will not dissolve, and the acid will remain colourless; but further tests must be tried before it can be proved to be gold.

Fill the graduated measure to the line marked 60 with hydrochloric acid, and add this to the nitric acid already in the flask; then mix the two together by whirling the flask. This mixture of twenty parts of nitric with sixty of hydrochloric acid (or one to three) is called aqua regia, which is the only practical solvent for gold.

If the metal be gold, it will dissolve slowly when heated in the aqua regia, furnishing a deep yellow solution. The mixture should be heated at least fifteen minutes, and even boiled, when the

action becomes quiet, in order to decompose the nitric acid; an excess of which would interfere with the following tests. When there is no longer any evolution of gas in the flask, it is to be filled to the top of the neck with clear rain water, closed with the thumb, and the contents well mixed. If the solution is not clear, it must first be filtered into the graduated measure, or another flask, through a filter made by folding one of the circular papers into a quadrant, and placing it when opened into a funnel. The solution being then put into the funnel lined with the porous paper, passes through, leaving the dirt upon the filter.

A small quantity of the clear solution is then put into two test tubes. A few drops of protochloride of tin is then added to the solution, in one of the test tubes, and a few drops of protosulphate of iron is added to the other. If a purple precipitate is produced in the first tube, and a very fine brown powder or blackish blue coloration is produced in the second, *these are positive proofs that the metal is gold.*

If the nitric acid alone dissolves the metal, and the solution remains colourless, (or only slightly tinged blue,) a portion of the solution is put into a perfectly clean test tube, and then a few drops of hydrochloric acid added. If a white precipitate is produced on the addition of this acid, this is evidence that the metal is silver, but is further proved as follows: close the top of the test tube

with the thumb, and shake it well, then allow the precipitate to settle; decant off the clear liquid above, and add a little ammonia. If silver, the white precipitate will dissolve, and will again precipitate if a little nitric acid is added to the solution in ammonia. The white precipitate is chloride of silver, which is soluble in ammonia, but insoluble in acids. Another proof of silver is, that when the above white chloride is exposed to daylight, (especially sunshine,) it speedily becomes dark coloured.

If the nitric acid dissolves the metal, and the solution becomes *blue*, it may be a mixture of silver and copper, or copper only. Put a little of the solution into a test tube, and add a few drops of hydrochloric acid. If the solution contains silver, a white precipitate will be produced, which is soluble in ammonia. The colour being blue is a sufficient test for copper; but if the solution is so dilute as to prevent a decision as to the colour, a few drops of ammonia added will produce a clear solution of a fine azure blue colour.

If the nitric acid dissolves the metal, and the solution becomes of a deep reddish brown colour, the metal is iron, which is further proved by putting a little of the solution into a test tube, and then adding ammonia till the mixture smells of it after being well shaken. If iron, a copious precipitate of a reddish brown colour will be produced, which is the peroxide of iron.

According to late reports, platina is also found in California. This is very probable, as the two metals are generally found in the same localities. I therefore think it advisable to give a short description of platina, and the method of testing it, so that the finder may be enabled to know this valuable metal, which in its native state is worth about three or four times as much as silver.

Platina is found in small shining spangles or grains of about the same size and form as gold, but of a different colour; this metal being white like silver. It can be easily distinguished from silver, by heating it in a flask with nitric acid. Silver dissolves readily when heated in this acid, and gives a colourless solution, unless contaminated with copper, in which case the solution has a shade of blue. But platina is insoluble in nitric acid, although it is sometimes contaminated with other metals; the latter of which may dissolve, leaving the platina unacted upon.

Platina, like gold, dissolves in aqua regia when heated. The solution is of a deep reddish brown colour, resembling that from iron, but it is easily distinguished from that metal and all others, by the addition of a small quantity of chloride of ammonium. If the metal in solution be platina, this last test will give a precipitate of a yellow colour, which is *positive proof that the metal is platina.*

There is no doubt of the existence of mercury (quicksilver) in California. I have tested a sample of the ore said to have been obtained there,

and it proved to contain mercury, by the following process, which is adapted to be used with the articles in the test chest.

The ore from which mercury is extracted is called cinnabar. When pure, it has the same composition as the vermillion of commerce.

