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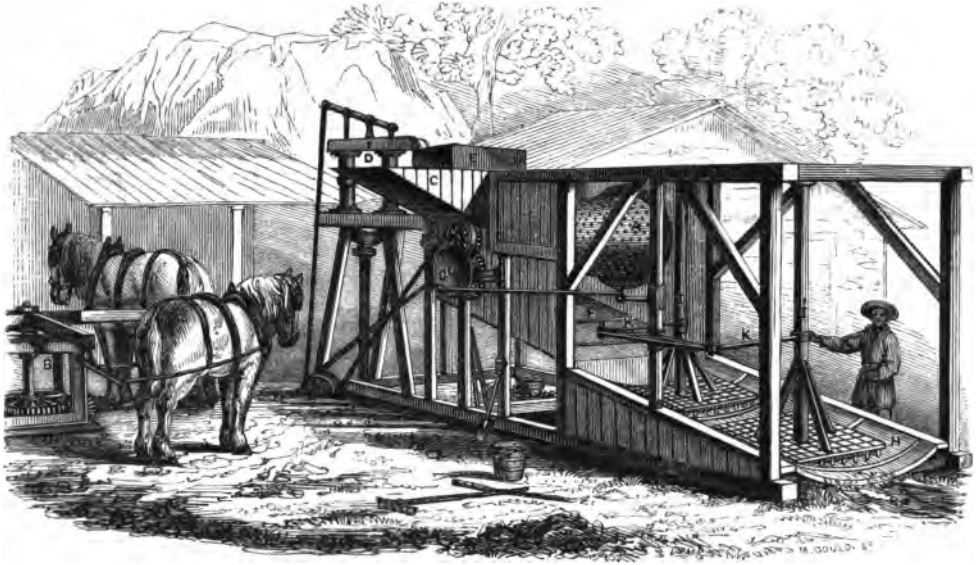

Gold-washing Apparatus employed in the Ural.

GOLD-MINING AND ASSAYING:

A

Scientific Guide for Australian Emigrants.

BY

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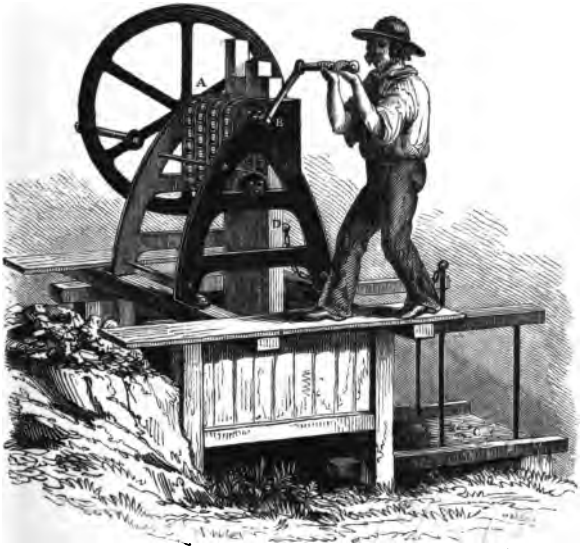

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PREFACE.

THE purpose of the following pages is to furnish the Australian Emigrant with the information necessary to enable him to conduct with facility the operations which are necessary to the successful prosecution of Gold-Mining.

The search for Gold is commonly regarded as a species of lottery, in which there are more blanks than prizes. It is, however, certain that much of its speculative character may be removed by an acquaintance with the various processes of Mining and Metallurgy.

That Australia possesses vast advantages in the form of mineral wealth, there can be no reason to doubt, and we may be equally certain that the larger proportion of these riches will ultimately fall to the share of the intelligent and the industrious.

The Emigrant who makes himself acquainted with the conditions under which Gold occurs, and the operations by which it may be most readily obtained, will evidently find himself far in advance of the less intelligent adventurer, who trusts to accident alone for success.

Habits of careful observation ought, on all occasions, to be assiduously cultivated, and then, should the harvest of the gold fields fail, a fund of information will have been acquired which may be advantageously applied to other branches of industry.

J. A. P.

8, Upper Stamford Street,
August, 1852.

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GOLD-MINING.

SOURCES OF GOLD.

GOLD is invariably found in the metallic state, but is never quite pure, and usually contains a certain proportion of silver, and not unfrequently iron, copper, and small quantities of several other metals. The chief sources from which gold is obtained are the various alluvial deposits, consisting of sand and gravel produced by the disintegration of siliceous, granitic, and other igneous and metamorphic rocks, and which have been transported by the agency of water from districts where gold is more or less disseminated.

In addition to the supply afforded by the washing of these deposits, a comparatively small quantity is obtained from the treatment of certain minerals, in which it occurs in the form of minute spangles,

imbedded in a matrix of quartz, which is itself found in the form of veins traversing various kinds of schistose or slate rocks. In these cases the quartz is generally more or less porous, and almost invariably stained of a brown rusty colour, from the presence of peroxide of iron. The working of such veins is, however, seldom attended with such satisfactory results as are obtained from the alluvial washings; not only from the circumstance that the labour required is considerably greater, but also from such sands being continually enriched by the action of the currents of water to which they are exposed. In Brazil, the mines of Gongo Soco, and some others, have been, however, extensively worked in veins, but from the heavy expenses entailed by this method of extraction, and from the fact that the mineral obtained is seldom much richer than the alluvial sands, these undertakings have been but rarely conducted on a very extensive scale.

The gold mines of Russia and Siberia are situated on the eastern flank of the Ural mountains, in a belt extending through five or six degrees of latitude to the north and south of the town of Ekatharineburg. There is, likewise, a second deposit of a similar nature in the districts of Tomsk and Yeneseik, where low hills extend northward from the great chains of the Altai, over an extent of many thousands of square miles.

The gold mines of Brazil are, for the most part, situated at the foot of the great mountain chain which runs parallel with the coast, from the fifth to the thirtieth degree of south latitude. Gold also occurs, in greater or less quantities, in the beds of the streams forming the upper branches of the Francesco, Tocantins, Araguay, and Gauporé rivers, but more particularly in the first. The rock in these localities consists of primitive granite, inclining to gneiss, and the soil, which, from being highly ferruginous, is of a red colour, often extends to a very considerable depth. The gold is chiefly found in a bed of gravel and rounded pebbles, called *cascalho,* immediately in contact with the surface of the solid rock.

Wherever water is found in the valleys, large excavations are made, for the purpose of washing these deposits; and, by conducting a rivulet to the declivities of many of the hills, gold is often collected from a short distance only beneath the roots of the grass. The most recent washings have been established in the vicinity of Villa Rica, near the village of Cocaes, where the gold occurs either mingled with the sands of the river, or in the alluvial deposits lying in valleys between elevated hills. Gold is also procured in the province of Minas Geraes, where it is extracted both by subterraneous excavations, and by the washing of alluvial deposits.

This metal is likewise found in many other parts of South America; but the gold of Peru and Mexico is constantly associated with silver. The only auriferous veins worked in the latter country as gold mines, are in Oaxaco, where they traverse formations of gneiss and mica-slate.

The gold obtained from Africa is principally found between Darfur and Abyssinia, as also to the south of the great deserts from the mouth of the river Senegal to the Cape of Palms. A certain amount is also collected on the Mozambique coast, between latitudes 22° and 25° south. Gold is likewise obtained in small quantities from the sands of the Niger, the Gambia, and the Senegal, as well as from the gold coast near the equator, from whence large quantities of this metal were formerly exported.

The gold obtained from Europe, with the exception of European Russia, is very small in quantity. The most important of these deposits are in Transylvania, although the sands of the Moldau and other Bohemian rivers contain a certain amount of this metal.

The valley of the Rhine, between Bâle and Mannheim, is also known to be auriferous, although the gold occurs in quantities too small to admit of its profitable extraction.

The mines of Spain, which were anciently rich, and actively carried on, are now neglected, as are

also those of the Tagus, the Rhone, and the Danube. The British islands also furnish from time to time small quantities of gold, although seldom in sufficient amount to be equivalent to the cost of procuring it. The principal localities in which gold has been found in the United Kingdom, are in Ireland and Wales, although specimens are occasionally obtained from the Cornish stream-works, and from the district of Lead-hills in Scotland, where, in the time of Elizabeth, extensive washings were carried on for this metal. Specimens of native gold have also, at different periods, been procured from various parts of Devonshire, and mining operations have recently been undertaken for its extraction. It remains, however, to be proved, whether the amount obtained will ultimately be found to repay the outlay incurred for its production. Gold likewise occurs in Cumberland, in Lanarkshire, and at Glen Turret, in Perthshire. The quantities obtained from these localities are, however, extremely small; and, notwithstanding that small accumulations and occasional lumps have sometimes been discovered, no workings of a regular kind, and on an extensive scale, have been attempted, except in Ireland.

In that country, a considerable quantity of native gold was accidentally discovered towards the close of the last century, disseminated in the beds of the streams which flow from the northern flank

of Croghan Kinshela, on the confines of Wicklow and Wexford, and in the immediate vicinity of the granite and clay-slate. This gold was chiefly found in massive lumps, one of which weighed nine, another eighteen, and a third twenty-two ounces. Soon after the discovery of this gold, its extraction was undertaken by Government, but, during the two years the mines were in operation, only 945 ounces of gold were obtained; and, as the expense of the production of this quantity exceeded the value of the metal raised, the mines were ultimately abandoned, and have not since been resumed.

In addition to the supply of gold obtained from the plains of Siberia, Asia has also contributed considerable quantities of this metal from the rivers of Syria, and other parts of Asia Minor, as well as from the peninsula of Hindostan, and the various islands in the Indian Ocean.

The gold mines of the United States of America are chiefly situated along the eastern slope of the Appalachian chain, and extend from Maine to Alabama, from whence the deposits, although chiefly confined to the states of Virginia, North and South Carolina, and Georgia, extend into Canada. The gold region of California occupies the northern part of New California, commencing near the mouth of the Sacramento river, in lat. 39° North, and long. 122½° West, to the North-east of

the bay and town of San Francisco. The alluvial deposit in which the gold is found consists of sand, apparently produced by the disintegration of quartzose, granitic, and porphyroid rocks.

The valley of the Sacramento takes its origin in several parts of the Sierra Nevada, and in the transverse range proceeding from the coast at Cape Mendocino. Many of these affluents, and particularly that called the Rio de los Americanes, have proved especially productive.

Professor Blake, who has minutely examined the auriferous regions of California, gives the following description of some of their more remarkable geological peculiarities.*

"With the exception of the diluvial strata, the whole geological formation of the Sierra range consists of igneous and metamorphic rocks: the former are mostly porphyritic in the lower hills, whilst higher up trachytic rocks are more frequently met with. The metamorphic rocks consist of micaceous schists, slates both talcose and micaceous, metamorphic sandstones and limestones, with occasional beds of conglomerate. The stratified rocks have been much displaced; it is rare to find them with a dip of less than 70°, and they are generally very nearly perpendicular. The strike of the beds

* American Journal of Science and Art.

in that section to which my observations have been confined (between the Stanislaus and Yuba Rivers) is extremely uniform, being from 5° to 10° W. of N. and E. of S. The extent of the diluvial deposits is commensurate, or nearly so, with that of the gold-bearing region, in that part of the country which I have examined. They are found in a belt of land from thirty to sixty miles broad, and running parallel with the axis of the range; and, from facts that I have ascertained from others, I have no doubt but that they exist throughout all the gold-bearing region, both north and south. These diluvial deposits are met with as we advance towards the lower hills of the Sierra, extending frequently some miles into the plain. They are often of considerable thickness, and frequently rest on tertiary rock. On approaching the foot of the lower hills, the conglomerate and gravel are found in greater abundance, the pebbles and boulders are larger, and contain more of the heavier rocks. They are seen also covering extensive valleys or flats of many miles in extent, enclosed by low ridges of porphyry and slate, which rise rather higher than the surface of these beds. On ascending from the lower hills towards the mountains, the diluvial beds no longer occupy the same relative position: occasionally deposits of rounded stones can be found in the valleys and on the sides of the hills, but when this is the case their origin can always be traced to

deposits existing on the tops of the surrounding hills, from which they have been brought down by the action of the causes now at work. As we ascend towards the axis of the chain, these deposits become more extensive, and at a distance of twenty or thirty miles from the lower hills, they are found occupying the crests of almost all the highest ridges in the country; but besides being found on the crests of the ridges, where their extent frequently does not exceed a few yards in breadth, they are also met with covering in the extensive elevated flats which exist on the benches between the different watercourses, forming continuous beds of some miles in extent, which are rarely interrupted by the protrusion of any of the older rocks. Where found in these elevated situations, the lower hills and valleys are entirely free from them; frequently a large section of the country will be enclosed from two high ridges capped by deposits, and diverging from a common point; in the intervening space will be seen many secondary ridges, sometimes fifteen or eighteen hundred feet high, formed entirely of the older rocks, no traces of deposits being found on their surface, nor in the ravines that lead from them.

"The depth of these deposits is extremely variable. Sometimes nothing more than a trace of them in the presence of a few round pebbles lying on the top of a ridge is found; the valleys and

ravines in the neighbourhood containing their disintegrated elements in considerable quantities. In other instances, particularly where spread out over the elevated flats, they are of a moderate and pretty uniform thickness for a considerable distance, varying from two or three feet to a few inches, and this, too, in positions where the surface could not have been exposed to any great amount of denudation. They are again found many hundred feet in thickness, composed of superimposed strata of different mineralogical constitution, generally horizontal and conformable with each other.

"The localities where these deposits are met with most extensively disclosed, and that have been worked, are at Nevada and at Mokelumne-hill. At the former place they form the crest of a high mountain called the Sugar Loaf, full 2,000 feet above the level of Deer Creek, the upper 600 feet being formed entirely of diluvial strata. At Mokelumne-hill they are also some 200 feet deep, forming here also the summit of a high and isolated mountain. The elements of which they are composed differ considerably in different localities, although there are through the whole series many points of resemblance. In the lower valleys and flats, between the ranges of the lower hills, they appear to consist of beds of gravel, containing occasional boulders of quartz, and the harder rocks. On the elevated flats higher up in the mountains,

the surface of these deposits is generally covered by a reddish loam, mixed with small gravel; whilst reposing on the bed rock, and a few inches above it, is found a stratum containing large boulders and gravel, the boulders being principally quartz. On the top of the hills and the crests of the ridges, where they generally attain their greatest thickness, we find them composed of many distinct strata lying nearly horizontal, and conformable with each other, and generally also with the surface of the underlying rock. In these situations, the most superficial stratum is composed of a mass of extremely hard conglomerate, containing principally trachytic rocks, imbedded in a hard argillaceous cement. It is this hard stratum that has undoubtedly preserved the underlying beds from the destructive influences which have so powerfully acted on the surrounding rocks.

At other points the whole series consists of conglomerates and soft friable sandstone. In the lower strata, quartzose conglomerates, with an argillaceous cement, or loose quartzose gravel, always prevails, with large boulders of quartz, weighing frequently two or three tons, having their surface worn smooth and the angles rounded. The deposits of these heavier rocks have been formed on spots which were evidently lower than the level of the surrounding rocks; whilst on those parts which were higher at the time the deposits were formed, the

higher trachytic rocks are found. As far as my researches have extended, the more quartzose conglomerates have been invariably found on the erupted rocks, whilst the stratified rocks which they had upheaved were only covered by the trachytic conglomerates. The pebbles of which these conglomerates are composed present specimens of all the harder rocks. Metamorphic sandstones, clinkstone, trap porphyries, and quartz, make up the larger part of the mass. They are all perfectly rounded, but in the lower deposits are so soft, that, with the exception of the trap and quartz, they generally fall to pieces on exposure to the air. The strata, as before observed, are nearly horizontal and conformable: if they have any dip, it appears to have been owing to the slope of the surface of the rock on which they were deposited; in fact, no displacement seems to have taken place in this country since the period of their formation. They lie perfectly horizontal over the almost vertical edges of the upheaved slate rocks.

"Pieces of half-carbonised wood and impressions of leaves are sometimes found in the clayey beds of these deposits; and at Nevada, it is said that the trunk of a tree had been traced for some distance in the clay, at about forty feet below the surface. I have obtained specimens of wood, and also imperfect impressions of leaves, taken out four or five hundred feet below the surface of the ground, and

three hundred and fifty feet from the side of the hill at the same locality. The wood belongs to one of the Coniferæ, but I was unable to determine the character of the leaves. A tooth also has been found in some of these deposits. I have not seen it, but from description it would appear to be a bicuspid belonging to some large Pachyderm. The surface of the rock on which they repose generally presents evidence of considerable abrasion, but I have been unable to detect any regular grooves in it. Where it is more elevated it has been less worn, some of the edges of the slates being not much broken.

"As regards the mineral riches of these deposits, it would appear that gold is found wherever they exist. The ravines coming from the ridges on which they are found are generally extremely rich, and always contain gold, even in places where the deposits themselves have been worked without success. In some places where they have been worked, as much as thirty thousand dollars have been taken from a claim of fifteen feet square; and there are many instances where ten and fifteen thousand dollars have been taken from claims of the same size. But few of these rich spots have, up to the present time, been opened, yet there can be no doubt but that many still remain to be discovered. Where these deposits are found extending over a large surface on the elevated flats, gold

is always met with, generally diffused through the gravel immediately above the rock on which they rest, which yields from fifteen to forty cents to the 100 lbs. of dirt. There are spots where acres of these deposits have been turned up, in which the gravel never contains less than fifteen cents to the 100 lbs., and generally more. In the valleys in the lower hills, and even on the plains to the west of them, where they are extended over vast tracts of country, these deposits are still auriferous, the gold being very generally diffused, and found in greater quantities the deeper they are worked. At present they will not pay for working, owing to the distance from water, and from the high rate of wages. In one place, where water could be readily obtained, a portion of these deposits, situated to the west of the lower hills, has been worked, and has been found to yield from five to thirty cents to 100 lbs. of earth, through an extent of 150 acres, the soil being found richer the deeper it is worked."

The first official notification of the discovery of gold in our Australian colonies is contained in a despatch from Governor Fitzroy to Earl Grey, and bears date May 22nd, 1851. In this it is announced that a gold field had been discovered westward from the town of Bathurst, and at a distance of about 150 miles from Sydney; his

Excellency at the same time states his suspicions that the specimens sent for inspection might be the produce of California, and that both the nature and value of the discovery had been much exaggerated. These accounts were however deemed of sufficient importance to warrant the stationing of a strong police force in the road leading from Bathurst to the capital.

On the 19th of May, Mr. Stutchbury, the geological surveyor, writes from Summer Hill Creek, that gold had been obtained in considerable quantity in that locality, and that, with no better washing apparatus than an ordinary tin basin, from one to two ounces per day were readily obtained by each washer. He also adds that 400 persons were busily at work at the time of his visit, and that the gold was not only found in the creek itself, but also at various points far above the line of its flood, so as to leave no doubt of its general existence over a considerable tract of country. This camp of the gold finders was called the City of Ophir, and to it flocked vast numbers, eager to obtain their share of its golden treasures.

The existence of gold among the various mountain chains of New South Wales had not only been predicted by Sir Roderick Murchison as early as the year 1848, but had also been insisted on by Mr. Clarke, a native geologist, who expressed his conviction that the Blue Mountains would at some

time prove to be auriferous. These views were to a certain extent confirmed by the circumstance of a shepherd having long been in the habit of bringing into Sydney, for sale, fragments of native gold, but refused to state from whence he had obtained them.

About two years before the actual discovery of gold in the colony, a Mr. Smith, who was engaged in some iron works in the vicinity of Berrima, produced to the Colonial Secretary a lump of gold imbedded in quartz, which he said he had picked up in a place which he offered to make known to the Government on being previously rewarded for the intelligence by the payment of a considerable sum. The reply to this offer was, that no blind bargain upon such a subject could be entered into, but that if Mr. Smith thought proper to trust to the liberality of the Government he might rely on being rewarded in proportion to the value of the alleged discovery, when that had been ascertained.

To the conditions of this proposal Mr. Smith refused to accede, and here, for a considerable time, the matter rested, as, apart from the suspicion entertained by the governor that the piece of gold produced by Mr. Smith might have come from California, or some other foreign locality, he was of opinion that any investigation instituted by the Government with a view of ascertaining whether

gold did in reality exist to any amount in that part of the colony, which, from its geological formation, might be supposed to afford it, would be liable to agitate the public mind to such an extent as to divert the attention of the colonists from their proper and more certain avocations.

On the 3rd of April, 1851, Mr. Hargraves, who had recently returned from California, addressed a letter to the Colonial Secretary, to the effect that, having occupied himself for two months in exploring a considerable extent of country, in which, from his experience in California, he was led to believe gold was to be found, he had prosecuted his speculation to a successful issue, and offered to point out to the Officers of Government the localities in which he had discovered gold, on condition that he should receive the sum of five hundred pounds as a compensation. To this proposal a reply was returned similar to that given on a former occasion to Mr. Smith, and on the 30th of April Mr. Hargraves addressed a second letter to the Colonial Secretary, expressing his willingness to leave the remuneration of his discovery to the liberal consideration of the Government, and naming the localities from which he had obtained specimens of gold.

On the 8th of May the discovery became generally known, as some persons, who had been employed under the directions of Mr. Hargraves at Summer Hill Creek, one of the localities named by

him as auriferous, had obtained several ounces of gold; and on May the 13th, very great excitement prevailed from a report that a solid piece of gold, weighing 13 oz., had been obtained. This, on inquiry, proved to be correct, and hundreds immediately started for the diggings.

The Government now issued a proclamation declaring that all persons digging for gold without a license would be proceeded against; and regulations were issued authorising the Crown Commissioners to grant such licenses for a fee of £1. 10s. per month. The Commissioners were also furnished with a force of ten men, for the purpose of collecting these fees, and for the maintenance of order; strong detachments of police being at the same time posted along the principal roads leading to the gold fields. Mr. Hargraves, and the Government geological surveyor, Mr. Stutchbury, with whom Mr. Clarke was afterwards associated, were now ordered to make an immediate survey of the various localities in which it was thought that gold would be found.

As might be expected, the excitement spread rapidly, and large numbers of persons left their employments and flocked to the spot. On the 19th of May 400 persons were reported to be occupied at the diggings on Summer Hill Creek. On the 29th, 1000, and on the 5th of June 1500, were stated to be thus employed. About the 14th of

June a fresh enterprise was opened on the Turon River, one of the localities first pointed out by Mr. Hargraves, and afterwards more specifically indicated by Mr. Stutchbury. This at once carried off a large number of those previously employed at Summer Hill Creek, or Ophir as that locality is now called, since early in July it was stated as probable that at this place the number of diggers for the month would not exceed 400, while at Turon it would be considerably above 1000. In December the number of diggers on the Turon amounted to 6000; and since that time gold fields have been discovered in various places, of which the following are the most productive:— Muckewa Creek, Louisa Creek, and Meroo Creek in the County of Wellington, Frederick's Valley, Campbell's River, and Winburndale Creek in the County of Bathurst, Abercrombie River in the County of Georgiana, and Araluen River, and its various tributaries in the County of St. Vincent's. Of these the principal appears to be the Araluen and its tributary creeks, where the yield is larger than on the Turon, and the auriferous deposit spreads over a great extent of surface, as the valley is in this place three quarters of a mile in breadth. In the course of a few days 1200 licenses were granted for this locality.

Mr. Commissioner Hardy, in speaking of the geological nature and physical conformation of the

Turon and Summer Hill Creek districts, remarks that they differ considerably in both particulars. Summer Hill Creek is narrow, and confined between high ranges, with so great a fall as to give rise to a rapid current of water during or immediately after the fall of heavy rains. The bed of the stream is extremely broken and narrow, and lies between hills of mica slate, intersected in every direction by broad and well-defined veins of white quartz. The Turon, on the other hand, runs through a valley of some miles in width, bounded by mountains at least twice the height of those at Summer Hill. These consist of mica slate, containing but little mica, and are entirely without the quartz veins referred to as occurring in the other locality. As might be anticipated from the width of the valley, the bed of the Turon is broad, level, and less tortuous than that of the Summer Hill Creek, and presents but few of the abrupt elbows so frequent in the former locality. This physical conformation of the country is found to have an intimate relation with the state of division in which the gold is found in the two places. In Summer Hill Creek the metal is invariably large in the grain, and often massive; whilst at Turon the gold procured is thin and scaly. Again, the Summer Hill Creek has its straight, barren reaches, and its profitable bends; whereas, in the whole course of the Turon, the production of gold is

said to be "as regular as wheat in a sown field." Mr. Stutchbury, the Government geologist, after a survey of those portions of the district which comprise Lewis's Ponds, Frederick's Valley Creek, the lower portion of Summer Hill Creek, and several of its tributaries as far west as Currin gurrac Creek, together with the Turon and several unnamed localities in the same district, reports as follows:—

"The trend of all the waterways is into the river Macquarie, and the general run of the latter river is in the direction of the strike of the strata—viz., from east of south to west of north; its deviations from this course being consequent upon the hard character of many of the rocks, especially those of igneous origin, such as the granites, syenites, porphyries, basalts, &c. The whole area may be considered as schistose, principally clay-slate, accompanied by nearly all the other varieties of slate rocks, in many cases greatly disturbed by the intruded rocks above mentioned, of subsequent igneous formation; also by a large amount of quartzites in veins or lodes parallel to the strike of the schist. The quartz is amorphous, very rarely crystallised; and in the neighbourhood of the gold-yielding localities it is accompanied by titaniferous iron, both crystallised and in loose grains.

"That the matrix of the gold is quartz in this district there cannot be any doubt, so many instances have occurred in which the quartz still

remains attached, and interlaced by the gold, as also the iron. It is a fact worth recording, that no washings have yielded gold without the iron sand (incorrectly termed emery) accompanying it.

"Gold in small quantities has been found on the summits and upon the flanks of the mountain ranges; but, with few exceptions, it bears evidence of abrasion. The largest produce in every instance has been found in the lower levels. Assuming that the auriferous deposits originated in the quartz rock, there is no difficulty in accounting for its presence most abundantly in the various gullies and creeks so numerous in this remarkably broken country. The schistose rocks, so readily acted upon by the atmosphere constantly disintegrating and exposing the quartzose dikes, leaves them unsupported, and, gravitating downwards, the largest blocks are crushed and crumbled in their onward course, letting loose the tenacious gold in large or small portions, which, in obedience to their gravity and the force of the impelling torrents, roll on until they are arrested for a time in hollows, or the cleavage fissures of the slaty rocks, or quietly deposited in the sand or mud, as the case may be, by the cessation of the flood, until they are again removed by the repetition of similar causes; or they may remain for ages undisturbed by the torrents taking another course, of which there are so many instances, leaving ancient bars of shingle debris now

covered by accumulated soil. It therefore follows that gold, even if it be of the earliest geological origin, may and will be accumulating in the lower valleys, as long as mountains waste, and valleys exist for its reception."

In another paragraph the same gentleman remarks—"That quartz is the principal matrix of gold is well known to all collectors of minerals; there is scarcely a cabinet without an example; and nearly all the mines properly so called (not washings in alluvial drifts), have been in quartz lodes from the time of the Romans, who worked it in Transylvania and in Wales, at the Ogofan in Caermarthenshire, during their occupation under Trajan, to the present time; but it has also been found in its original position in nests and veins, usually of small extent in granite (as at North Tawton, Devon, and St. Just, in Cornwall), syenite, greenstone, porphyry, trachyte, the crystalline schists, and transition strata, all largely developed in this portion of the colony."

Mr. Stutchbury further remarks that he has not yet seen gold in its unmoved original matrix, except in the case of some found far above the present water level, on land, near Summer Hill, belonging to W. Wentworth, Esq. The gold found in this locality was much mixed with angular fragments of quartz, accompanied by an ochreous loam and minute crystals of titaniferous iron.

By the process of "prospecting," that is, washing small quantities of earth in a tin dish, he subsequently established the presence of gold in the following localities:—

Lewis's Pond, to its junction with the Frederick's Valley and Summer Hill Creeks.

On the Range between Frederick's Valley and Gosling's Creek (Mr. Wentworth's land.)

Along the whole line of Frederick's Valley Creek.

Emu Swamp Creek.

Summer Hill Creek down to Belarida.

Oaky Creek, west of Summer Hill Creek, and falling into the Macquarie.

Macquarie River from the junction of several small creeks west of Bosh's Creek, to Killinbutta, especially at Wallgumbulla.

Macquarie River, at the junction of several small Creeks west of Bosh's Creek.

Junction of the Turon River.

Neele.

Stony Creek.

Wallenbutta.

Turon River on the various "bars," from its junction with the Macquarie to Choenarang Creek.

Callallia Creek.

With few exceptions, the hills to the west of the principal gold diggings are capped with basalt;

and at Bruno, a cattle station on a creek leading from Frederick's Valley Creek, there is a waterfall, exhibiting a good example of columnar basalt, supporting an homogeneous mass of the same rock. (See fig. 1.)

1.

It is also observed that the trappean rocks, such as basalt and porphyry, have in many places been forced to the surface, thus projecting through the schistose rocks, and by degradation giving origin to most of the round-topped hills. Many of these contain frequent lodes or veins of iron-flint in many cases, assuming the character of jasper or passing into semi-opal.

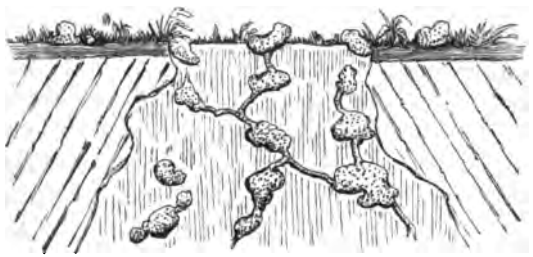
On the land belonging to W. Wentworth, Esq., near a large mass of quartz rock, specimens of gold have been found, mixed with fragmentary quartz, in an ochreous earth containing titaniferous iron. This gold did not appear to have been in the slightest degree water-worn, and was evidently derived from the adjacent quartz.

On the western flanks of the Summer Hill Creek, as far down as the Belarida pass, rocks of the same schistose character occur; and at a distance of about a mile above the place of crossing, they assume a very contorted appearance. At the western extremity of the Belarida range, and to the north of Mount Mogo, a very interesting conglomerate of sand and quartz pebbles occurs; this is cemented together by a ferruginous clay, and much resembles the cascalho or diamond gangue of the Brazils.

From this point basalts and schists extend in an easterly direction as far as Wallgumbulla, on the Macquarie River; from thence to the junction of the river Turon, schists and quartzites, intersected by occasional large dykes of porphyry, again prevail. Near the north-west angle of the junction of these two rivers a great abundance of transparent quartz, or rock crystal, may be obtained. At about midway between the points of junction of the Winburndale Creek with the Macquarie and Yorkey's Corner, now called Ophir, a large range of granite of about two miles in width is found running in a

direction nearly north and south. Many large boulders of this granite are loosely scattered on the surface of the ground.

These blocks appear to derive their origin in the way represented in Fig. 2.



2.

On the dividing range about four miles south of Callallia Creek, is observed the first evidence of the existence of a gneiss, composed of compact feldspar, translucent quartz, and black mica; this is followed by various porphyries, more or less stratified, and by siliceous slates. On reaching the lower road to Wellington the quartz becomes so predominant, and appears in such angular fragments, as to give the idea of having been collected for the purpose of repairing the roads. The Callallia Creek, and as far as Sammy's flat, consists of more or less altered clay-slate, frequently producing jasperoid rocks.

A short time after the announcement of the existence of gold in the colony of New South Wales Proper, a still more amazing discovery was made in Victoria. In a despatch dated 25th of August, 1851, Lieutenant-Governor Latrobe communicated to Earl Grey that large auriferous deposits had been found in that colony. The three localities first named were Clune's Diggings, about forty miles from Melbourne, where the gold was found in an alluvial deposit, chiefly consisting of quartz gravel; at Boninyong, or Ballarat, situated on the river Leigh, about seventy-five miles from Melbourne, and forty-five from Geelong, where the gold was sometimes imbedded in compact quartz; and at Deep Creek, only nineteen miles from the capital, where the precious metal was found to exist in connection with slate rock. At Ballarat, from whence the greatest quantity of gold was obtained, the metal is found in lumps of various sizes—sometimes in the superficial soil, but more generally scattered through three or four successive strata, principally composed of clay and gravel, and occupying from 10 to 30 feet in depth. The richest deposits are, however, found in certain small beds of blue clay, four or five inches in thickness, and lying almost immediately above a stratum of pipe-clay, in and below which no gold has been found. In addition to the above localities gold was also found near Geelong; at Mount Disappointment; in the

Pyrenees; and finally the people of Melbourne began to break up the streets, which were macadamized with quartz pebbles obtained from the gold districts. By this time Melbourne and Geelong were almost emptied of their male inhabitants. The shopmen and day-labourers were the first to leave, and the superior class of farmers and tradesmen speedily followed, partly from sharing the same mania, and partly because, after losing their subordinates, they could do nothing else. In some cases they placed themselves at the head of digging parties, consisting of their dependents; and in others worked singly and with their own hands. At this time the public excitement became so great that it was found impossible to retain the services of the government *employés* without an addition to their salaries of first 25, and subsequently 50 per cent. In about a month after this a fresh gold field was discovered in the range of Mount Alexander, on the east of the Lodden River, and about seventy miles north-west of Melbourne, which shortly surpassed in richness not only the Ballarat diggings, but all others which had been previously discovered.

The whole structure of Australian society now became completely disorganised. The number of diggers at Ballarat, which had previously risen to 6,000, were quickly reduced to about 1,600, whilst the number at Mount Alexander soon amounted

to 20,000. From this time gold began to be collected from all the various streams flowing from the Mount Alexander range, on the Goulburn River, and throughout the whole of the Omee country, by which the supply was so far increased that gold soon arrived at the sea-ports at the rate of two tons per week. At the present moment many other localities have been discovered, and up to the receipts of the latest intelligence the supply of the precious metal was rapidly on the increase.

MINERALOGICAL AND CHEMICAL CHARACTERS OF GOLD.

NATIVE gold in most cases presents the characteristic yellow colour peculiar to this body when in a state of purity; but its natural surfaces in other instances require to be rubbed with some hard substance before they assume the ordinary appearance of manufactured gold. Gold is not so hard as iron, copper, or silver, but is harder than either lead or tin. It is extremely tough or tenacious, but when broken by repeated bendings it presents a fibrous silk-like structure, which is more or less fine in accordance with the purity of the specimen. Native gold occurs crystallised, in branches, in filaments and plates, traversing the fissures in various kinds of rocks in desseminated grains, and in *pepitas*, or "nuggets," mixed with, and forming part of various alluvial deposits. In the two latter forms by far the largest portion of this metal is obtained; but as these sands are themselves produced by the destruction of auriferous rocks, the gold which they contain must be regarded as the debris resulting from the disintegration or grinding of the matrix in which it was originally enclosed. Crystals of gold seldom occur in an isolated form; but when found should invariably be preserved as cabinet specimens, for which purpose their value is much

greater than that which they are intrinsically worth for the gold they contain. The faces of these crystals are generally dull, and in most instances slightly rounded, even in specimens obtained directly from veins, and which, consequently, cannot have been exposed to attrition.

In the Gongo Soco mines, in Brazil, an alloy of gold and palladium, of a pale yellow colour, is sometimes found; and in some parts of Columbia a somewhat similar mixture is procured, in which the palladium is replaced by another rare metal, called rhodium.

The composition of various specimens of Native Gold, as obtained from different localities, is given in the following table:—

Experimenters	Locality	Gold	Silver	Copper	Iron
G. Rose.	From the mine of Beresof	93·78	5·94	0·08	
	From the mine of Sinarowski, Altai	60·08	38·38	0·33	
Boussingault.	From the mine of Santa-Rosa	64·93	35.07		
	From Transylvania	64·52	35·48		
	Gold from Ojas-Anchas	84·50	15·50		
D'Arcet.	„ Rio-Sucio	87·94	12·06		
	„ Senegal	84·97	10·53		
	„ Brazil	94·00	5·85		
T. H. Henry.	Anamaboc, Africa	98·06	1·39	...	0·15
	„ „	88·25	11·17	0·10	0·36
	Bathurst, Australia	95·68	3.92	...	0·16
Norrie.	„ „	91·15	8·28	...	0·57

Gold is so extremely malleable, that one grain of it may be beaten out into a leaf having a surface of fifty-six square inches, and of which the thickness is only one two-hundred-thousandth of an inch. When reduced to very thin leaves, gold is to a certain degree transparent; and on being held against the light appears of a beautiful green colour. According to Daniell, this metal melts at a temperature corresponding to 2016° Fahr.; and when still more intensely heated, affords perceptible metallic fumes. A globule of gold, exposed between two charcoal points to the action of a powerful galvanic battery, gives off abundant metallic vapours, by the escape of which its weight is rapidly diminished. When precipitated from its solutions, gold assumes a dark brown colour, but on being rubbed with a piece of polished steel, or other hard body, it readily assumes its ordinary yellow colour and metallic aspect. Pure gold may be exposed for an indefinite length of time to the action of air and moisture, without becoming in the least degree tarnished; nor is it oxidised by being kept in a melted state in an open crucible. Neither sulphuric acid (oil of vitriol), hydrochloric acid (spirits of salts), nor nitric acid (aquafortis), attacks gold, even when in a finely divided state; but by aqua regia, which is a mixture of nitric and hydrochloric acids, it is readily attacked and dissolved in the form of chloride. Gold may also be dissolved

by hydrochloric acid, to which has been added some substance capable of liberating chlorine: among these may be mentioned chromic acid and peroxide of manganese.