The sample from California which I examined appeared to be impure, being so hard as to strike fire with steel. It is difficult to reduce it to powder. The ore, in mass, is of a dull red colour, which when powdered appears brighter. A small quantity heated in a flask with aqua regia (1 part nitric to 3 of hydrochloric acid) till the red colour was destroyed, left a white powder, which is evidence of an impurity. The solution was then diluted with four or five parts of water, and filtered. A few drops of ammonia added to the clear solution (to neutralize the excess of acid) gave a white precipitate, which was re-dissolved by the addition of one or two drops of hydrochloric acid.

A few drops of this solution were put on a clean plate of copper, (a cleaned cent answers,) it soon caused a dark spot, and after being left a few minutes, it was rubbed off with a cloth, a white spot of metallic mercury was left.

Protochloride of tin, added to another portion of the solution, gave a white precipitate at first, but by adding more of the solution of tin, the precipitate was converted into a gray powder,

which, when boiled with hydrochloric acid, united into a globule of metallic mercury.*

By heating powdered cinnabar, mixed with its weight of quick-lime, to redness in an iron retort, the mercury is separated and distils over. For small operations, the retort described in Chapter III. will answer, but for manufacturing purposes on the large scale, I refer to Dumas's Traité de Chimie, t. iv. p. 306—323, or Ure's Dictionary of the Arts, article Mercury.

I have now described all of the tests necessary to distinguish gold, silver, platina and mercury; and to insure success in testing for these metals, a few words are necessary, in regard to some minor directions, which if properly followed will prevent a possibility of failure.

The operator should be careful to well wash each article of apparatus after it has been used, and never use the same flask, test tube, or funnel, for two different purposes, without washing. Care must also be used that the chemicals do not become contaminated, by being accidentally mixed with one another. A single drop of the contents of one bottle falling into another, may spoil it in

* The last test is not very easy to perform, even in the hands of a chemist. The dark mixture requires to be boiled a long time in order to unite the globules of mercury into one. With the microscope, the little globules can be readily discovered, even when there is no appearance of metallic mercury to the naked eye. The first test will generally be sufficient to prove the presence of mercury in an ore.

such a manner, that although no difference in the colour of the liquid may be visible, it would give a different reaction from the pure article, and thus, when applied for testing would produce fallacious results, perplexing to the operator and injurious to his interests. After the glasses have been well washed, they should be dried before putting them away in the box; otherwise the moisture will be likely to injure the box, and after a time deface the labels, so that the different tests cannot be distinguished from each other.

By careful attention to the above directions, the operator will have the satisfaction of reaping a rich reward for his trouble, and will probably lay the foundation of a love for the study of the enchanting science, which teaches the nature and composition of bodies, and explains the beautiful phenomena which he will have witnessed while performing the chemical experiments described in these pages.

CHAPTER III.

AMALGAMATION—MELTING GOLD—FURNACES—CRUCIBLES—FLUXES—FUEL—TONGS, ETC.

THE process of amalgamation is used to separate the noble metals from the ore or matrix, when they exist in such small particles as to be invisible, and consequently cannot be picked out by hand.

On the large scale, the ores are ground and amalgamated in mills constructed for the purpose, and composed of two stones. The lower one is stationary, and enclosed in a rim or case, while the upper revolves by the aid of water or steam power. The ore is first stamped, then ground to powder between the stones, and subsequently mixed with metallic mercury, which forms an amalgam with the gold.

It is hardly probable that the readers of this little work will operate so extensively as to require the use of steam or water power. I shall therefore describe in detail the whole process of separating gold by amalgamation, but confine myself to the use of such apparatus and means as can be readily obtained without a great outlay of capital.