Gold is not directly attacked by sulphur at any temperature; but when fused with the alkaline sulphides, it is readily acted on, with the formation of a double sulphide of gold and the alkaline metal employed.

The examination of an auriferous rock for gold is an extremely simple operation. It is first pounded very fine and sifted; a certain quantity of the sand thus obtained is washed in a shallow wooden or tin pan, and as the gold sinks the lighter portions of the substance are allowed to float off into some other receptacle. The largest part of the gold is thus left in the angles of the pan, and by a repetition of the process a further portion is obtained. When the bulk of sand is thus reduced to a manageable quantity, the gold may be amalgamated with clean mercury, and the amalgam obtained finally heated in an iron retort, by which the mercury is expelled, whilst the gold remains in the vessel. By successive trials in this way the proportion of gold contained in a specimen of rock or alluvial gravel may be ascertained with considerable exactness. This affinity of mercury for gold is largely employed in the treatment of auriferous substances. The various processes by which these

results are obtained on a large scale will be described in a future chapter. When gold is associated with other metals, such as copper or lead, the true proportion in which it exists can only be ascertained by means of an assay.

From the great weight and flexibility of gold, as well as from its colour, it might be thought impossible to confound it with any other substance; yet experience has proved, that various other natural productions are sometimes mistaken for it. The substances which most frequently lead to these mistakes are iron pyrites, copper pyrites, and yellow mica; but in every case a very superficial examination only is required in order to detect the true nature of the mineral under consideration. Iron pyrites, which is certainly more frequently than any other substance mistaken for gold, occurs in small cubical crystals, in veins disseminated in various slate rocks and in the coal fields: it is also abundantly found in globular concretions, or kidney-shaped masses, imbedded in indurated clay and chalk. This substance also accompanies the ores of all the other metals, and extends from the oldest formations up to the newest alluvial deposits. Iron pyrites is, however, readily distinguished from gold, since instead of flattening like that metal under the hammer, it is extremely brittle, and therefore readily broken. In the second place, its weight, or rather its specific gravity, is only about one-fourth that of

gold; and lastly, when heated with nitric acid, it is dissolved with evolution of copious red fumes, whilst gold when thus treated is in no way affected. It is a remarkable fact, that this mineral, which is so frequently mistaken for gold, often contains minute traces of that metal, although it seldom occurs in sufficient amount to render its extraction a remunerative operation.

Copper pyrites, the second mineral which is frequently mistaken for gold, has a strong metallic lustre and deep brass-yellow colour. This mineral is formed in lodes or veins, which usually occur either in granite, grauwacke, or clay-slate, although it is sometimes met with in serpentine, gneiss, and some other rocks. It is most commonly associated in these deposits with iron pyrites, blende, and galena, together with the carbonates, phosphates, and other ores of copper. When heated on a piece of charcoal before the blowpipe, this mineral readily fuses into a dull black globule, which, from the presence of iron, is magnetic. If mixed with carbonate of soda and a little borax, it yields, when similarly treated, a button of metallic copper. In order to ensure success, however, this operation requires a little skill on the part of the operator; and consequently the non-production of a button of copper should not be regarded by the inexperienced assayer as a proof of its absence in the mineral examined. An easier and far more

satisfactory experiment, to determine the presence of copper in an ore of that metal, is the following:—Pulverize the ore either in an iron mortar, or, if that be not at hand, with a heavy hammer: the powder thus obtained is dissolved in nitric acid, and the solution evaporated nearly to dryness in a saucer or some other shallow vessel; water is added, and afterwards ammonia (spirits of hartshorn) in excess; if the liquor now assumes a blue colour, it is a proof of the presence of copper in the mineral examined. If copper be present in appreciable quantity, a knife, or any other bright steel object, will immediately become coated with it if immersed in the dilute nitric acid solution.

Mica is one of the constituents of gneiss granite, and mica slate, and gives to the former its lamellar structure: the specific gravity of this substance never exceeds 3·00; and this circumstance, together with its foliated structure, is quite sufficient to distinguish it from gold, which in colour it to a certain extent resembles.

METHOD OF EXAMINING AURIFEROUS DEPOSITS.

When a country is suspected to contain gold, the points to be most carefully examined are the sands of the rivers and streams flowing through it, as well as the particles of disintegrated rock which often accumulate in the eddies of ravines formed on the sides of hills by the action of water during great floods. The sections of rock thus laid bare are also to be examined, with a view to the discovery of veins of auriferous quartz, from which specimens must be broken, and afterwards carefully assayed. In examining the sands brought down by rivers, such portions should be selected for experiment as have, from local causes, been subjected to the action of rapid currents and eddies; since, from the great density of the metal sought, it invariably accumulates in those situations. It is usually found, and particularly in the Australian gold fields, that if a river or creek produces fine scaly gold in those parts of its course which lie through a flat, open country, it will, if followed into the mountainous districts in the direction of its source, become more productive, and yield gold in the form of "nuggets" and less finely-divided grains. The

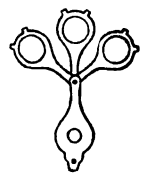
most productive localities hitherto found have been the bends or curves of rivers, and in these places the conformation of the banks on the convex and concave sides of the stream are found to be materially different. On the convex side, the banks in these cases consist of long slopes, opposite to which are nearly perpendicular bluffs. These slopes appear to have been formed by the reverberation of the stream from the opposite perpendicular cliff, and on all such slopes the gold is found to be much more plentiful than on the banks of the same river, where the water flows through a straight and uninterrupted channel.

The section of a river through one of the curves above described would present very nearly the appearance represented in fig. 3, in which *a* is the auriferous slope, and *b* the perpendicular bluff.

3.

As a general rule, in looking for gold, the rocks in the district to be examined should be either granitic, porphyritic, or quartzose, although it is also found in other formations, and particularly in clay-slate. The quartz in auriferous localities is frequently stained of a rusty brown colour, from the presence of peroxide of iron, and in many instances presents a cellular or honeycombed appearance. The tools employed by persons looking for new gold fields, or *prospecting*, as it is usually called in Australia, are extremely simple, and consist of a crow-bar, pick-axe, shovel, and a large round flat-bottomed tin dish. When a spot has been found which from its geological appearances would indicate the presence of gold, the pan is filled with the earth to be examined, and carried to the nearest stream, where its contents are carefully washed. This is done by placing the vessel slightly below the surface of the water, and then agitating the earth and sand which it contains, first by the hand, and afterwards with a sort of oscillatory movement of the basin itself, so as to allow the lighter portions to float away in the stream, whilst the heavier matters accumulate at the bottom of the pan. By thus alternately filling and washing out the dish, a considerable quantity of heavy sand is at length accumulated at the bottom; and by a careful examination of this residue it is easy to determine whether gold exists, and if

found, whether it be present in sufficient proportion to pay the expenses of working. In this subsequent examination of the earthy residue a small magnifying lens, fig. 4, will be found extremely useful, as by its aid the presence of gold may be detected in cases when, particularly if in a very fine state of division, it would otherwise escape observation. Should the spot examined appear to yield a remunerative amount of gold, a larger quantity is employed; and the process of digging and washing regularly commences.



4.

When the auriferous deposit is situated at a distance from any creek or pool, its working constitutes a dry digging, and the earth and sand removed have to be carried for the purpose of washing to the nearest available water. River diggings are, however, generally speaking, the most productive, and in these the larger fragments or nuggets are most frequently found. In such localities, however, a very careful examination is required, as the gold is seldom found at the surface, but at a greater or less distance below the present bed of the river, and the nuggets and larger grains are most frequently obtained from holes and crevices existing in the rocks on which the sand and gravel repose. When the surface consists of a loose gravel, the precious metal will in most instances have subsided

beneath this coarse deposit, and is found mixed with a blue tenacious clay, which is not readily disintegrated by the current. On the surface of this second bed the gold is usually distributed in a thin stratum, which must therefore be carefully collected and washed. With this view trenches are dug, and by means of what are called "back troughs" the course of the stream is entirely diverted. When the bed of the creek has been thus exposed, and all the larger pebbles and gravel removed, the exposed stratum of blue clay is collected and carefully washed.

It may also be remarked here, that parties prospecting should carefully examine the surface of the country, in order to discover the beds of any old stream, now become dry, through the river which they formerly conveyed having chosen other channels. By closely examining these old water-courses it is easy to ascertain the points at which eddies formerly existed: and in such places a search is often well repaid. Here the earth and sand must be removed until the original bed of the stream has been reached; and when this has been effected the firm blue clay is collected and washed, as in the case of that which occurs in the beds of existing rivers. When these situations prove productive, the pits are sometimes sunk to a considerable depth, and from such holes hundreds of pounds worth of gold have sometimes been collected in a single day

by persons with only the most rudimentary knowledge of mining; whilst others, with a still less degree of intelligence, have worked during the same time at a hole only a few yards distant, without obtaining a single particle of the metal sought.

ASSAY OF MINERALS CONTAINING GOLD.

Fusion.—In the assay of minerals containing gold, the object sought is to obtain that metal in the form of an alloy with lead, which is afterwards placed in a muffle, and cupelled, with various precautions. The mineral operated on is to be first finely pulverized in an iron mortar, and afterwards fused in an earthen crucible, with a certain proportion of litharge or red lead, and a sufficient quantity of powdered charcoal, to reduce to the metallic state a quantity of litharge varying with the nature of the ore treated, and the weight employed for each operation. The weight of litharge used must also itself be varied in accordance with the richness of the ore, and the nature of the gangue or matrix with which it is associated. If, which will frequently be the case, the substance operated on be either crushed gold quartz, or alluvial sands which have been more or less concentrated by washing, the following mixture will be found extremely convenient. For the sake of being more definite in the directions given, I will suppose the ore to be tolerably rich, and therefore 400 grains

will be a sufficient quantity to employ. If, however, poor ores are to be examined, double or even treble that quantity may be operated on, and in this case a proportionate quantity of flux must be used. In the case supposed, where 400 grains is the quantity treated, the resulting button of lead should at most not weigh above 200 grains, since, if the resulting button of alloy were too large, a greater length of time than convenient would be required for the cupellation. Neither should it be too small; as, in that case, a part of the gold is liable to remain in the slags. In order, then, to obtain a satisfactory result, the 400 grains of powdered ore must be intimately mixed on a sheet of highly-glazed writing paper, with its own weight of litharge or red lead (dry white lead will do equally well when these are not to be obtained), 200 grains of dry carbonate of soda, and from 7 to 8 grains of dry and very finely-powdered charcoal. This mixture is introduced into an earthen crucible, of which it should not fill more than two-thirds the capacity. This is now covered with a thin layer of borax, and fused in an assay furnace, care being taken to withdraw the crucible from the fire as soon as a liquid and perfectly homogeneous slag has been obtained, since the unreduced litharge would otherwise be liable to cut through the pot, and spoil the experiment.

When the substance operated on contains other

metal besides gold, the addition of charcoal or any other reagent to reduce the litharge is in many cases unnecessary, as litharge readily attacks all the sulphides, arsenio-sulphides, &c., and oxidises nearly the whole of their constituents, with the exception of silver and gold, whilst a proportionate quantity of metallic lead is at the same time set free. The slags thus formed contain the whole of the excess of litharge added, whilst the button of alloy produced is extracted by breaking the crucible, after it has been allowed to cool, and is then subjected to the process of cupellation. The proportion of oxide of lead to be added to ores of this description necessarily varies with the amount of oxidisable substances present, but should in all cases be added in excess, since, if the slags retain any traces of an alkaline sulphide, the whole of the gold contained in the mineral will not be present in the button of alloy obtained. For the assay of iron pyrites, about 30 parts of oxide of lead are necessary; whilst for mispickel, zinc blende, copper pyrites, grey cobalt, and sulphide of antimony, from 15 to 25 times their weight only may be employed.

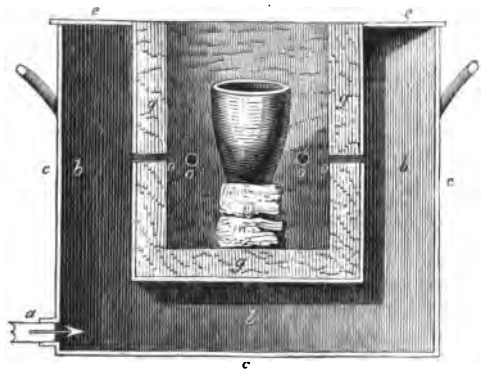
The only objection to be made to this method of assay is the large amount of lead which is produced for cupellation; since pure iron pyrites affords, when thus treated, 8½ parts of lead, whilst sulphide of antimony and grey copper ore yield from 6 to 7

parts. This inconvenience may, however, be obviated, by effecting the partial oxidation of the mineral by the aid of nitrate of potash or saltpetre; by the skilful use of this reagent a metallic button of almost any required weight may be obtained. Should the nitre be employed in excess, it would determine the oxidation of all the metallic and combustible substances contained in the mineral. To this the gold alone would be an exception; but from the comparatively small quantity in which that metal exists, it could not thus be obtained in the form of a button.

When, however, the mixture contains at the same time a large excess of litharge, and the nitre has not been added in sufficient quantity to decompose the whole of the sulphides present, a reaction is established between the portions of undecomposed sulphide and the oxide of lead added. The exact amount of nitre to be added in these cases will necessarily depend on the nature and richness of the ores treated; but it should in all cases be borne in mind that $2\frac{1}{2}$ parts of nitrate of potash are sufficient to completely oxidise one part of iron pyrites, and that $1\frac{1}{2}$ and 2-3ds their weight in the case of sulphide of antimony and galena are respectively sufficient to produce the same effect on these ores. In certain cases, however, the process of scorification is to be preferred.

One of the arrangements best adapted for the

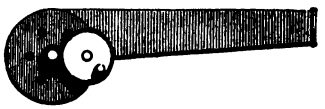
operations above described, is known by the name of Seftström's Blast Furnace, and from its extreme portability offers great advantages to the travelling assayer. Such a furnace is represented in fig. 5, and is formed of two cylinders of sheet-iron placed one within the other. *c* represents the outer cylinder, and *g* the inner one, lined with a coating of fire-clay, about an inch in thickness.



5.

Both cylinders are provided with a bottom, and are fixed together by the top, air tight, in such a way as to leave an equal space between their sides and bottoms, as exhibited in the figure. The smaller cylinder and its lining of fire-clay is pierced near the middle of the sides with eight holes, all pointing towards the centre of the furnace. The crucible

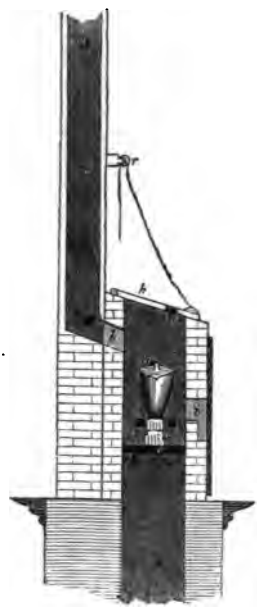
to be heated is placed in the middle of this arrangement on a piece of fire brick, kept in its place by a little fire-clay. The air is blown into the opening *a*, which is connected with the nozzle of a double-action bellows, and is thus compressed into the space *b*, and thence driven through the holes *o* into the cavity of the furnace. Instead of using bellows a current of air may be advantageously supplied by means of a rotating fan, as shown in the wood-cut (Fig. 6), similar to those which are employed for domestic purposes.



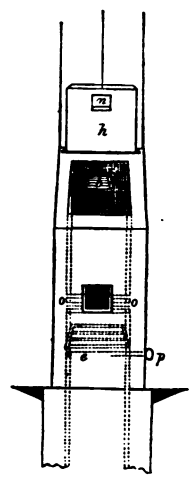
6.

When this blower is employed, the nozzle should be held at a distance of about a quarter of an inch from the orifice *a*, which in this case must be made slightly funnel-shaped. The heat thus produced is exceedingly intense; so much so, that a furnace having an internal diameter of six inches, and externally as large as an ordinary hat, is capable of melting, with the greatest ease, several ounces of cast iron. The fuel used for a small furnace of this kind should be charcoal broken into pieces of about the size of nutmegs. This uniformity is readily obtained by breaking the fuel into fragments of

nearly the size required, and then sifting it through two sieves, one of which retains all the pieces which are too large, whilst the other lets through all those which are too small. When, however, the materials for its erection can be obtained, the ordinary wind furnace is to be preferred. Figs. 7, 8, represent this apparatus.



7.



8.

Wherever it can be conveniently managed, it is

desirable that the ash-pit of the furnace should be placed beneath the floor of the room in which it is situated, and communicate either with the cellar of the house or with an opening made in front, which for the sake of the draught is covered by an iron grating. The inner cavity of the arrangement may be made either round or square; but for large operations round furnaces are generally preferred, although, for the purposes of assaying, square ones are more commonly used. The cross section of this furnace is a square, of which each side may measure twelve inches. At *e* is the grate, consisting of several bars of wrought iron, united together and turning on a hinge. The side of the grating opposite to the hinge rests upon an iron bar *p*. This bar is moveable, and can be withdrawn on pulling a knob on the outside of the furnace. When this is done, the grate falls perpendicularly on its hinges, and allows the fuel to escape into the ash-pit beneath. The mouth of the furnace is closed by an iron plate *h*, lined with fire-clay, and fastened to a chain, by the aid of which and a pulley *r* it can be opened, when it is necessary either to throw in fuel or to stir the fire. In this plate there is a small hole *n*, which can be closed by a moveable iron cover. This is used for occasionally viewing the interior of the furnace. From the internal cavity the heated gases pass into the chimney *c* by the canal *b*; the cross section of the flue, like that of

the furnace itself, is a square, and the depth of the furnace, from the fire bars to the moveable cover, may be from two feet to two feet two inches. In many furnaces the cover, instead of being hung on hinges, as above described, is simply made to slide loosely over the aperture. The chimney of a furnace of this description should be at least 20 feet in height.