Gold often exists in veins, and, when mined, is mixed more or less with stony gaugue. In

this case the ore is first to be stamped in an iron mortar, (Fig. 11,) and then reduced to powder by pulverizing in one of porcelain. Fig. 12. A small quantity of metallic mercury is then poured into the mortar, and the mixture ground together until the gold is dissolved, which is judged of as follows: By adding at first but a *very small* quantity of mercury, it will soon combine with the gold when ground as directed, and form a solid amalgam. A little more mercury is then added, the grinding continued, and so on repeatedly till the mercury no longer becomes solid by further grinding. Water is then added, and mixed well with the contents of the mortar to wash out the dirt, which is separated by decanting off the water. After a few washings in this way the residue will become clean, and is then to be wiped dry with a cloth or sponge. A piece of chamois leather is now to be spread out in a basin or bowl, and the amalgam of mercury and gold poured into it. The corners and edges of the leather are then to be gathered up, so as to form a bag, with the amalgam at the bottom; it is tied tightly with a stout string, and the contents squeezed as strongly as possible, by pressing and twisting the bag, by which operation a fluid portion of mercury containing a *little*

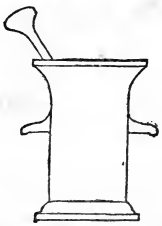


Fig. 11.

Fig. 12.

gold is separated by passing through the pores of the skin. This fluid portion is preserved by itself, and is to be used in the commencement of another operation on a fresh portion of ore.

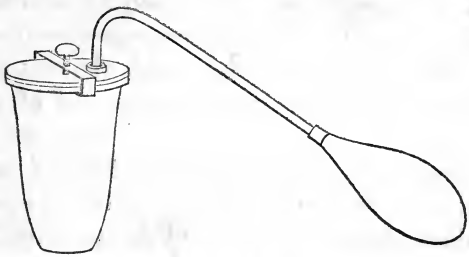


Fig. 13.

Fig. 14.

A solid amalgam of mercury and gold remains in the bag, which is to be taken out and placed in the iron retort. Fig. 13. A little lute, made by mixing powdered pipe clay into a paste with water, is put on the rim of the retort, and after putting on the cover, it is screwed down tightly by means of the clamp. The retort is then placed in a furnace, and heated slowly, at first, to expel moisture, then gradually raised to a low red heat. The end of the retort is meantime placed in a small India rubber bag resting in a vessel filled with cold water, to condense the mercury which distils over and is collected in the bag.

When no more mercury distils over, the operation is finished. The gold remaining in the crucible is of a dull colour, and in a porous mass. It is to be transferred to a small crucible, mixed with

a little borax, and melted in the furnace by a strong fire urged with a double bellows. The fused contents of the crucible are then poured into a conical ingot mould. Fig. 14. This mould is formed like a tall wine glass, and from its conical shape is well adapted for a small or large quantity of metal. When the product is cold, the flux is to be separated from the metal by the aid of a hammer.

If the quantity of solid amalgam obtained at one operation is but small, the results of several amalgamations should be reserved for one distillation, because it is but a little more trouble to distil as much as will fill the retort, than one quarter of that quantity; and a smaller proportion of mercury is lost, which is an important consideration.

The gold obtained in the above process is more or less pure, according to the quality of the ore. It almost always contains a portion of silver, the amount of which, and the standard of fineness of the gold, is to be ascertained by the process of assaying, which will be described in the fourth chapter, together with the process of refining gold.

For melting gold, a strong fire is necessary, and the operation is generally performed in a forge or furnace. The following is a description of a new form of furnace, invented by the author, and which is admirably calculated for melting in crucibles, for the distillation of mercury, for cupellation, and

for every other chemical operation requiring the use of a furnace:

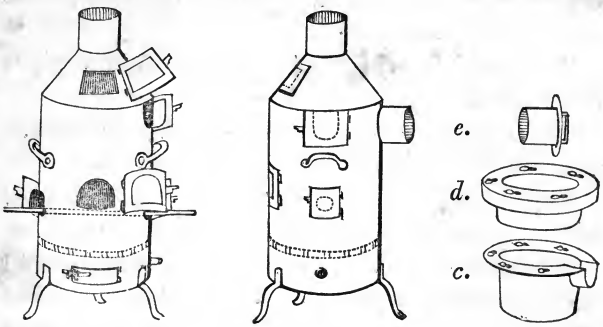


Fig. 15, *a*. 15, *b*. 15.

(Fig. 15,) front view, (*a*.) Side view, (*b*.) Sand-bath for retorts, (*c*.) Sand-bath for evaporating, (*d*.) Stopper for pipe, (*e*.)