The opening *b*, between the furnace and the chimney, should be about 8 inches by 2; but, should it be required, these dimensions may be readily diminished by means of a little fire-clay, and some pieces of refractory brick. The internal lining of such furnaces is commonly made of refractory bricks, bedded in fire-clay, but in default of the former material a lining of fire-clay alone may be readily substituted. The chimney must be provided with a damper for the regulation of the draught.

When this furnace is to be employed to effect a fusion, the opening *i* is closed by a piece of fire-brick; another fragment of brick is placed on the grate, and on this stands the crucible in which the experiment is to be made.

When employed for making cupellations, the muffle is introduced through the opening *i*, and rests on the bars *o o*. This furnace is not recommended as being of the best form and dimension that could possibly be used for the purposes of

assaying, but is extremely useful for general purposes, and can, if required, be employed for running down large quantities of gold dust.

Cupellation.—In order to ascertain the amount of the precious metals, *i. e.* the silver and gold contained in the buttons of lead obtained by the foregoing operations, they are subjected to a process called cupellation.

This process is founded on the circumstance that when silver and gold are exposed, in a state of fusion, to the action of the air, they neither give off perceptible vapours, nor are sensibly oxidised, particularly when more oxidisable metals are present.

In order, then, to obtain the gold contained in the buttons of auriferous lead taken from the crucibles in which the fusions have been conducted, it is only necessary to expose them on some absorbing medium to such a temperature as may oxidise the lead, whilst the gold is not so affected. The oxide of lead, or litharge, which is thus produced, becomes rapidly absorbed by the porous substance by which the assay is supported, and nothing but a small button of gold, or of gold containing a certain quantity of silver, ultimately remains in the metallic state.

These supports are called cupels, and are made of bone-ash, tightly consolidated by pressure in an

iron mould, which gives to them the form represented by figs. 9 and 10.

9.

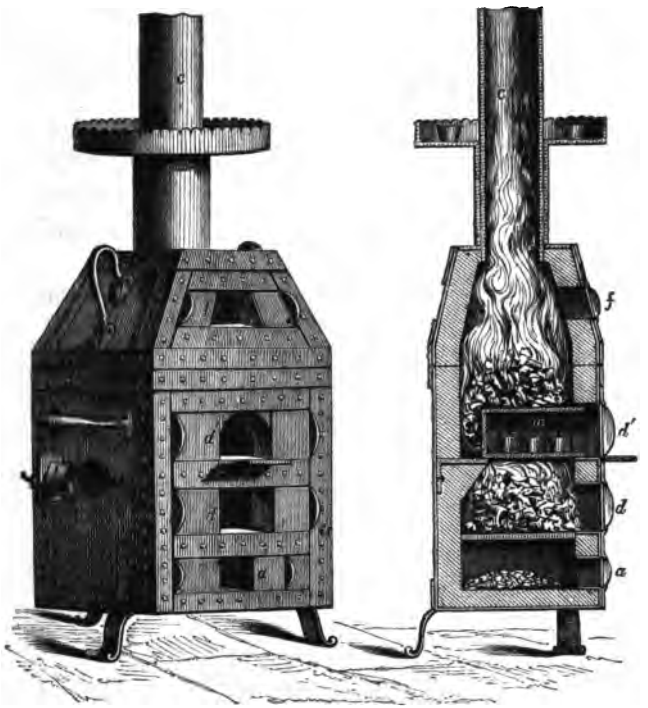
10.

A very convenient kind of furnace for the purpose of cupellation is represented by figs. 12 and 13. The first of these figures represents the furnace in elevation, and the second in section. This furnace, as shown in the drawing, is made of sheet iron, thickly lined with fire-clay.

The most important part of this apparatus is the muffle *m*, which is a small arched retort of fire-clay closed at one of its extremities, and furnished either with small holes or perpendicular slits in the sides and end, in order to allow of the free circulation of air through its internal cavity. The accompanying wood cut (Fig. 11) represents a muffle of this kind, before its introduction into the furnace.

11.

When fixed, it is so arranged that whilst one of its extremities is supported by a proper shelf, the other corresponds to the opening *d'*, to the sides of which it is carefully luted by a little moistened fire-



12. 13.

clay. This position of the muffle in the furnace admits of its being readily heated on every side; whilst the openings in its end and sides admit of the passage of a current of air from the door *d'*

into the cavity of the furnace. In this way the interior of the muffle is constantly traversed by a highly oxidising current of air, and the draught of the furnace is kept up by the addition of a long chimney of sheet iron *c*. To light this apparatus a little ignited charcoal is introduced by the opening *d*, and the cavity of the furnace afterwards filled up with the same fuel; the whole of the openings must be now closed by their proper slides, with the exception of the ash-pit *a*. Instead of charcoal, good hard coke, broken into small pieces, may be employed; and when the muffle has become red-hot, six or eight cupels, which have been previously drying on the ledge around the chimney, are taken by tongs of the form shown fig. 14, and placed on the floor of the muffle. This, to prevent its being corroded should any lead be spilt upon it, is previously covered by a thin layer of pounded bone-ash.

The opening *d'* is now closed by its doors, so as to prevent the introduction of a current of cold air, and the cupels are thus raised to the temperature of the muffle itself. When this has been done the door is again removed, and into each of the cupels is introduced, by a pair of slender steel tongs, a button of the alloy to be assayed. The door is now a second time closed during a few minutes, in order to facilitate the fusion of the alloy, and on its removal each of the cupels is found to contain a

bright convex metallic globule, in which state the assay is said to be *uncovered*. The air thus admitted rapidly converts the lead into litharge, which, as fast as it is produced, is absorbed by the bone-ash of the cupels; and at the same time there arises a white vapour, which is gradually carried off through the openings in the sides of the muffle. An annular stain is also formed around the the metallic bath: this gradually extends, and penetrates into the substance of the cupel in proportion as the metallic globule itself diminishes in size. When nearly the whole of the lead has been thus converted into litharge, and absorbed, the remaining bead of rich alloy appears to become agitated by a rapid circular movement, by which it seems to be made to revolve with great rapidity. At this stage of the operation the agitation will be observed to cease suddenly, and the button, after having for a moment emitted a bright flash, becomes brilliant and immoveable.

14.

This phenomenon is called the *brightening* or *coruscation* of the metal, and a button remains on the cupel, which, if the original mineral merely contained gold, mixed with the more oxidisable

bodies, consists of that metal in a state of almost chemical purity; but if the ore be argentiferous, as well as auriferous, it will be composed of a mixture of gold and silver.

The litharge employed in the first stage of this process, for the purpose of supplying the lead necessary for the assay, in almost every instance contains a certain portion of silver, for which due allowance must be made in the results obtained. In order to do this, it is necessary to ascertain, by a preliminary experiment, in what amount silver is present in the lead reduced from such litharge; and having ascertained the weight of the button obtained, the proper reduction is calculated, and subtracted from the button of alloy obtained. When, however, the fusion has been conducted by the aid of nitre, it is extremely difficult to arrive at accurate results by this means, and consequently in all such cases, as well as when the ore contains silver in addition to gold, recourse must be had to the process of *parting*, which will presently be described.

If, after the brightening of the button, the cupel were immediately removed from the muffle, the metallic globule would be liable to *sprout* or *vegetate*, by which its surface would not only be covered by numerous arborescent asperities, but a portion of the metal would probably be thrown off and lost. This effect is only produced when a

large portion of silver is present, and it appears to be partly due to the sudden cooling of the surface exposed to the air, which by its contraction compresses the liquid metal contained in the interior, and causes it to burst through the outer coating. The effect is, however, chiefly owing to the expulsion of oxygen gas, as silver is known to absorb that body when in a fused state, and again to part with it at the moment of consolidation. The oxygen in this case would almost appear to be mechanically combined.

To prevent this sprouting from taking place, and to guard against the loss of metal that is liable to ensue, the cupel on which the button has brightened should be immediately covered by another, which has been kept red-hot for that purpose. The two are now withdrawn together, and allowed to remain on the ledge before the muffle, until the metal has been solidified, when the upper cupel may be removed, and the globule of rich alloy detached and weighed.

From the circumstance that silver is sensibly volatile at elevated temperatures, it becomes necessary to make cupellations of the buttons obtained from ores containing that metal at the lowest heat at which the absorption of the litharge can be readily determined. If, however, the cupel be not made sufficiently hot, an annular incrustation of crystallised litharge will begin to accumulate around

its edges, and if at this point the fire be not immediately attended to, the deposit of oxide spreads rapidly over the whole surface of the metal, and the further progress of the operation becomes entirely stopped. In case of this happening, the mouth of the cupel must for a few minutes be closed by its door of sheet iron, and the heat of the muffle raised by the addition of fresh fuel: should this fail to uncover the bath, a small quantity of powdered charcoal may be sprinkled over its surface.

The temperature best suited for cupellation is obtained when the muffle and the enclosed cupels are at a full red heat, and the vapours which arise from the alloy curl gradually away, and are promptly removed by the draught. When the muffle is heated almost to whiteness, and the vapours rise to the crown of the arch, the temperature is too high, and when on the contrary the fumes lie over the bottom, and the sides of the openings in the muffle begin to darken, a little more fuel must be added through the door *f*, and the heat gradually raised. When the operation is conducted at a proper temperature, the cupel should be of a cherry-red colour, and the fused alloy very bright and convex. At the commencement of the operation the heat must be a little raised, for the purpose of fusing and uncovering the button, and just before the globule is about to brighten, a slight elevation of

temperature is again advantageous, but if a proper heat has been kept up during the progress of the operation, this is by no means necessary.

The success of an experiment is likewise considerably influenced by the force of the draught passing through the muffle. When the current is too rapid, the cupel becomes cooled, and the lead is oxidised with greater rapidity than it should be: in this case the litharge produced is not absorbed by the test as fast as it is generated, and consequently the surface of the alloy is covered by a coating of oxide of lead, by which it ultimately becomes protected from any further oxidation. When, on the contrary, the current is too feeble, the assay remains a long time in the muffle, and, if silver be present, a large amount is lost by sublimation.

If an assay has been properly conducted, the residual button is round, bright, and smooth on its upper surface, and beneath should be crystalline, and present a frosted metallic appearance; it is easily detached from the cupel, and readily freed from any adhering litharge. This globule is now removed by a pair of fine steel forceps, and slightly crushed between the jaws of a pair of pliers, by which the oxide of lead, which frequently attaches itself to it, becomes pulverised, and is removed by scratching with a small brush made of stiff hogs' bristles. When the buttons obtained on the cupels are ex-

tremely small, they are best flattened on a small anvil or steel stake, before being cleaned by the brush. The flattened discs are then examined by the aid of a powerful lens, in order to be sure that their surfaces are perfectly clean, and afterwards weighed in a balance capable of turning with 1-1000th of a grain weight. For the purpose of weighing the ore previous to its fusion with the litharge, as well as for ascertaining the weight of the button of lead obtained, when that is required, a pair of common apothecaries' scales may be conveniently employed.

When, in addition to gold and lead, the button obtained by the fusion likewise contains copper, it must be cupelled like the similar alloys of silver and lead, but as copper possesses a much greater affinity for gold than for silver, a proportionately large addition of lead must be made, in order to ensure the production of a button in which copper is not present. This proportion varies in accordance with the composition of the alloy operated on, as shown in the following table, in which is indicated the total amount of lead to be added to the various alloys of gold and copper, in order to obtain the former metal in a perfectly pure state.

Proportion of Gold contained in the Alloy.	Quantity of Lead necessary to completely remove the Copper by Cupellation.
1000 thousandths	1 part
900 „	10 „
800 „	16 „
700 „	22 „
600 „	24 „
500 „	26 „
400, 300, 200, 100, 50 „	34 „

Instead of using the cupellation furnace described at the beginning of this chapter, a small one, made of fire-clay, and bound with iron hoops, may sometimes be used with advantage. These small clay furnaces are, however, liable to be broken, and are consequently inconvenient when they have to be carried to any considerable distance. The best crucibles to be employed for the fusion of the ore, are either the Cornish, or those known by the name of London pots, although, when made of good material, I usually prefer the latter. Those called four-inch pots are of the most convenient size.

Cupels.—The manufacture of cupels is an extremely simple operation, and is thus conducted. The bone-ash obtained by burning bones, either in heaps, or in the larger assay furnace, page 50, is first pounded, and then passed through a sieve of fine wire gauze, and afterwards mixed with water

until sufficiently moistened to retain the marks of the fingers when taken up and tightly squeezed in the hand. To give to the cupels, when made, a certain degree of firmness, a little carbonate of potash is sometimes added to the water with which the bone-ash is moistened. The amount of alkaline carbonate required for this purpose is exceedingly small, since a fragment of the size of a hazel nut will be amply sufficient to add to a pint of water. Instead of water, some persons use sour beer, and thus dispense with the use of any kind of alkali. The form of mould best adapted for the manufacture of cupels is represented by fig. 15, and consists of a bevelled steel ring, *b*, and a die, *a*, made of the same metal, and fitted with a wooden handle. To make a cupel, the cavity is nearly filled with moistened bone-ash, which is first compressed slightly by the hand, and afterwards by the die, which is tightly driven into the ring by the use of such a mallet as is shown fig. 16. When sufficiently consolidated the die is withdrawn, and by introducing a wooden cylinder which exactly fits the aperture, the cupel is without difficulty removed. The use of this wooden cylinder is sometimes liable to crumble the edges of the cupel, and for this reason a loose plate, *c*,

15.

exactly fitting the bottom of the mould, is frequently introduced, before the bone-ash is placed

16.

in it. When this precaution is taken, the iron protects the bottom of the cupel, and enables the operator to use considerable force without injury to the edges of the newly made test. This iron plate must of course be replaced each time a cupel is made, and, with the test before it, is again forced out of the mould.

Scorification.—Scorification, like the fusion of the ore with litharge, has the effect of producing an alloy, which may be subsequently passed to the cupel, and a very fusible slag, composed of oxide of lead, and all the other substances present, with the exception of the precious metals. In the fusion with litharge, however, the oxidation of the various substances which are to be removed is produced by the action of the oxygen contained in the litharge itself, whilst an equivalent amount of lead is reduced to the metallic state, and enters into

combination with the gold and silver which the mineral may contain, to furnish the required alloy. When, on the contrary, the process of scorification is adopted, these substances are oxidised by the aid of atmospheric air, whilst the litharge necessary for the fusion of the earthy and siliceous matters is itself formed by the oxidation of a portion of the metallic lead which is added to the ore to be assayed. For this operation, instead of using cupels made of bone-ash, small vessels, of the form represented fig. 17, and made of close-grained fire-clay, are employed. These scorifiers are heated in the muffle of an ordinary assay furnace, and as many assays may be introduced at one time as there is room for in the muffle.

17.

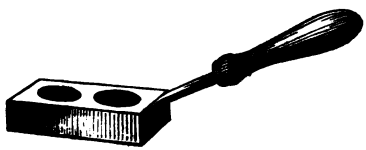
Before introducing the scorifiers into the furnace, they are each charged with a determined weight of the mineral to be operated on, reduced to the state of a fine powder, and intimately mixed with a certain quantity of finely granulated lead. They are now placed in the muffle, and there strongly heated during a quarter of an hour, with the door at the mouth closed. At the expiration of this time the lead will be found to be melted, and the mouth of the muffle is again opened. The current of heated air which now passes through the muffle immediately begins the process of roasting, which is continued tranquilly, without there being any necessity

for continual stirring, as is frequently the case when substances are roasted in the muffle without the addition of lead. The effect of this oxidation is to produce a slag on the surface of the metallic bath, and this, which at first accumulates around the edges of the scorifier, soon becomes extended over its whole surface. These slags, which at the commencement of the operation are frequently solid, gradually become soft, and finally remain in a perfectly liquid state; since, in proportion as the operation advances, the quantity of oxide of lead which they contain becomes more and more considerable.

When it is thought that the scorification has been sufficiently advanced, the fused matters are well stirred with a slender iron rod, for the purpose of mixing with the mass any hard and pasty substances which they may contain, and which might otherwise remain attached to the sides of the vessel. After this the muffle is for a short time strongly heated, and the slags thereby rendered as completely liquid as possible. The point at which the scorification has been sufficiently advanced may be recognised by placing in the mixture a small iron poker, previously heated to redness; and when, on withdrawing this, it is found covered with a slight film of scoria, which runs off without forming a small solid drop at the end of the rod, the operation may be considered complete. This condition of

the slag is indispensable, in order that no metallic buttons may remain adhering to the sides of the vessel.

When this point has been attained the operation is terminated, and the scorifier immediately withdrawn from the fire by means of proper tongs, and the alloy poured into a mould of the form represented fig. 18.



18.

When cold, the metallic button is readily separated from the slags, and may be passed on a cupel in the usual way.

The process of scorification is, without exception, applicable to the assay of all kinds of auriferous and argentiferous ores, and is at the same time one of the most exact methods that can be employed. When the gangue or matrix of the ore assayed is siliceous, the oxide of lead, which is formed by the roasting of the metallic lead, combines with the silica to form a fusible silicate; whilst the remainder of the lead, which escapes oxidation, unites with the silver and gold which may be present in the ore. When these metals are in combination

with other metallic substances they absorb oxygen from the atmosphere, and the oxides produced combine with the litharge formed at the same time, and thus give rise to various fusible compounds.

The chief and most valuable feature of the process of scorification is, that however small may be the proportion of the lead employed, the slags produced never contain any oxy-sulphides at the close of the operation; and from this it follows that they rarely retain the most minute trace of either gold or silver. We have, moreover, seen that the assay of the sulphides and arsenio-sulphides by means of litharge is attended with considerable inconvenience, from the amount of that oxide which it is necessary to employ; since for the first 30 parts, and for the second as much as 40 parts, are sometimes required, and if these amounts be not respectively added the slags will retain sulphides in combination, by which the results of the experiment will be more or less vitiated.

Parting.—When, as is frequently the case, the button produced by the fusion of the ores contains, in addition to lead and gold, a certain proportion of silver together with traces of copper, it must be cupelled at a moderate temperature, and, if necessary, an additional quantity of silver added. By operating in this way the button obtained on the cupel consists of an alloy of silver

and gold, which is afterwards treated with an excess of nitric acid: this effects the solution of the silver, and leaves the gold untouched in the form of a brown sponge, in the bottom of the flask in which the experiment has been conducted. In order, however, to obtain perfectly exact results, it is necessary that a certain relation should exist between the amount of the two metals of which the alloy is composed; since, if the silver be not present in sufficient quantity, the mixture is not completely attacked by nitric acid; whilst on the other hand, when too large a proportion of this metal is added, the gold remains in a pulverulent form, which renders its collection for the purpose of weighing extremely difficult.