This furnace is 14 inches high, (not including the dome,) and 7 inches diameter. It is made of strong plate iron, and lined with the most refractory fire clay. It has six doors; one in the dome for feeding with coal in crucible operations, one in the middle of the front for feeding, while distilling or evaporating, and for a muffle in cupel operations, and one at the bottom for air; one door on each side, for iron or porcelain tubes, or for holding an iron bar to support the end of a muffle, and one door in the side at top, for the neck of a retort or sand-bath. There is a small pipe at the bottom, to attach a bellows, and thus convert this into a blast furnace.

There are two pipes for connecting with the flue of the laboratory, one at the top, to be used in crucible operations, and the other at the back, to be used when evaporating.

The stopper (*e*) is to close either of these pipes when not in use.

There are two sand-baths, one (*c*) for retorts, and one (*d*) made double, for evaporations.

The dome is lined with fire clay, and is used when a great heat is required.

The whole furnace is made in the most careful manner, of strong and durable materials.

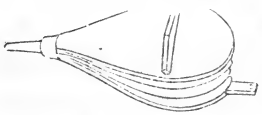


Fig. 16.

For obtaining the greatest heat which can be produced by the above furnace, a double bellows (Fig. 16) should be connected with the small pipe at the bottom of the furnace, by means of a bent iron pipe, formed so as to raise the bellows a few feet from the floor.

Fig. 17.

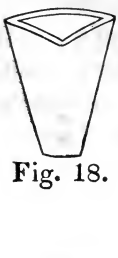


Fig. 18.

For melting gold, and other metals, good crucibles are required. Of these there are different kinds; those most generally used for metals are the Hessian. (Figs. 17 and 18.) These crucibles are imported in nests, and may be had of different sizes, in shape either round or triangular. They are generally without covers, and as a substitute for these, a smaller crucible inserted within a larger one may be used.

The French crucibles, (Fig. 19,) manufactured by M. Beaufaye, in Paris, and used by the French chemists and refiners instead of the Hessian, are far superior to the above, being particularly remarkable from their power of well supporting alterations of temperature; but unfortunately they cost too high to be generally used in this country. A full description of them may be found in *Dumas's Traité de Chimie*, t. 2, p. 691.


Fig. 19.

In the use of crucibles for melting gold, the smallest which can be employed is the best, as it requires less heat to fuse the metal, and the loss in the operation is not so great; but when gold exists in mixture with earthy or stony particles, these are to be powdered and fused with a flux, and in this case a much larger crucible is required, on account of the evolution of carbonic acid, or swelling of the mass.

The use of the flux is to dissolve the stony particles, forming with them a glass or slag. It also cleans the surface of the particles of metal when heated with it, so as to cause them to unite and fuse into a globule or button, at the bottom of the crucible.

Fluxes of different kinds are used according to the purpose required, but for most all crucible operations with gold and silver, a mixture of one part of the ore with three parts of a flux composed of equal parts of carbonate of potash* and of nitre,

* Carbonate of potash is the salt of tartar of commerce, and of which "pearlash" is an impure variety.

will answer an excellent purpose. The carbonate of potash in this flux dissolves the silica, &c., in the ore, and cleans the surface of the metal, while the nitre destroys dirt and other organic matters, and at the same time oxydizes any copper which may be present, causing it to become dissolved in the flux.

When gold or silver free from gaugue is to be melted, they require no other flux than a little borax to cause the particles to unite in a button, its use being exactly analogous to that of rosin when used by the tinsmith in soldering.

An important consideration in crucible operations is the choice of fuel. In England, coke is generally used, either alone or mixed with charcoal; but in America it is difficult to obtain coke, and consequently we are obliged to use anthracite or charcoal. No better fuel than charcoal would be needed if it did not burn away so fast; this is its only disadvantage, as it burns freely, without any clinker, and does not fuse together; but the softer kinds of anthracite, such as peach orchard coal, fuse at a high heat, stick to the crucible, and form large quantities of clinker in the furnace, which makes it very unpleasant to use. The best kind of anthracite is the Lehigh coal. This does not ignite quite so readily as the softer kinds, but it contains less earthy matters, and consequently does not fuse in the furnace or form much clinker.

The best fuel for the crucible furnace is a mixture of charcoal and Lehigh. The fire is to be commenced with charcoal, in small pieces; a little Lehigh is then to be added, and so on alternately as the fire burns freely; first charcoal and then Lehigh is to be added.

In short operations, and even in those which require a strong fire for some time, charcoal alone may be used where economy is no object; but in this case, constant care is required in supplying the furnace with fuel. In the process of cupellation, charcoal only is used.

Fig. 20.

Where fluxes are used, a small iron ladle (Fig. 20) is very convenient for putting them into the crucible, which, when large, may be heated to redness before the materials are introduced, and thus cracks may be discovered before a loss of substance has taken place.

Suitable tongs are indispensable in these operations. The smallest, (Fig. 21,) 8 inches long, for very small crucibles; (Fig. 22,) 16 inches long, made light, and used principally for charcoal; (Fig. 23,) 2 feet long, is the best kind for general operations. A moderate sized crucible, if not too heavy, may be lifted out of the furnace, and the contents poured out with these tongs; but if the crucible is heavy, a piece might be broken out of the side, and the contents lost. To avoid this, tongs are made of the form of Fig. 24; these are two feet long, and made so as to clasp round a crucible to

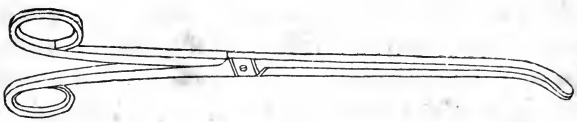


Fig. 22.

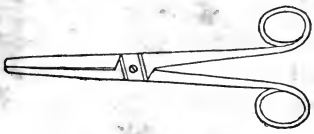


Fig. 21.

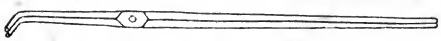


Fig. 23.

Fig. 25.

Fig. 24.

take it out of the furnace. Those represented in Fig. 25, are then used to pour out its contents. It is therefore almost absolutely necessary to be provided with a pair of each kind of tongs in order to suit all contingencies.*

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* For a full description of all other chemical operations and apparatus, I refer the reader to a new work called "Chemical and Pharmaceutical Operations," by Campbell Morfit, practical chemist, Philadelphia.

This work contains upwards of 400 illustrations, and will be a valuable assistant to all who are engaged in, or contemplate the study of chemistry.

CHAPTER IV.

TOUCHSTONE AND NEEDLES—CUPELLATION—PARTING, OR QUARTATION—STANDARD OF GOLD—REFINING OF GOLD AND SILVER.

THERE are three methods for ascertaining the quality of gold, viz., by the touchstone and needles, by cupellation, and by parting or quartation.

The first is the process which, from its simplicity and convenience, is used by jewellers and others for learning at a glance the value of the articles which they buy and sell, and which are composed of gold, alloyed with different proportions of silver or copper; and this is ascertained by making a comparison between the specimen under examination and others of known value. The test is made upon a black silicious mineral called a touchstone, which is a variety of jasper known as the Lydian stone; and the specimens with which the alloys are compared, are points of gold alloyed with different proportions of silver and copper, attached to small bars of silver, each marked with the number of carats of which the point is composed. These bars are connected together by a silver wire, as represented in Fig. 26.

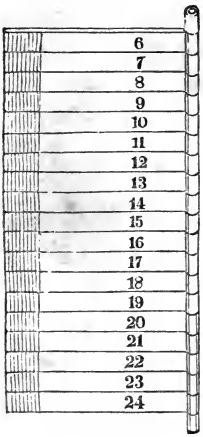

Fig. 26.

Sometimes the points are attached to a brass plate in the form of a star. The points on each are numbered from 6 to 24, being alloys from 6 to 24 carats fine.

When an article is to be tested by this process, a corner of it is to be rubbed on the stone in such a manner as to form a mark about $\frac{1}{32}$ of an inch wide, and $\frac{1}{2}$ an inch long. A touch needle, resembling in colour the specimen under examination, is then rubbed in the same manner, so as to form a mark on the stone near to, and of the same size as the first. A drop of the acid mixture (which will be described shortly) is then put upon the two marks, and particular notice is to be taken of the difference in the marks produced by the acid. If the spot produced by the article examined, is brighter than that from the needle, this shows that it is better than the quality of that needle; and if it is not as bright, that it is not so good. If no difference can be seen, this shows that the specimen examined is of the degree of fineness marked on the needle. After a few trials the operator will find the needle corresponding with the specimen he wishes to test.