This operation, which has received the name of *parting*, is found to succeed most fully when the alloy contains a little less than three parts of silver to one of gold, and therefore, in all cases where the greatest exactitude is required, the addition of silver must be so managed as to agree as closely as possible with this proportion. If the alloy contain less than two-and-a-half parts of silver to one part of gold, the solution of the silver is not readily effected, as in this case some of its particles are so enveloped in gold as to resist for a long time the action of the strongest nitric acid.

The operation of adding the proper amount of silver to an alloy of gold to reduce it to the best

standard for the process of parting, is called *inquartation*. The quantity of silver necessary for this purpose is estimated in accordance with the approximative composition of the alloy produced by direct cupellation. This may be judged of either by the touchstone, as will be presently described, or in many instances by a simple inspection of its colour and hardness.

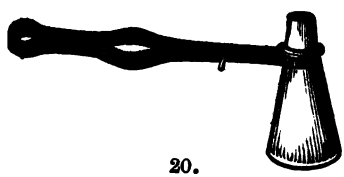
The inquarted button, when obtained, should be carefully flattened with a polished hammer (fig. 19) on a steel anvil, and afterwards attacked in a small flask or test-tube by nitric acid of specific gravity, 1·15. After being boiled with acid of this strength until the red vapours at first given off have ceased to be evolved, the residue is again heated to ebullition during from ten minutes to a quarter of an hour in acid of specific gravity 1·25. At the expiration of this time the acid is carefully poured off, and the residual gold, after being carefully washed with distilled water, is transferred to a thin porcelain capsule, from which the water is partially removed by pouring, and the remainder evaporated by exposure to a gentle heat. After being heated to redness the pulverulent gold may be either weighed directly in an accurate balance, or be folded in a small piece of poor lead-foil, and

19.

again passed to the cupel so as to obtain it in the form of a pure metallic globule. It is of the greatest importance that the acid employed for the above operation should be perfectly free from chlorine.

Assay of Gold Dust and Artificial Alloys.—As in these cases the standard operated on is in most instances approximatively known without having recourse to any preliminary investigation, the operation usually commences by fusing the alloy in a cupel with about five times its weight of poor lead, and then adding the amount of pure silver necessary to bring the mixture to the proper composition. After having in this way obtained a button by cupellation, it is first flattened on an anvil, and afterwards annealed by being heated to redness in the muffle, and allowed to cool. It is then drawn out into the form of a long slip by being repeatedly passed between the rollers of a small flatting-mill. During the progress of this operation the metal requires to be a second time annealed, and when sufficiently reduced in thickness should represent a metallic ribbon of about three-eighths of an inch in width, and three inches in length. A convenient weight of alloy to operate on is 12 grains, as this, as will be shortly explained, bears a simple relation to the carat. In laminating the cupelled button, it is, however, necessary that it should be reduced to a suitable thickness, so that on the one hand the

silver may be readily dissolved, whilst on the other, if the lamination be carried too far, the gold remaining at the close of the experiment will not possess sufficient coherence to admit of being conveniently removed and passed to the muffle. The strip of alloy thus prepared is now wound in the form of a spiral around a piece of iron wire, or the barrel of a quill pen, from which it is removed to a small glass matrass capable of holding about six fluid ounces, which, with the tongs used for holding it, is shown fig. 20. Instead of employing a flask of the form here represented, a small bulb-shaped matrass with a long neck is fre-



20.

quently used: this latter form is now generally adopted by the best assayers of bullion, both on the continent and in this country. About two ounces of nitric acid of specific gravity 1·15, are now added, and the whole exposed to the temperature of ebullition until red fumes have ceased to be given off: when this occurs the first liquor is carefully poured off and replaced by the same

quantity of acid having a specific gravity of 1·25; with this the residue is briskly boiled for another ten minutes, after which it is poured off, and the remaining gold carefully washed. The flask is now entirely filled with distilled water, and after covering the neck with the thumb, so as to prevent the escape of any of the liquid, it is so inclined as to allow the cornet of spongy gold, which retains the form of the original alloy, to descend slowly and without breaking to the neck of the matrass. The metallic spiral is now carefully allowed to drop into a small earthen crucible, fig. 21; the water is carefully poured off, and when quite dry the whole is heated in the muffle to bright redness. In these operations the stronger acid is not at first applied, because it is liable, by its rapid action on the silver, to divide the gold in the form of powder: but some of the best assayers are in the habit of using acid of the density of 1·20, and in this case, if the operation be skilfully conducted, there will be no need of any subsequent addition of stronger acid. When the attack has been carefully conducted the gold remains in the form of a friable brown sponge, having very nearly the same dimensions as the original spiral of alloy: on heating this, however, as before described, it contracts very considerably, and at the same time acquires the colour and consistence of ordinary malleable gold. The results

21.

thus obtained differ from one-quarter to one-half-thousandth from the actual truth, and are therefore sufficiently exact for every commercial purpose.

The Touchstone.—When the apparatus and reagents necessary for the carrying out of a complete assay cannot be procured, a very near approximation to the truth may be obtained by the use of the touchstone; and as the materials employed for these operations are extremely portable, its use is sometimes attended with considerable advantage. This process essentially consists in rubbing some convenient part of the object to be examined on a hard siliceous stone of a dark colour, on which it thus leaves distinct metallic traces: from the aspect of these marks, and their behaviour when treated with nitric acid, either with or without a slight addition of muriatic acid, the operator judges of the value of the gold subjected to examination. The material employed for this purpose, and which is generally known by the name of touchstone, is a coarse-grained species of quartz coloured by bituminous matter, and of which large quantities are found in Saxony, Bohemia, and various other localities.

In order to be enabled to judge of the value of an alloy from the nature of the marks left by it on the surface of the stone, the assayer is furnished with a series of small bars or touch needles, formed of alloys either of copper and gold, or of silver and

gold, as the case may be, and of which the composition is accurately determined.

The trace left on the stone by the alloy to be examined, is successively compared, both before and after the action of an acid, with the different marks obtained from these needles when similarly treated, taking care to employ those containing copper for all alloys of that metal, and those alloyed with silver when silver is supposed to be present in the specimen operated on. In these examinations the gold operated on is supposed to possess a similar standard to the needle whose mark agrees most closely with it under all circumstances. The acid most commonly employed for this purpose is nitric acid of sp. gr. 1·20, to which about 2 per cent. of muriatic acid has been added. In making these assays, the first streak obtained on the stone cannot be employed to ascertain the composition of the object examined, if it be a manufactured article, as the surface of jewellery is invariably rendered, by the process of colouring, of a higher standard than that of the alloy of which it is throughout composed. For this reason, therefore, the object must be passed once or twice over the surface of the stone, in order to remove the superficial coating of richer alloy, before making the streak from the comparison of which with those of the needles the commercial value of the mixture is to be determined. This method, although affording much less accu-

rate results than those obtained by inquartation and subsequent parting, is, nevertheless, for many purposes sufficiently exact.

When, in addition to copper, gold, and silver, the alloy also contains a certain proportion of platinum, the separation by cupellation of the oxidisable metals, and especially copper, is rendered extremely difficult. In this case, it is necessary that the silver present should be at least double the united weights of the gold and platinum contained in the alloy, and that it should be cupelled at a very high temperature, with the addition of large quantities of lead. The button thus obtained is afterwards to be treated by nitric acid in the usual way, when the presence of so large a proportion of silver determines the solution of the platinum, whilst the gold remains untouched in the bottom of the flask, and is collected and weighed as already described.

For commercial purposes the quantity of gold contained in any given mineral is estimated in ozs., dwts., and grains, one ton of ore being taken in all cases as the standard of unity.

TABLE showing the QUANTITY OF GOLD to the TON OF ORE, corresponding to the WEIGHTS IN GRAINS obtained from 400 Grains of Mineral.

If 400 grains of Ore give Fine Gold.	One ton of Ore will yield	If 400 grains of Ore give Fine Gold.	One ton of Ore will yield
grs.	oz. dwts. grs.	grs.	oz. dwts. grs.
·001	0 1 15	·200	16 6 16
·002	0 3 6	·300	24 10 0
·003	0 4 21	·400	32 13 8
·004	0 6 12	·500	40 16 16
·005	0 8 4	·600	49 0 0
·006	0 9 19	·700	57 3 8
·007	0 11 10	·800	65 6 16
·008	0 13 1	·900	73 10 0
·009	0 14 16	1·000	81 13 8
·010	0 16 8	2·000	163 6 16
·020	1 12 16	3·000	245 0 0
·030	2 9 0	4·000	326 13 8
·040	3 5 8	5·000	408 6 16
·050	4 1 16	6·000	490 0 0
·060	4 18 0	7·000	570 13 8
·070	5 14 8	8·000	653 6 16
·080	6 10 16	9·000	735 0 0
·090	7 7 0	10·000	816 13 8
·100	8 3 8	20·000	1633 6 16

Gold is seldom found in nature in a pure state, and for the purposes of the arts is alloyed with a small quantity of either silver or copper, by which its hardness as well as its fusibility are considerably increased.

In this country the standard of the alloys of gold is calculated in fractions of unity expressed in carats. Unity is supposed to be divided into

24 carats, whilst the carat itself is subdivided into 32 thirty-secondths; so that unity may be considered as made up of 768 thirty-secondths of a carat. In this way the gold coinage of the United Kingdom is said to have a standard of 22 carats; or, in other words, a sovereign consists of an alloy in which, in every 24 parts, there are 22 parts of fine gold, and 2 parts of alloy. It is for this reason that, for the assay of bullion, 12 grains of the substance are conveniently operated on, since every half grain of fine gold found by experiment will evidently correspond to one carat in the composition of the alloy. The various subdivisions of the carat are represented by fractions of a grain, and the true standard is thus strictly and readily determined. It is needless to remark, that in all the foregoing operations the greatest accuracy is required, both in making the various weighings, and also in the fusion and separation of the buttons. It is likewise advisable, in all cases, to make at least two separate experiments on every sample examined; and if these should not agree to within two or three-thousandths of a grain, other assays must be made until the desired approximation has been obtained.

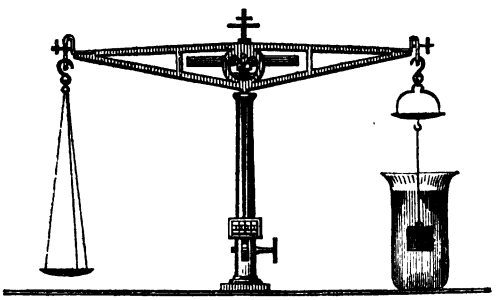
Specific Gravity.—The specific gravity of gold having been mentioned in a former chapter as a means of distinguishing that metal from other substances of nearly the same colour, it is neces-

sary that the meaning of the term specific gravity should now be explained, as also the methods by which the specific gravities of bodies may be conveniently ascertained.

By the specific gravity or *density* of a substance is understood its weight as compared with that of an equal bulk of some other body taken as a standard of calculation. In the case of solids and liquids, distilled water, at the temperature of 60° Fahr., is taken as this point of comparison; but the densities of the gases are usually estimated in relation with common air taken as unity.

In order to determine the specific gravity of a body, it is necessary to ascertain its weight when weighed in air, and also to learn how much it loses in weight by immersion in water. If we call its weight in air W, and its weight when suspended in water w, it is evident that $W-w$ will represent the weight of an equal volume of that liquid, as whenever a solid is placed in a liquid that covers the top of it, it must necessarily displace precisely its own bulk of the medium in which it is situated. The specific gravity of a body being, then, its weight in comparison with an equal bulk of some other substance taken as unity, it will readily be obtained from the above data, and is nothing more than the relation existing between W and $W-w$, which will consequently be represented by $\frac{W}{W-w}$.

The most common method of taking specific gravities, when large pieces of the substance to be operated on can be readily procured, is by means of what is called the hydrostatic balance. This consists of an ordinary balance (fig. 22), of which the pans are suspended by strings of



22.

unequal length. In order to obtain a density by this instrument, the substance to be operated on should be suspended by a hair or filament of silk to the shorter pan, which has a hook attached to its under side for that purpose. Weights should now be added in the other pan until the equilibrium is restored; and when this takes place the weight W will be noted as that of the substance in air. To obtain the corresponding weight of an equal bulk of water at the temperature of 60° Fahr., a vessel of that liquid is now placed under the shorter pan in such a way that the suspended fragment of

which we desire to know the density may be completely immersed in it, and weights are to be removed from the other pan until the equilibrium be again restored. The second weight thus obtained w, deducted from W, ascertained by weighing the substance in air, gives the weight $W-w$ of an equal volume of water, and the required specific gravity $\frac{W}{W-w}$ is at once obtained by dividing the weight in air by this difference. When it is required to conduct these operations with great accuracy, it is necessary to employ a very delicate balance, and to remove any air-bubbles that may attach themselves to the substance when placed in water, by means of a camel's hair brush. The temperature of the water in such cases should also be constantly kept at 60°, and any deviation of the barometer from 30 inches should be duly allowed for. In cases where but small fragments of a substance can be obtained, the instrument called the specific gravity bottle is most conveniently employed. This is nothing more than a common bottle of which the stopper, nicely fitted by grinding, is traversed by a capillary tube, and so arranged that it cannot sink beyond a line marked upon the neck of the phial. By this means it is easy to obtain a constant weight of water in the instrument, since, if it be filled beyond the line and the stopper afterwards forced into it, the

residual liquid will escape through the capillary tube, and the bottle remain exactly full. In order to take a specific gravity by the aid of this phial, it should first be weighed when full of water; a counterpoise equivalent to the weight of the bottle being placed in the opposite scale-pan. The substance to be examined must then be weighed in air, and afterwards dropped into the phial, care being taken to avoid the loss of the most minute particle. The stopper is now replaced, so that the bottle may again remain exactly full, and the whole is reweighed. The difference between the weight of the bottle of water, W, added to the weight of the substance in air, W' or W + W; and that of the weight of the bottle of water, *w*, when containing the fragment to be examined, is evidently W + W − *w*, and the specific gravity sought will, consequently, be expressed by $\frac{W+W'}{W+W'-w}$.

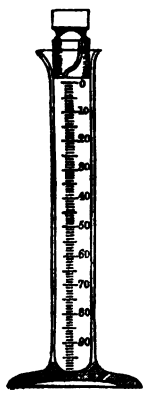
The following example may probably render the above explanations more readily understood. I find that the bottle full of distilled water weighs 995·74 grains = W.

Another substance, which is supposed to be gold dust, weighs in air 105·30 grains = W'. The bottle, with the supposed gold dust and water together, weighs 1095·52 = *w*. The united weights of the substance and bottle of water together being 1101·04 grains = W + W', the weight

of the equivalent volume of water displaced will be $1101{\cdot}04 - 1095{\cdot}52 = 5{\cdot}52 = W + W' - w$. It consequently follows that the specific gravity of the substance is—

$$\frac{105{\cdot}30}{5{\cdot}52} = 19{\cdot}07 = \frac{W + W'}{W + W' - w}$$

The above result shows, then, that the substance examined was really gold dust, and but little mixed with any kind of alloy.



23.

Instead of operating as above described, the density of any finely divided body, such as gold dust, may be readily and accurately determined by the following process: — The substance is first weighed in air, and then placed in a specific gravity bottle of known capacity, and the bottle carefully filled from a graduated pourette (fig. 23), up to the point marked on its neck.

On consulting the pourette, every division of which may represent one grain of distilled water, it is at once seen how many grains of water have been required to fill the bottle, when containing the known weight of gold, up to the mark on its neck. On deducting this from the ascertained

capacity of the bottle, the weight of the displaced water is at once seen. The weight of the substance in air is now to be divided by this result, and the specific gravity of the body examined is at once obtained.

The advantages of this method under circumstances in which distilled water cannot be obtained is very obvious, as not only will any liquid not acting on the substance under examination answer for the experiment, but the results found are also perfectly independent of both temperature and pressure.

From the known speeific gravity of gold, as well as that of the quartz rock with which it is commonly associated, it becomes easy, after determining the density of the mixture, to ascertain by calculation the relative amount of each present in any particular specimen.

To find the Proportion of Gold in a Mixture of Gold and Quartz.

The specific gravity of the gold = 19·000
The specific gravity of the quartz = 2·600

These numbers can be corrected when experiment shows the specific gravities to be different.

A. Ascertain the specific gravity of the mixture of gold and quartz. Suppose it to be 8·067.

B. Deduct the specific gravity of the mixture from the specific gravity of the gold: the difference is the ratio of the quartz by volume:—

$$19{\cdot}000 - 8{\cdot}067 = 10{\cdot}933.$$

C. Deduct the specific gravity of the quartz from the specific gravity of the mixture: the difference is the ratio of the gold by volume:—

$$8{\cdot}067 - 2{\cdot}600 = 5{\cdot}467.$$

D. Add these ratios together, and proceed by the rule of proportion. The product is the per-centage of gold by bulk:—

$$10{\cdot}933 + 5{\cdot}467 = 16{\cdot}400.$$

16·4 is to 5·467 as 100 is to 33·35.

E. Multiply the per-centage of gold by bulk, by its specific gravity. The product is the ratio of the gold in the mixture, by weight:—

$$33{\cdot}35 \times 19{\cdot}00 = 633{\cdot}65.$$

F. Multiply the per-centage of quartz by bulk, by its specific gravity. The product is the ratio of the quartz in the mixture by weight:—

$$66{\cdot}65 \times 2{\cdot}60 = 173{\cdot}29.$$

G. To find the per-centage add these ratios together, and proceed by the rule of proportion:—

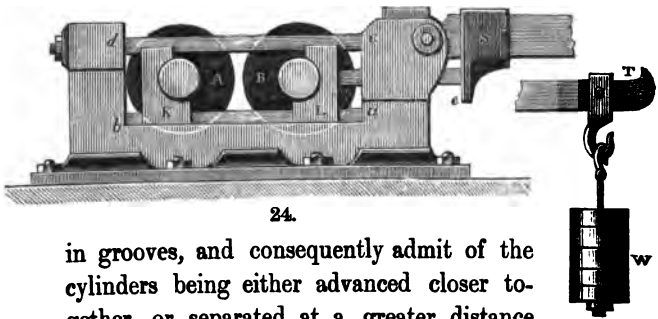
$$633{\cdot}65 + 173{\cdot}29 = 806{\cdot}94.$$

806·94 is to 633·65 as 100 is to 78·53.

Hence, a mixture of quartz and gold, having the specific gravity of 8·067, contains 78·53 per cent. of gold by weight.

MECHANICAL PREPARATION OF GOLD ORES.

Crushing.—Although the amount of gold annually obtained by crushing auriferous quartz is small in comparison with that procured by the direct washing of various alluvial deposits, it is nevertheless necessary that the more common appliances by which the process is effected should be here described. These operations, however, are usually conducted by regularly established mining companies, and very rarely on the responsibility of an individual emigrant. The arrangements employed for the grinding and pounding of mineral ores are extremely varied, although in every instance the principles involved are very nearly the same. In order to reduce the fragments of ore, as obtained from the mine, to the proper size for their subsequent mechanical concentration, large cylinders of cast iron, moving in contrary directions, are frequently used. In this machine (fig. 24), A B are the crushing rollers set in motion by steam or water power; *a*, *b*, *c*, *d*, represent a strong framing of cast iron firmly secured to a strong wooden frame-work by means of screw bolts. The bearings K, L, of the rollers are so arranged as to slide



24.

in grooves, and consequently admit of the cylinders being either advanced closer together, or separated at a greater distance from each other. To prevent accidents from the passage of large pieces of stone too hard to be broken, a certain elasticity is given to the apparatus by means of the lever S, T, which by a sliding bar and the shoulder *e* constantly tends to keep the surfaces of the two grinding cylinders in contact, since its other extremity is loaded with a heavy weight, W, so adjusted as to suit the hardness of the mineral to be broken. On passing between the roller, the crushed ores fall into the higher extremity of an inclined cylinder of coarse wire gauze. This being set in motion by the same power as the rollers themselves, divides the pulverized ore into two classes: the ore passing through the meshes of the trellis falls on the floor of the building, whilst the other portion, which is too large to pass through the apertures, is carried out at the lower end of the cylinder, where it falls into the buckets of an

endless chain, by which it is again brought to the level of the mill for the purpose of being re-crushed.

Stamping.—When the minerals operated on require to be be reduced to a finer state of division than can be readily effected by means of the cylinders above described, they are usually pounded into small fragments by large pestles moved either by steam or water power. In this arrangement, which is called a stamping-mill, vertical wooden beams are so attached to large masses of cast iron, that when raised by cams placed around a moveable axle, and corresponding with tongues attached to the lifters themselves, they fall on the ore placed beneath them, and thus by repeated blows reduce it to a fine powder. The cams on the axle are so arranged in a spiral that each lifter shall give three blows during each revolution, and as soon as the first lifter in the series has been released from the cam, and begins to fall, the second cam on the spiral comes in contact with the tongue of the next lifter, and so on until each has in succession struck a blow, when the first lifter is again caught by the first cam belonging to the second system on the axle, when another series of blows is dealt by the moveable pestles. The lower portion of this arrangement, where the iron heads come in contact with the mineral to be broken, is enclosed in a large wooden trough, in which are

openings filled with fine gratings, made by punching small holes in thin sheets of soft iron. By means of a spout, a stream of water is made to flow constantly into this trough, and therefore, whenever fragments are reduced sufficiently to enable them to pass through the apertures of the grating, they are carried off by the water into a series of reservoirs prepared for their reception, and in which they are by subsidence deposited in a more or less finely divided state.

The size of these stamp heads or pestles varies in accordance with the nature of the mineral to be broken, but their general weight is from 300 to 400 pounds. In order to attach the iron heads to the wooden lifters, the former are provided with wrought iron shanks, which after being let into the ends of the beams, are kept in their places by shrinking on two stout iron collars.

In some of the more modern stamping-mills both the axles and lifters are of iron, and in this case the upper ends of the lifters are kept in their places by iron collars, whilst the lower are fixed by keys into a square hole left in the head for that purpose.

A great improvement on the old method of raising the lifters by means of cams in the way above described, has recently been made by Mr. Walker, of the City Road, who, by the use of two series of carriers and endless chains, is, without

any increase in the power required to work the machine, enabled to increase the height of their fall to any required extent. In this arrangement (see vignette) the tongues on each lifter are caught by projecting links on the endless chains, A, once during every revolution of the handle, and then raised to the height of the second carriers, B, a little above the centre of which they are released, allowing the lifter and its attached iron head to fall heavily on the mineral placed beneath. The projections on the links being in this way so arranged that each of the lifters may in rotation be raised and successively let fall, as in the case of the cam motion before described, it follows that a rapid succession of blows is struck, a second lifter being slightly raised from its bed at the moment the first is released, with its whole weight on the mineral placed below.

The box in which the pestles are worked, as in the case of the older stamping-mills, is provided with fine gratings through which the pulverized ore is carried by a current of water, which is admitted through the trough. This is then conducted over an inclined table set in motion by the chain, D, and here the richer and heavier portions accumulate, whilst the lighter are washed away. This machine, which consists of four lifters, each weighing about one hundred pounds, requires the strength of two men to work

it, and constitutes an effective and very portable apparatus for the mechanical reduction of mineral ores, particularly if associated with a water-wheel or small steam-engine.

Grinding.—When it is required to reduce the minerals operated on to a still greater degree of fineness, various kinds of mills and edge-stones are employed. In Mexico, where large quantities of silver are annually obtained by amalgamation, the sands obtained from the *morteros,* or stamping-mills, are afterwards ground with water in *arrastras,* or grinding-mills, until reduced to the state of a most impalpable powder. These mills consist of a circular bed-stone of hard granite surrounded by a wooden tub, in the centre of which is supported a vertical shaft, which carries the mullers by which the grinding is effected, and kept in its place at its upper extremity by a horizontal beam, to which the upper pivot is attached. This vertical axis is traversed by two horizontal arms by which the granite mullers are supported; and to the extremity of one of these, which is left longer for that purpose, are attached the two mules by which, when water-power is not to be obtained, the machine is set in motion.

In place of this machine, a mill of a very primitive construction is frequently employed. To construct this apparatus, a situation is chosen where a small stream of water can be procured, and a fall of

some eight or ten feet be obtained: here a circular well is constructed of the whole depth of the fall of water, and of from five to six feet in diameter. In its centre is supported a perpendicular wooden shaft, turning at its lower extremity on a bearing let into a large block of stone, and secured at the other end by a circular wooden collar. This shaft, at a short distance above its lower bearing, passes through the centre of a rudely-constructed wooden wheel, around the circumference of which are arranged several spoon-shaped float-boards, making altogether a wheel of about five feet in diameter. These are arranged around the axle in a somewhat oblique direction, and are set in motion by the stream of water falling with considerable impetus against them. The upright axis passing through the centre of the well is continued about six feet above its surface, and at about half this height is inserted a horizontal arm, which serves as a spindle for a large granite edge-stone, which is made to revolve in an annular trough formed either of the same material or of extremely hard wood. The stamped ore which is placed in this trough is here gradually bruised down by the weight of the heavy stone rolling on its edge continually over it, and is either taken out and sifted in the dry state, or ground into an impalpable paste with a certain quantity of water.

In the latter case, the circular trough in which

the stone revolves is provided with a small aperture a little below its edge, and from this the finer particles of ore are carried off in suspension by a current of water constantly flowing through the apparatus. The fine particles of ore thus removed are conducted through a series of pits, where they are allowed to settle, and from which they are subsequently withdrawn for the purpose of amalgamation.

WASHING OF GOLD ORES.

Before describing the various methods by which this is effected, it will be necessary to explain the principles on which all such operations are based. If we let fall into a liquid in a state of repose bodies of various forms, sizes, and densities, it is evident that the amount of resistance which they experience in their fall will be very unequal, and, consequently, that they will not arrive at the bottom of the liquid at the same time. This, then, produces a classification of the fragments, which becomes very evident on examining the order in which they are deposited.

In the first instance, let us suppose that the fragments have the same form and dimensions, and that they differ from each other in their densities only: since the resistance that a body will experience in moving through a liquid medium depends entirely on its form and the extent of its surfaces, and is in no way affected by its specific gravity, it follows that all substances will lose, under similar circumstances, an equal amount of their moving force.

This loss is more sensible, however, in those substances which possess this power of movement in a

less degree; or, in other words, it will be proportionably greater in light bodies than in those having a more considerable density. The former, for this reason, fall through the liquid with less rapidity than the denser fragments, and must consequently arrive last at the bottom; so that the deposit will be composed of different strata, arranged in direct relation to their various densities, the heavier being at the bottom, and the lighter at the top of the series.

If, on the contrary, we suppose that all the bodies that fall through the fluid possess similar forms and equal specific gravities, and that they only differ from each other in point of volume, it is evident that their rapidity of motion will be in proportion to their size, and the larger fragments will be deposited at the bottom of the vessel.

Since, at starting, we have supposed them to have the same form and density, it follows that the resistance which they experience in their descent through the water will be in proportion to the surface exposed; and as the volumes of bodies vary according to the cubes of their corresponding dimensions, whilst the surfaces vary only as the squares of the same measurements, it follows that the force of movement animating them is regulated by their cubes v^3, whilst their resistance is in proportion to their squares v^2; thus showing that the size of the fragments augments their

descending force with much greater rapidity than the resistance offered by their surfaces.

If, in the last place, it be imagined that the fragments have all the same volume and density, but are of various forms, it follows that those which possess the largest amount of surface will arrive last at the bottom, and consequently the upper part of the deposit will consist of the thinnest fragments.

It is, then, evidently of the greatest importance that the grains of ore which are to be concentrated by washing should be as nearly as possible of the same size, as otherwise the smaller surface of one fragment, in proportion to its weight, will in a measure compensate for the density of another grain, and thus cause it to assume a position in the series to which, by its constitution, it is not entitled.

This difficulty is found to constantly occur in practice; and, in order to obviate it as much as possible, care is taken to separate, by means of sieves, into distinct parcels, the fragments which have nearly the same size. Although, however, the grains of ore may in this way be to a certain extent classified in accordance with their respective dimensions, it is evidently impossible, by any mechanical contrivance, to regulate their forms, which must in a great degree depend on the natural cleavage of the minerals operated on, and there-

fore this circumstance must always, to some extent, affect the result obtained.

From what has been said it is evident that each of the broken fragments of ore must belong to one of the three following classes :—The first consists of those particles which are composed of the substance sought without any mixture of matrix or earthy matter. The second will comprehend all the fragments which are made up of a mixture of ore and earthy matters; whilst the third division will be composed of earthy gangue, without any admixture of ore. By a perfectly successful washing, these three classes would be entirely separated from each other, but in practice this state of perfection is of course seldom attained. The same principles which regulate the fall of solid bodies through a liquid medium in a state of rest, are equally applicable to their removal by the action of a stream of running water; and on these facts are based all the various contrivances applied to the mechanical concentration of mineral ores.

From the great difference of density existing between the particles of gold and the siliceous and ferruginous gravel with which it is commonly associated, its separation from these bodies becomes an extremely simple operation. The methods practically employed for the purpose of effecting this object vary both with the localities in which the operation is carried on, and also in accordance

with the nature and composition of the matrix with which the gold is associated. In some parts of South America, where hand-washing is extensively practised, the instrument employed is a round iron or zinc pan, from which the lighter and stony

25.

matters are carried off by suspension in water: the residuum thus obtained contains the greater part of the gold present in the soil, which is subsequently separated by amalgamation or otherwise. In Hungary, in place of the pans above described, the washing of auriferous sands is conducted on inclined tables traversed by a number of transverse grooves. The inclination of these tables varies in accordance with the nature of the mineral treated. The sand to be washed is placed in the first groove of the series, and there exposed to a current of water until the gold, together with a small portion of ferruginous sand, alone remains in the furrows. The matrix is now removed into flat wooden basins, where the impurities are gradually separated by repeated washings.

In Brazil the method of proceeding anciently

employed was to open a square pit in the soil until the cascalho or auriferous stratum was attained. This was then broken up and placed in slightly inclined wooden vessels narrower at the bottom than at the top. These cases were exposed to the action of a stream of running water, and briskly shaken from side to side until the whole of the earth had been washed away, and the metallic particles alone remained. All these workings were situated either in the dried-up beds of rivers, or on the table-lands over which a stream of water had at some period flowed. At the present time, instead of opening the ground by manual labour, and afterwards carrying the auriferous gravel to the nearest stream for the purpose of being washed, the water is conducted directly to the mining ground; and by thus washing away the mould, and exposing, without the trouble and expense of transport, the cascalho to the action of a stream of water, great economy of labour is evidently effected.

From the simplicity of the operations required, river mining, or rather washing, is the most easily and cheaply carried on; and consequently by far the greater proportion of the streams known to be auriferous have been wrought in some part of their courses. When gold is found in veins it is not often laid bare by subterraneous excavations, but is more frequently explored by means of open cuttings made by clearing away the soil from the

surface. The washings of this kind in the vicinity of St. John del Rey were formerly very rich, but have of late years much diminished in importance. The principal digging in this locality is now situated on the eastern side of the hill, in immediate proximity to the town, and consists of an open area, of which three sides have been excavated in the rock, whilst the fourth, which fronts the west, is left open. The rock here consists either of sandstone or indurated clay, more or less mixed with mica, and is wrought by the aid of numerous streams of water divided into small rivulets, and conducted down its sloping sides. In working the mine, the loosened soil is thrown into these channels, and kept in suspension by constant agitation with shovels until it reaches a pit sunk at the bottom of the excavation, and in which the auriferous, and consequently the heavier, particles are deposited. This well is occasionally emptied, and its contents subjected to a second series of washings, by which the particles of gold are finally obtained in a state of greater or less purity. By this way of mining, large masses of gold (called *caldeiros*) are occasionally met with; but in most instances the chief supply of the precious metal is obtained by the repeated washings of the sands collected in reservoirs situated at the bottom of the excavation.

In the district of Lower Parahybuna, large

quantities of auriferous sand are annually dredged from the bottom of the rivers by windlasses and iron scoops. The sands thus obtained are received in canoes, to each of which is allotted a gang of four blacks, three of whom superintend the working of the boat and the management of the dredge, whilst the fourth stands on a platform ready to receive the sand brought up by the iron scoop. These boats seldom collect above three-quarters of an ounce of gold each, in the course of a day's work, although the quantity of sand obtained is extremely large.

In the neighbourhood of Villa Rica, once remarkable for its richness in this metal, various methods of extraction are still adopted, since not only the auriferous sands are subjected to a careful washing, but numerous drifts and levels have been extended into the softer parts of the mountains. Both these excavations and the river washings are entirely conducted by negroes. When at work, these gold-washers are each dressed in a leathern jacket, and furnished with a large wooden bowl about two feet in diameter, and nearly one foot in depth; before them is also tied a leathern bag, for the reception of the particles of gold dust which they may collect. The localities generally chosen for these washings are those parts of a river in which the water does not flow with too great rapidity, and where it forms deep holes, and makes numerous

bends. The large stones and upper layers of sand are first removed, and the bowl is then filled with the deeper and older gravel of the river, which is shaken and washed, and the stones and sand on the top scraped off, until the grains of gold, together with a little ferruginous sand, alone remain at the bottom of the vessel. This residue is now moistened by a little water thrown on by the hand, and washed into the leathern bag before mentioned. Instead of operating in this way, the final washing of auriferous sands is often conducted in long shallow troughs, the bottoms of which are sometimes covered with skins tanned with the hair on, and placed with the grain against the current of water flowing over the tables. In place of employing skins for this purpose, coarse baize is sometimes used; but in either case the moveable lining is at short intervals removed from the case, and beaten over a tank containing about two feet of water: it is afterwards carefully washed in the same vessel until the last traces of the gold are removed, after which it is again replaced in the trough. In order to obviate the inconvenience of having to so frequently remove the baize cloths or skins from the bottoms of the washing vessels, an endless web, either of skin or coarse cloth, has of late years been employed with considerable advantage. When this arrangement is used, it is made to move by means of rollers set in motion by the water

wheel, used for the purpose of stamping the ore, in a direction opposite to that of the stream of water flowing on the table. Between the two rollers on the upper side, this web is supported on a wooden table; but when it has turned over the upper roller, it falls down loosely, and is drawn through the vessel of water, where the gold is washed off and accumulates.

To prevent theft, the tanks in which the gold is deposited are carefully locked up during the night; and when they have become full, their contents are carefully washed (often in hand-bowls,) until nothing but the gold, mixed with a greater or less amount of ferruginous sand, remains.

This residue, whilst in a damp state, is now intimately mixed with a small quantity of metallic mercury, which combines with the particles of gold, and leaves the oxide of iron free. The semi-fluid amalgam, which is readily separated from the oxide of iron and other impurities which float on the top, and are scraped off, is now carefully folded in a closely-wove cloth, and wrung until about two-thirds the quicksilver originally added has been separated in a free state. What remains is generally placed in a metallic dish, covered by another provided with a spout, for the collection of the sublimed mercury. In this way a considerable quantity of mercury is obtained; and the gold, in the form of a dirty-looking brown mass, still

retaining a certain proportion of mercury, remains in the bottom of the dish.

In the Ural districts, from whence, notwithstanding the extreme poverty of the auriferous sands there found, the chief annual supply of gold has to within a very recent period been obtained, the methods of washing employed are very various. In some cases the auriferous sands are thrown into boxes, of which the bottoms are composed of thin sheet iron, pierced with numerous small holes; these are placed immediately under a considerable fall of water, and the mineral kept constantly agitated by workmen, who keep it stirred with shovels. By this treatment the finer particles are carried through the apertures in the bottoms of the boxes, and fall on a series of sloping tables, on which the workmen constantly brush the ore from the foot to the head of the arrangement with a small heath broom, and there the particles of gold and other heavy substances accumulate. The sand, after having been thus concentrated and separated from the lighter matters, is further enriched by a second washing on a series of tables of smaller dimensions. The titaniferous iron, together with the magnetic oxide of iron, which is invariably present, is now partially separated by the aid of a powerful magnetic bar, and the residue subsequently fused in a graphite crucible, with a mixture of carbonate of soda and nitre, to which borax is sometimes added.