With a little experience, this process gives results, correct within one carat, which is sufficiently near for commercial purposes.

The test acid used with the above needles is composed of 98 parts nitric acid, of specific gravity, 1.34, 2 parts hydrochloric acid, sp. gr. 1.17, and 25 parts of distilled water. The acid is kept for use in a low glass bottle, with a long tapering stopper, which nearly touches the bottom. (Fig. 27.) When used, a drop of the acid is to be taken out on the end of the stopper.

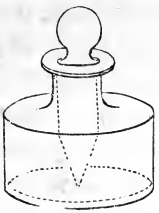

Fig. 27.

The process of cupellation is an ingenious method of separating foreign metals from silver or gold, by means of lead. To perform this operation, the furnace described in Chapter III. is well adapted. A vessel of refractory fire-clay, resembling a small oven, and called a muffle, (Fig. 28,) is put into the furnace, the front end of the muffle being supported by the lower opening, or door, in the front, and the back rests on a small bar of iron put through the two small doors at the side. A good charcoal fire is then to be made, with the front door closed; and when the muffle is bright red-hot, a perfectly dry cupel is put into it. Metallic lead, weighing about $\frac{2}{3}$ of the weight of the cupel, is then put into it, and when the lead is fused, a portion of the gold to be assayed (about $\frac{1}{14}$* of its weight) is to be

Fig. 28.

* When silver is assayed by cupellation, a portion weighing 1-5th of the weight of the lead may be employed.

wrapped in a thin piece of sheet lead, or blotting paper, and introduced into the melted metal. A good fire is now to be kept up, and the front door then opened so as to allow air to pass through the muffle, which causes the lead to oxydize, and become converted into litharge, which dissolves the impurities in the alloy of gold, and is then absorbed by the porous cupel. Towards the last of the operation, the melted metal moves round rapidly, and becomes dull; suddenly the agitation ceases, the button becomes very brilliant and immovable. This is the end of the cupellation, and is called the *brightening*.

The cupel is then to be left in the muffle for a few minutes, and drawn gradually towards the mouth, before it is taken out, so that it may cool slowly. The button is then taken off, brushed and weighed. Its weight compared with that of the alloy used, gives the per centage of fine gold.

With practice and good management cupellation becomes easy, and is quickly performed; and although it does not give results which are *exactly* correct, it is sufficiently so for most purposes, and it is the process generally in use by goldsmiths for assaying gold and silver.


Fig. 29.

The cupels used for this process are made of powdered bone-ash, as follows: 4 lbs. of the ash are well mixed with 1 lb. of beer; the bottom ring of a cupel mould (Fig. 29) is then filled with the mixture, and the handle pressed down; this gives form to the cupel; the ring is then turned over, and the

cupel removed by pressing on the bottom. When dried and ignited it is ready for use.

The only process which is absolutely correct for assaying gold, is that in use at the mint, and is called parting, or quartation.

Small portions of the specimen to be assayed are cut off from different parts of the ingot, so as to get a fair sample of it. Twelve grains of the metal are then carefully weighed on a delicate balance (and for making a *correct* assay a delicate balance is necessary, together with a set of accurate assay weights, made for the purpose.)

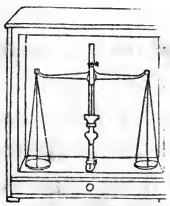

Fig. 30.

The balance represented in Fig. 30 is the kind employed. It is enclosed in a glass case, with a sliding-door, to keep it from dust and currents of air, while weighing. The set of platina weights contains 12, 6, 5, 3, 2, 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$ grains. These are made very carefully from the standard used in the mint.

Having previously ascertained the comparative value of the alloy, by means of the touchstone, 12grs. are carefully weighed and mixed with a proportion of silver, which, added to that already in the alloy, shall make the proportion of silver equal $2\frac{1}{2}$ times the weight of the fine gold. The mixture of gold and silver is then cupelled with twice its weight of lead. The resulting button is flattened by a hammer, then rolled out into a thin ribbon,

about 2 inches long. This is to be wound on a quill or pencil, so as to form a thin spiral, which is to be put into a small flask, of the capacity of 3 ounces. 2oz. of nitric acid, of 22°, (sp. gr., 1.16) is then poured on, and the mixture heated for 3 or 4 minutes. Then replace the first acid with 2oz. of that which is 32°, or stronger, (sp. gr. 1.26,) boil ten minutes, then replace with fresh acid of 32°., and boil ten minutes longer. The residue of gold, which is of a dull red colour, is to be washed well in the flask, and then transferred to a small crucible, dried and heated without fusion. It is then to be carefully weighed on the assay balance.