From its greater density, the gold collects at the bottom, whilst its surface is covered by a more or less liquid slag, which retains numerous globules of metallic gold. This scoria is afterwards stamped and washed, and the rich slimes thus obtained are subsequently fused in a cupola furnace, together with lead ores; the auriferous lead thus obtained is ultimately treated by cupellation. Instead of washing the auriferous sands by means of wooden vessels with perforated iron bottoms, many of the workings for gold in the Ural mountains are conducted by the aid of the washing cylinder represented in the frontispiece. This machine consists of a cylinder of sheet iron A, pierced with holes of about half an inch in diameter, and strengthened on the inside by a strong iron trellis. The cone, which may be about 8 feet in length, and has a mean diameter of about 3 feet 6 inches, is larger at one extremity than at the other, and is fixed on a spindle capable of being set in rapid motion by means of a train of wheels, worked by the horse gin B, securely fastened to the ground by strong oak or other sleepers. The auriferous sands to be treated are brought in waggons running on iron rails to the hopper C, from whence they fall into the moveable cylinder through the aperture formed by its smaller circumference. At the back of the arrangement is a double pump D, set in motion by a crank on the shaft, which communicates

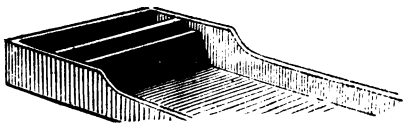
motion from the gin B to the cylinder A. This pump raises water from a well or some other convenient source, to the cistern E, from which it is conducted by means of four iron pipes into the cylinder A; these pipes enter the cavity of the drum through the two open ends, and are so arranged with regard to length as to afford a nearly equal supply of water throughout its whole capacity. When set in motion, the perforated cylinder makes from thirty to thirty-five revolutions in a minute, and consequently throws, by its centrifugal action, the water and finer particles of sand and gravel through the numerous perforations which it contains; whilst the pebbles and other fragments, which are of too large a size to pass through the holes, are carried off through the larger end of the cylinder, and there fall into a box not shown in the drawing. This receptacle will contain any nuggets which may have been present in the sands; and as, by passing through the cylinder, they will have been washed perfectly clean, they may now be readily seen and picked out. The sand and water, after having escaped through the apertures in the drum, fall on the inclined platform F, which is provided with numerous horizontal bars, for the purpose of separating the heavier from the lighter portions of ore. From this platform the current flows on to the concave table H, also provided with checks, in the form of wooden bars, nailed across

it at distances of about 3 feet from each other. The sands which have arrived at this part of the table are now kept constantly agitated by the wooden pendulums I. I′, provided at their lower extremities with frames made to suit the concavity of the table, and fitted with flattened teeth, like those used in some kinds of farming implements. These pendulums are made to swing by means of the rods K, driven by the crank G, and are so arranged as to move constantly in opposite directions. In this way the operation is continued, until a considerable accumulation of rich auriferous sand has taken place at the upper part of the tables, where, being retained by the horizontal slips of wood, it remains; whilst the lighter matters are carried off by the current of water to the lower end of the table H, from whence they are either made to pass over a fresh series of tables, or if, as is usually the case, they are found to be sufficiently impoverished, they are allowed to run entirely away.

When a sufficient accumulation of rich auriferous sand, called grey schlich, has taken place behind the various check-boards nailed across the tables, it is carefully collected for the purpose of further concentration on small inclined tables. These consist of wooden troughs, figs. 26, 27, of about 9 feet in length, and 3 feet 6 inches in breadth, provided with a head board, as shown in the sketch, fig. 26, and in which a constant and very equal flow of water

is obtained, by the use of the boards *a b*. The schlich to be washed has to be placed at *b*, and an equal and

26.



27.

very light (gentle) current of water allowed to flow over its surface, whilst it is being constantly moved by a small wooden rake, or heath broom, towards the head of the arrangement. By skilful treatment in these tables, or fine washing as it is called, the gold may be almost entirely separated from the associated sterile matters, and may then be treated either by amalgamation or direct fusion. The cylindrical machine above described is, when driven by three bullocks, or two good horses, capable of passing 120 tons of alluvial sand in the course of an ordinary working-day of ten hours. The sand is thus concentrated to about two tons, which are washed, as before described, on small inclined tables. With a small machine of this description, one man may, without aid, readily wash at least ten tons of sand and gravel per day. Nothing need be said of the efficiency and economy of these machines, when it is stated that the sands of the

Ural rarely contain above eighty grains of gold to the ton of mineral, and are nevertheless advantageously treated by this and various similar, though slightly modified arrangements.

The gold-mining associations hitherto carried on in Australia have for the most part been conducted on a very rude scale, but many extensive and well-appointed establishments have already commenced their operations in different localities. The vessels at first made use of, for the purposes of washing, were tin pans, although a rude machine, called a cradle, was also very extensively used. This consists of a wooden trough, six or eight feet in length, across the bottom of which, two pieces of wood, serving as rockers, are nailed. At the head of the arrangement is placed a coarse grating on which the sand to be washed is charged; the bottom of the cradle is also provided with a few transverse pieces of wood, serving the same purpose as those in the large cylinder machine above described.

To work this apparatus four men are required; one breaks the ground and collects the auriferous sand, another carries it to the washing-place and deposits it on the grating, a third violently rocks the trough, by means of an upright handle nailed against the side, whilst the fourth attends to the supply of water and the regular washing of the ore. The coarser gravel and large stones are prevented from entering the trough by the grating at the top;

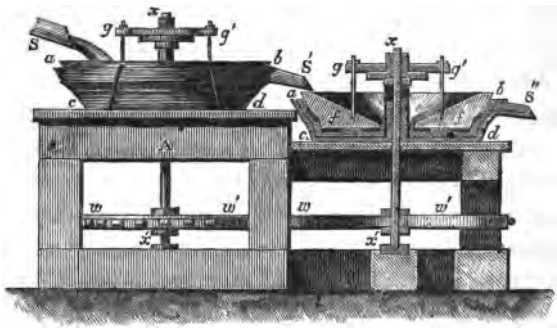
the earthy matters are washed off by the current of water escaping at the lower end, where there is an opening left for that purpose, whilst the gold, mixed with a small quantity of ferruginous sand, collects on the higher parts of the trough, which in its whole length has an inclination of three or four inches.

At the close of the operation, the gold, together with the ferruginous particles, is collected in a tin pan, and after having been dried in the sun, the lighter portions are removed by blowing strongly on the mixture.

When gold exists in veins which at the same time produce other metals—such as silver, lead, or copper—the ore is at once treated for those metals with which the gold combines and forms an alloy, and from which it may be afterwards separated by various metallurgic processes. If, in addition to gold, the mineral also contains lead, auriferous lead is obtained, which is subsequently treated by cupellation. When copper ore contains gold, either the black copper obtained by its metallurgic treatment is subjected to a process called *liquation*, or the matts produced by direct fusion are made to undergo a process of amalgamation. The separation of gold from silver is effected by the operation of parting.

Amalgamation of Gold Ores.—In the Tyrol, and in some other localities, where small quantities

of gold are extracted by amalgamation, from an auriferous iron pyrites, the operation is conducted in a kind of mill, of which fig. 28 is a representation.



28.

A number of these machines are so arranged, one above another, that the products escaping from the first may flow into the second, and so on throughout the whole length of the series. The pyrites to be treated is first reduced by stamping-mills to the state of fine powder, and whilst held in suspension in a stream of water is conducted into the upper mill by the spout *S*, and flowing through it, escapes by the spout *S′* into the second, from which it is subsequently conducted into others not shown in the woodcut.

The fixed part of these mills consists of a cast iron basin, *a, b, c, d,* fastened by screws to the top

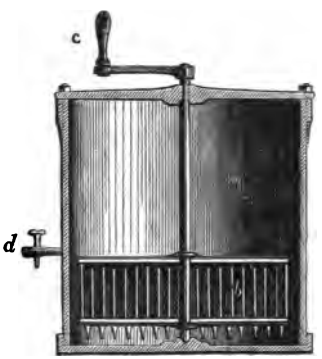
of a strong wooden table, A. The centre of this casting is furnished with a tubulature traversed by the rotating axis $x\,x'$, and set in motion by the toothed wheel $w\,w'$. The upper and moveable part of this arrangement, $f\,f'$, is composed of hard wood, and fixed to the upright spindle by the iron collar, $g\,g'$. This moveable part of the mill has externally the same form as the internal cavity of the fixed iron casting, from the surface of which it works at the distance of about half an inch; it is also furnished with several raised ribs nailed to its under side, and which come almost in contact with the bottom of the iron pan.

The upper surface of this wooden muller is hollowed out in the form of a funnel, into which is conducted the liquid slime, which quickly penetrates into the space remaining between the surfaces of the upper and lower parts, and then flows from the basin by a spout adapted for that purpose. On the bottom of the iron pan is placed about half a hundred weight of mercury, which forms a stratum of rather more than half an inch in thickness, and with which, when the machine is set in motion, the pounded mineral is constantly agitated by the projections nailed to the bottom of the revolving block of wood. The spangles of gold are thus instantly dissolved the moment they come in contact with the mercury, while those which escape combination in the first mill of the series are arrested by the

others through which the mineral has afterwards to pass.

After this apparatus has been at work during four or five consecutive weeks, the mercury is drawn off, and filtered through a piece of chamois skin, for the purpose of obtaining the solid amalgam. This usually contains about one-third of its weight of pure gold, which is obtained by a process of distillation by which the quicksilver is eliminated and the gold remains behind in the form of a metallic spongy mass.

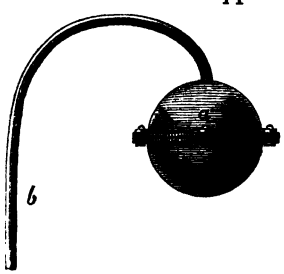
When the amalgamation of the enriched auriferous sand or "black schlich," as it is called, is to be performed by manual labour, the arrangement, fig. 29, may be conveniently employed for the purpose. This consists of a cylindrical vessel of sheet



29.

iron *a*, through the centre of which passes a spindle of the same metal carrying the perforated agitator *b*, which is readily turned by means of the handle *c*.

To make an amalgamation with this contrivance, a small quantity of mercury is first poured into it, and kept constantly agitated by the stirrer *b*, whilst the ore to be amalgamated is added in successive small portions. When the operation is supposed to be completed, the matters floating on the top of the bath are skimmed off; the liquid amalgam is strained through a leathern bag, by which the solid amalgam is separated from the mercury, which is squeezed through the pores of the skins. The mercury thus separated is set aside to be employed in other processes of amalgamation, whilst that which remains in the form of solid amalgam is separated by distillation at a high temperature in a cast iron vessel prepared for tha purpose. A convenient form of apparatus to be



30.

employed is that represented, fig. 30. It consists of a cast iron globe *a*, made in two parts, and capable of being joined together in the middle by a flange and screw nuts; into the upper hemisphere is tapped a curved piece of gas-pipe *b*, which serves to carry off the sublimed mercury to the condenser. When used, the two hemispheres of which the globe is composed are separated, and the compressed amalgam introduced; the two halves are now again closed, and heat is gradually applied, care being first taken to place a small vessel of water below the orifice of the tube *b*, into which its end is allowed to dip for a short distance. When this has been done the globe is heated either by a wood or coal fire: for this purpose it may be conveniently supported at a short distance from the ground on two or three refractory bricks. Attention must also be paid to prevent the end of the iron pipe from being allowed to dip too deeply into the water, as, if this were allowed, the liquid might, in case of the temperature of the ball being slightly lowered, rise into its cavity and cause an explosion. For this reason, then, the end of the pipe, *b*, should only just touch the surface of the water. At the close of the operation the mercury found at the bottom of the vessel of water is collected to be used for future amalgamations, and the impure gold remaining in the retort *a*, treated according to directions which

will be shortly given. The lighter substances skimmed from the surface of the amalgam previous to its introduction into the leathern bag are carefully assayed, and should they contain an appreciable amount of gold, they are first subjected to a series of washings, and then added to the auriferous ingredients employed in the next process of amalgamation.

The apparatus fig. 29, besides being available for the purposes of amalgamation, may also be employed as a washing vessel, and in this case forms a contrivance known by the name of a *dolly-tub*. When thus used it is nearly filled with water, and the agitator kept in constant motion by one man, whilst another throws into it, in small portions at a time, the auriferous sands which are to be subjected to its action. As soon as the whole of the ore has been thus introduced, the cross-bar through which the spindle works is withdrawn, and the agitator, *b*, rapidly removed. The particles held in suspension, on being thus allowed to follow the impulses of their respective densities, will arrange themselves on the bottom of the tub in accordance with their weights, and consequently, the gold, together with all the heavier particles, will sink to the bottom of the series, whilst the lighter fragments are deposited last. After the solid particles have completely subsided, the water is drawn off by the tap, *d*, and the upper

and lighter portions of the deposit scraped off and thrown away; the heavier portions, on the contrary, must be collected for the purpose of being further concentrated, either by a repetition of the same operation, or by being washed in a hand-bowl, or on an inclined table. This apparatus as a washing machine, is, however, less to be recommended than many others which have been described, but as it is applicable to the two purposes above referred to, as well as constituting a light and efficient water-tank, it is not without claims on the attention of the emigrant. In connection with the washing of auriferous ores a small portable hand-pump may often be conveniently employed, as it not only affords the means of readily removing any water from the workings themselves, but through its aid a supply may frequently be obtained by sinking a shallow well into the clay, on the surface of which the auriferous gravels are commonly found. One of the most convenient forms for a pump of this description, is that represented (fig. 31), in which the tube *a*, so slides in that marked *b*, as to form a telescope-joint, which is readily made tight by a small quantity of stiff clay, firmly pressed into the funnel-shaped end of the larger

31.

pipe. Such a pump will be found extremely convenient for the removal of the water which accumulates in the pits from which auriferous sands are extracted.

METALLURGY OF GOLD.

Fusion of Gold Dust.—The most simple metallurgical operation connected with the treatment of gold ore is the melting down into ingots of the gold dust obtained by the mechanical treatment of the various gold-bearing deposits. This may be readily effected in ordinary black-lead crucibles, which can be either treated in the furnace represented figs. 7 and 8, or in a round pot furnace, such as is used by brass-founders for the fusion of the various alloys of copper. Before the gold is introduced into the pot (which should be previously heated to redness) it must be mixed with a little dry borax, and as soon as the complete fusion of the mixture has taken place, the slag, which will be found floating on the surface, is thickened by the addition of a little lime or bone ash, and carefully skimmed off. The pot is now removed from the fire by the aid of powerful tongs, which grasp it firmly on the outside, and the metal rapidly poured into a cast iron mould previously warmed, and slightly greased on the inside. Instead of employing borax alone, a mixture of borax and corrosive sublimate is sometimes used: the advantages of the addition of this substance

are, however, extremely problematical, as its only effect on the results obtained would appear to be entirely due to the mechanical action communicated to the mixture by the volatilisation of the mercurial salt. When the gold dust operated on contains a considerable quantity of the more oxidisable metals, the addition of a small amount of nitre will be found advantageous. The slags skimmed off from the surface of the liquid metal, as well as the pots in which the fusions have been conducted, are subsequently ground down, and subjected to a careful mechanical preparation. The auriferous schlich thus obtained is afterwards fused with various substances yielding lead, and the resulting alloy treated by cupellation.

Smelting Gold Quartz.—From the great degree of infusibility exhibited by silica, of which sand and quartz are almost entirely composed, the process of smelting gold ores,—that is to say, of extracting from them the metal by direct fusion, instead of first effecting their concentration by mechanical means, has hitherto failed in its application.

A process has, however, been recently secured by patent, which is stated to be extremely successful in the separation of gold from the siliceous gangue with which it is commonly associated. The ores to be treated by this method are first reduced to the state of a fine powder, and then fused with a mixture of lime and oxide of iron with which

the silica combines, giving rise to the production of various fusible silicates or slags. Into the fused mass thus obtained, plates of wrought iron are from time to time introduced, and again withdrawn as soon as a thin deposit of metallic gold has taken place on their surfaces. As soon as these iron plates are removed from the fused ore they are plunged into a vessel of melted lead, by which the gold is dissolved off, and the iron plate is again placed in the furnace. It is stated, that by the continued repetition of these manipulations the whole of the gold is extracted from the ore, and that this is effected at a considerably less cost than is incurred by the usual processes of washing and amalgamation. Whether this process will really be found applicable to manufacturing purposes, experience alone can decide.

It was some years since proposed by a Russian gentleman called Anossow, to smelt the auriferous sands of the Ural mountains with iron, or iron ore, instead of subjecting them to the various processes of washing, by which they are at present treated. The auriferous cast iron thus obtained was dissolved in sulphuric acid, and the gold remained in the form of an insoluable residue in the bottom of the vessel in which the attack was made. This process, although stated by the inventor to be extremely economical, was never practically applied; and, in spite of the assertions made to the contrary,

its success, if attempted, would be extremely doubtful.

The usual method of smelting auriferous ores, when they are sufficiently rich to admit of being metallurgically treated, is to fuse them either with metallic lead, or with some compound capable of liberating that metal during the elaboration of the charge in the furnace. The materials most commonly employed as sources of lead in the smelting of gold ores, are litharge and galena, although the rich slags obtained both from the smelting furnace and ore-hearth are also occasionally used. In all these cases, the lead produced acts at elevated temperatures on the particles of gold in precisely the same way as the globules of mercury in the ordinary process of amalgamation. The auriferous lead, so prepared, is subsequently subjected to cupellation, and the gold is thus obtained either in a free state or in combination with a certain amount of silver, from which it may be separated by the operation of parting. When litharge is chosen as the medium for the introduction of lead into the furnace, it will be sufficient to add with it about five per cent. of small coal or coke-dust, in order to determine the reduction of the necessary quantity of lead; but when galena is employed, it is necessary to charge into the furnace a certain quantity of scrap iron, by the action of which the lead is set free.

The furnaces used for this purpose may be either of the reverberatory form, such as those employed in the English method of copper-smelting, or may resemble the ordinary slag-hearth, in which the lead is extracted from the slags of the smelting furnace and ore-hearth. The choice of the form of furnace to be used, as well as the nature of the fluxes to be employed, must not only depend on the nature of the mineral treated, but also on various local circumstances, with which the metallurgist must make himself acquainted. As a general rule, however, the fuel employed for the reverberatory furnace should be pit coal; and consequently, in situations where this is not to be readily procured, the blast-furnace and charcoal must be used. Those ores which contain large quantities of quartz (silica) are rendered more fusible by the addition of bases such as lime or oxide of iron; whilst ores in which oxide of iron and lime predominate, are rendered more easy of fusion by the judicious admixture of clay or siliceous sand. It may also be remarked, that, when the reverberatory furnace is not used, the addition of oxide of iron as a flux must be as much as possible avoided; since, in the blast furnace, a certain quantity of that oxide is invariably reduced, and unites with the other metals present.