The standard of gold is expressed by the term carat in commerce, and in thousandths by government. Pure gold is 24 carats or $\frac{24}{24}$ fine: 18 carats fine is $\frac{18}{24}$ pure, &c. Expressed in thousandths, pure gold is $\frac{1000}{1000}$ fine: 18 carats fine is therefore $\frac{750}{1000}$, &c.

Example. If in the process of parting, the pure gold remaining weighs 11 grains, this is $\frac{11}{12}$ or $\frac{22}{24}$ pure. That is, in 24 parts of the sample assayed, there is 22 parts of pure gold. It is consequently 22 carats fine.

If we wish to express this in thousandths, in the absence of a table, it is easily performed by the rule of proportion: as $\frac{24}{24}$ is a whole, so is $\frac{1000}{1000}$. In this example we have an alloy 22 carats fine; now the following statement expresses the thousandths: as 24 is to 1000 so is 22.

24 : 1000 : : 22
22

2000
2000

24) 22000 (916
216 ——
—— 1000
40
24

160
144

To save the trouble of calculation, tables are drawn up. By doubling the weight of the pure assay, the number of carats is given. On looking down the left hand column of the table, this number is found, and opposite to it is the decimals expressing the thousandths.

EXAMPLE.

Suppose in an assay of 12 grs. of an alloy, we have left $10\frac{1}{8}$ grs. of gold. Doubling $10\frac{1}{8}$, we have $20\frac{1}{4}$ carats.

Opposite 20 we find . . 0.833
" $\frac{1}{4}$ . . 0.010

0.843 thousandths.

Or, expressed in vulgar fractions, $\frac{843}{1.000}$

ASSAY TABLE,

FOR REDUCING CARATS TO THOUSANDTHS.

24	carats	1.000
23	"	0.958
22	"	0.916
21	"	0.875
20	"	0.833
19	"	0.791
18	"	0.750
17	"	0.708
16	"	0.666
15	"	0.625
14	"	0.583
13	"	0.541
12	"	0.500
11	"	0.458
10	"	0.416
9	"	0.375
8	"	0.333
7	"	0.291
6	"	0.250
5	"	0.208
4	"	0.166
3	"	0.125
2	"	0.083
1	"	0.041
$\frac{1}{2}$	"	0.020
$\frac{1}{4}$	"	0.010
$\frac{1}{8}$	"	0.005
$\frac{1}{16}$	"	0.002
$\frac{1}{32}$	"	0.001

Gold is refined by a process called quartation which is similar to that used for assaying.

The impure gold is melted with about 3 parts (3 times its weight) of silver; it is stirred well in the crucible so as to have a perfect mixture; and this is poured into a large dish of water, which

is kept in motion by an assistant, who stirs it with a stick while the alloy is being poured in. By this process the metal is divided into small lumps, which are more easy to act upon with acid than when in mass. The granulated metal is then put into a large glass flask, and heated on a sand bath, with twice its weight of nitric acid diluted with an equal measure of water. When the action ceases, a little more acid, stronger than the first, is put on and heated again till there is no action. The acid is poured off, and the gold remaining in powder is washed several times, till a portion which comes off will give no precipitate when mixed with a solution of common salt.

The gold is then taken out, dried, melted with a little borax, and poured into water, or an ingot mould. This is refined gold.

The solution in nitric acid is diluted with water, to form 2 or three times its original measure. Plates of copper are then immersed in it, and allowed to remain 24 hours or more, till the silver is all precipitated, and the solution no longer contains silver. This is ascertained by taking out a small portion of the blue liquid, and if it gives no precipitate on the addition of a solution of common salt, it contains no more silver. It is then to be washed repeatedly with water till the blue colour is entirely removed. Dilute sulphuric acid is then added, and allowed to cover it for a few hours. It is then washed again, till the washings are tasteless. The gray powder of silver is then dried and melted with a little borax. The product is refined silver.

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