Instead of employing lead as the means of concentrating the ores of gold, iron pyrites is some-

times the agent employed. This mineral, on being exposed to an elevated temperature, loses exactly one-half its sulphur, and becomes converted into a readily fusible sulphide, which has the property of uniting with the gold present, and separating it from the associated gangue. When, then, gold ores—such, for instance, as auriferous quartz—are fused in a small cupola furnace with iron pyrites, which may itself likewise contain gold, the sulphide of iron unites with the greater portion of the gold present, and forms a heavy regulus, or "matt," which subsides beneath the surface of the slags and scoriæ produced by the fusion of the earthy and siliceous gangue of the mineral treated. The matts thus obtained are subsequently roasted, so as to deprive them of a further portion of their sulphur, and again fused with fresh portions of the ore to be treated.

By operating repeatedly in this way, matts very rich in gold are ultimately obtained; and on fusing these with litharge, or a mixture of galena and metallic iron, the gold is abandoned to the liberated lead, from the top of which the impoverished sulphide is readily skimmed off. The rich lead thus obtained is afterwards treated by cupellation.

Cupellation on the large scale.—The extraction of the silver and gold contained in rich lead is conducted on a cupel forming the bottom of a peculiarly arranged reverberatory furnace. In this

operation, the litharge produced, instead of being absorbed by the substance of the cupel, as in the case of gold and silver assays, is run off in a fluid state. The fire-place of a cupelling or test furnace is usually about 2 feet in breadth, and 2 feet 6 inches in length. This is separated from the body of the furnace by a fire-bridge 18 inches in breadth, so as to allow the flame and heated air to pass directly over the surface of the cupel, from whence it escapes through separate flues into a high chimney. The cupel, or test, consists of an oval iron frame, surrounded by a ring 4 inches in depth; its greater diameter may be about 4 feet, and its lesser 2 feet 6 inches. This frame, in order to afford a better support for the bottom of the test, is provided with four or more cross bars, which are 4 inches in width, and half an inch in thickness: the first of these is placed 9 inches from the fore-part of the ring, and the others at about equal distances between this bar and the other extremity of the rim. This test-frame is now beaten full of finely-powdered bone-ash, slightly moistened with water, containing a small quantity of pearlash, which has the property of giving consistency to the bone-ash when heated. The centre of the cupel, when the ring has been well filled with this mixture, and solidly beaten down with iron rammers, is scooped out with a small trowel, until the sides are left 2 inches in thickness at top, and

3 inches at bottom; whilst the thickness of the sole itself is reduced to 1 inch above the surface of the iron cross-pieces.

At the fore-part of the test, called the breast, the width of the border is increased to 5 inches; and a space is here cut through the bottom, which communicates with the passage or gateway by which the fluid litharge makes its escape. The test, when thus prepared, is placed in the refinery furnace, of which it forms the bottom, and is firmly wedged at its proper height against an iron ring, built into the masonry of the furnace.

When this furnace is first lighted it is necessary to apply the heat with considerable caution, since if before the test had become sufficiently dry it were suddenly exposed to too high a temperature, it would be liable to split and fall to pieces. As soon as the test has in this way been raised to a cherry-red heat, it is nearly filled with the rich lead to be operated on, and which has been previously fused in a cast iron pot set in brickwork at the side of the furnace. The melted lead, when first laded into the test, becomes covered on the surface with a greyish dross; but, on further increasing the heat, the surface of the bath uncovers, and a film of ordinary oxide of lead, or litharge, begins to make its appearance.

The blowing apparatus, which furnishes the blast through a nozzle at the other extremity of the test,

is now set in motion, and forces the litharge from the back part of the cupel up to the breast, and over the gateway, from which it falls through the aperture in the test into a moveable iron pot placed on the floor for its reception. The current of air, which may be supplied either by a ventilator or bellows, not only sweeps off the litharge from the surface of the lead, but also furnishes the amount of oxygen necessary for its formation.

In proportion as the surface of the lead becomes depressed by its continual oxidation, and the constant removal of the litharge formed, more metal is added from the melting-pot so as to again raise it to its proper height; and in this way the operation is continued until six or eight tons of the original rich lead have thus been introduced into the cupel.

The contents of the test are now so far reduced in volume that the whole of the precious metals contained in the alloy operated on may remain in combination with only two or three hundred weight of lead, which is now removed from the test by making a hole through the bone-ash, of which the bottom is composed. When the lead has been thus removed, the tapping-hole is again closed by a pellet of moistened bone-ash, and another charge immediately introduced. As soon as a sufficient number of these parcels of rich lead have been obtained as are found by assay to yield from one

to two thousand ounces of the precious metals, they are again melted down and placed in a cupel, where the operation of refining is completed. The test used for this final cupellation differs from that in which the lead is first introduced, by being made more hollow at the bottom, so as to give a certain degree of thickness to the resulting plate of metal. When the operation is completed, the same brightening is observed which takes place at the close of experiments on smaller quantities; and if the gold present contains a considerable amount of silver, the surface of the mass, on cooling, sprouts forth into the most beautiful arborescent forms. The separation of the gold and silver obtained as above described is usually effected by means of nitric acid, although, on the Continent, sulphuric acid is largely employed for this purpose.

In addition to gold, many auriferous deposits, and particularly those of the Ural districts, afford a certain amount of platinum. This metal is invariably found in the native state, and presents the appearance of small flattened grains of a greyish-white colour. These are insoluble in all the simple acids, but are readily dissolved in aqua regia: on adding to the solution thus obtained a small quantity of chloride of potassium (muriate of potash), a copious yellow precipitate is obtained. This test, together with its high specific gravity (20·98), will be sufficient for the

recognition of this metal, which, when in a manufactured state, sells at about 30s. per oz.

Diamonds, which sometimes accompany the ores of gold and platinum, usually occur in the form of transparent octahedral crystals. These crystals resemble two four-sided pyramids joined together by their bases. The value of rough diamonds, unless of extraordinary dimensions, may be estimated at about £50 per oz.

APPARATUS AND REAGENTS REQUIRED BY THE GOLD ASSAYER.

APOTHECARIES' scales, with weights from 1 to 1000 grains. Assay balance, of good make, with weights from 1 grain to $\frac{1}{1000}$ of a grain. Forceps. Fire-clay crucibles, in sizes. Two hammers, weighing respectively 1lb. and 2lbs. Tongs, both curved and straight, for holding crucibles, cupels, &c. Cast iron ingot-mould. Assay furnace, with muffles. Scorifiers. Steel stirring and cleaning rod. Anvil. Copper scoop. Cutting pliers. Small shears. Scissors. Cold chisels, for cutting metal. Set of files. Small rolling mill. Iron mortar and pestle. Set of sieves (fine wire gauze.) Cupel mould. Bone-ash, for making cupels. Scratch brush. A few glass flasks. Some German glass parting flasks. Glass funnels. Stoppered bottles. A small pallet knife. Small porcelain crucibles. Spirit lamp. Poor lead for assaying, both granulated and in sheet. Litharge. Anhydrous carbonate of soda. Dry borax. Crude tartar. Nitre. Pure nitric acid. Hydrochloric acid.

The above, and all other necessaries for the assayer, may be obtained of Messrs. GRIFFIN & Co., 53, Baker Street, Portman Square.

GOVERNMENT REGULATIONS.

PROCLAMATION

By His Excellency Sir Charles Augustus FitzRoy, Knight Companion of the Royal Hanoverian Guelphic Order, Captain General and Governor-in-Chief of the Territory of New South Wales and its Dependencies, and Vice Admiral of the same, &c. &c. &c.

WHEREAS by Law all Mines of Gold and all Gold in its natural place of deposit within the Territory of New South Wales, whether on the Lands of the Queen or of any of Her Majesty's subjects, belong to the Crown: And whereas information has been received by the Government that Gold exists upon and in the soil of the County of Bathurst, and elsewhere within the said Territory, and that many persons have commenced, or are about to commence, searching and digging for the same, for their own use, without leave or other authority from Her Ma-

jesty: Now I, Sir Charles Augustus FitzRoy, the Governor aforesaid, on behalf of Her Majesty, do hereby publicly notify and declare that all persons who shall take from any Lands within the said Territory any Gold Metal, or Ore containing Gold, or who within any of the Waste Lands which have not yet been alienated by the Crown shall dig for and disturb the soil in search of such Gold Metal or Ore, without having been duly authorized in that behalf by Her Majesty's Colonial Government, will be prosecuted, both criminally and civilly, as the Law allows: And I further notify and declare, that such Regulations as, upon further information, may be found expedient, will be speedily prepared and published, setting forth the terms on which Licenses will be issued for this purpose, on the payment of a reasonable fee.

Given under my Hand and Seal, at Government House, Sydney, this Twenty-second day of May, in the Year of our Lord one thousand eight hundred and fifty-one, and in the fourteenth year of Her Majesty's Reign.

(L. S.) C. A. FITZROY.

By His Excellency's Command,

E. DEAS THOMSON.

GOD SAVE THE QUEEN.

Colonial Secretary's Office, Sydney,
May 23, 1851.

Gold Regulations.

Licenses to dig and search for Gold.

With reference to the Proclamation issued on the 22d May instant, declaring the rights of the Crown in respect to gold found in its natural place of deposit within the territory of New South Wales, his Excellency the Governor, with the advice of the Executive Council, has been pleased to establish the following Provisional Regulations, under which licenses may be obtained to dig, search for, and remove the same:—

1. From and after the first day of June next no person will be permitted to dig, search for, or remove gold on or from any land, whether public or private, without first taking out and paying for a license in the form annexed.

2. For the present, and pending further proof of the extent of the gold field, the license fee has been fixed at one pound ten shillings per month, to be paid in advance; but it is to be understood that the rate is subject to future adjustment, as circumstances may render expedient.

3. The licenses can be obtained on the spot from the Commissioner who has been appointed by his Excellency the Governor to carry these regulations

into effect, and who is authorised to receive the fee payable thereon.

4. No person will be eligible to obtain a license, or the renewal of a license, unless he shall produce a certificate of discharge from his last service, or prove to the satisfaction of the Commissioner that he is not a person improperly absent from hired service.

5. Rules adjusting the extent and position of land to be covered by each license, and for the prevention of confusion, and the interference of one licensee with another, will be the subject of early regulations.

6. With reference to lands alienated by the Crown in fee simple, the Commissioner will not be authorized for the present to issue licenses under these regulations to any person but the proprietors, or persons authorised by them in writing to apply for the same.

By his Excellency's command,

E. Deas Thomson.

Form referred to.

1851.

Gold License.

The bearer having paid to me the sum of one pound ten shillings on account of

the territorial revenue, I hereby license him to dig, search for, and remove gold on and from any such Crown land within the County of Bathurst as I shall assign to him for that purpose during the month of 185 .

This license must be produced whenever demanded by me or any other person acting under the authority of the Government.

(Signed) A.B.,
Commissioner.

Colonial Secretary's Office, Sydney,
August 5, 1851.

Additional Gold Regulations.

With reference to the proclamation of his Excellency the Governor-General, bearing date the 22d day of May last, and to the notice from this office of the 23d of the same month, his Excellency directs it to be notified that the licenses issued in accordance therewith to dig, search for, and remove gold found in its natural place of deposit, will, in future, be limited in their operations to alluvial gold, whether consisting of dust, grain, scale, or lump gold, and will not extend to matrix gold combined with quartz or any other rock remaining in its original bed or situation. Pending the esta-

blishment of regulations for the working of gold of this latter description, which will be speedily prepared and published, a royalty will be charged on the quantity obtained of 10 per cent. if found on Crown lands, and 5 per cent. if on private lands. These rates will be computed on the actual produce valued at £3. 4s. per oz. if procured by separation only, and £2. 8s. per oz. if by amalgamation.

2. Previously, however, to the working of any such matrix gold, notice must be given to, and a written permission obtained from, the Commissioner or Assistant Commissioner of the gold district, who will require such security, and make such arrangements for the protection of the public interests as he may deem necessary. If the parties concerned fail to give the required notice or security, or to observe the conditions prescribed by that officer, all such matrix gold, and also all alluvial gold of every kind, procured without due authority, will be seized as the property of the Crown, in whose possession soever it may be found; and the persons offending will render themselves liable to be prosecuted for the offence.

3. In conformity with the principle laid down in the provisional regulations of May last, above referred to, no person will be allowed to work matrix gold on private lands, except the proprietors thereof and such persons as they may authorise in

that behalf, but in other respects these regulations will be held to apply to all such private lands.

By his Excellency's command,

E. DEAS THOMSON.

Colonial Secretary's Office, Sydney,
August 12, 1851.

CONVEYANCE AND ESCORT OF GOLD.

HIS Excellency the Governor-General directs it to be notified, with reference to the notice of the 17th ultimo, that arrangements have been made for the conveyance of gold, under the charge of an armed escort, from Ophir and Sofala to Bathurst or Sydney, and from Bathurst to Sydney, once in each week.

2. The gold intended to be sent under this arrangement from Ophir or Sofala to Bathurst or to Sydney is to be delivered to the Commissioner of Crown Lands or Assistant Commissioner on the spot, to be transmitted in the chests or safes provided for the purpose to the Police Magistrate at Bathurst, who will deliver the bags addressed to that place to the persons or agents appointed to receive them, and forward the packages for Sydney by the mail by which the escort proceeds to the

Colonial Treasurer, at whose office they may be obtained by the persons duly authorised for the purpose.

3. The gold, whether received at Ophir or Sofala or at Bathurst, is to be placed in bags, sealed, marked, &c. in the manner pointed out in the notice of the 17th July, 1851*; and the receipts to be granted and the authorities to be produced to the Police Magistrate at Bathurst or to the Colonial Treasurer, Sydney, for obtaining the packages, are to be those required by that notice.

4. A charge will be made for gold forwarded under this arrangement from Ophir or Sofala to Bathurst of one half per cent., and from any of these places to Sydney of one per cent., on its value, estimated at £3. 4s. per oz. for washed gold, and £2. 8s. for gold obtained by amalgamation; and payment is to be made to the Police Magistrate at Bathurst for gold forwarded to that place, and to the Colonial Treasurer for that sent to Sydney.

5. The mails with escort will leave Ophir and Sofala every Tuesday morning, and Bathurst every Wednesday, arriving in Sydney at 11 o'clock on Thursday forenoon.

6. It is to be understood that in the event of a loss, notwithstanding the protection afforded by the escort, the Government will not, as explained

* Refers to a notice not accompanying the other official documents.

in the notice of the 17th ultimo, be responsible for it.

By his Excellency's command,

E. DEAS THOMSON.

Colonial Secretary's Office, Sydney,
October 7, 1851.

ADDITIONAL GOLD REGULATIONS.

With reference to the notices from this office of the 23d May and 4th August last, and pending the receipt of instructions from Her Majesty's Government, his Excellency the Governor-General has been pleased, with the advice of the Executive Council, to publish the following further provisional regulations for the search of gold.

1. Persons occupying portions of the gold field by erecting temporary buildings, tents, &c., and carrying on business in any way, shall pay a fee of thirty shillings monthly for the use of the land so occupied by them, and they are required to pay the same on demand and in advance to the officer appointed to receive payment of license fees.

2. Persons desirous of establishing claims to new and unoccupied ground by working in the ordinary method for alluvial gold, may have their claims marked out on the following scale; namely,—

(1.) Fifteen feet frontage to either side of a river or main creek to each person.

(2.) Twenty feet of the bed of a tributary to a river or main creek to each person.

(3.) Sixty feet of the bed of a ravine or water-course to each person.

(4.) Twenty feet square of table land or river flats to each person.

Every such claim shall be voided by the failure on the part of the claimant to work the same within ten days after the date of his acceptance, and persons found working on such or any other ground without having previously paid the license fee to the proper officer, shall pay double the amount for such license, and in default be proceeded against in the usual manner.

3. The license fee for private lands will in future be one-half only of that payable for Crown lands.

4. Persons desirous of working auriferous quartz veins may make application in writing to the Commissioner or Assistant Commissioner of the gold district, accurately describing the locality. Such application shall be immediately recorded by such officer in a book to be kept for that purpose, which shall be open at all reasonable times to the inspection of applicants. In case no previous application shall have been made as above directed, and should there be no valid objection to the proposal,

the Commissioner shall notify to the applicant his acceptance of the same. The applicant shall then enter into a bond binding himself and two or more sufficient sureties, to the satisfaction of the Government, jointly and severally, in the sum of two thousand pounds, to pay a royalty of ten per cent. on all gold obtained from any part of the land within the limits of his claim, to an officer to be appointed for that purpose by the Government. He shall further be bound to permit such officer to reside on the land in the neighbourhood of the works at such spot as may be assigned by the Commissioner, and also to give to such officer access at all reasonable times to the buildings or premises, and to all books and accounts connected with the production of gold; also to give all necessary facilities for the collection of the royalty daily or weekly as may be found most desirable.

5. All buildings, machinery, or other improvements erected or made on the land shall be considered as additional security for the due performance of the conditions of the bond.

6. The above claim shall consist of half a mile of and in the course of the vein, with fifty yards reserved on each side of such vein for building and other purposes. The right of cutting and using timber for building purposes or for firewood from adjacent Crown lands, as well as access to neighbouring water, shall also be conceded. The dura-

tion of the claim shall be three years, which shall, however, be extended for such further period as upon receipt of instructions from Her Majesty's Government may be determined upon, having due regard to the interests of the party concerned. At the expiration of the term of their holding, or on the sooner termination of their tenure by consent of the Government, the parties shall have liberty to remove all buildings, machinery, or other improvements erected or made by them, and a reasonable time shall be allowed for that purpose; provided always, that the conditions of the bond shall have been duly fulfilled.

7. A claim, such as the above, shall be forfeited by the failure of the applicant to enter within a reasonable period into the required bond;—by his neglecting to pay the prescribed royalty at the time and in the manner required by the bond;—by his not employing at least twenty persons on such claim within six months of the acceptance of his application for the same;—by his ceasing to employ that number of persons on the works for the period of one month thereafter;—by obstructing the officer in the proper performance of his duty, or in any other way violating the terms of the bond. Such vein shall then be open to selection by other parties.

8. Persons desirous of working auriferous quartz veins on their own lands shall be subject to the

terms of the above regulations, with the exception that the royalty payable on the gross production of gold shall be five per cent., and that they shall not be compelled to employ any specific number of persons, nor be liable to any penalty on their ceasing to work.

9. Persons desirous of draining ponds or waterholes may make application, in the mode above stated, to the Commissioner or Assistant Commissioner of the gold district, and shall be subject in all respects to the same regulations, with the exception that in the place of the payment of a royalty, the applicants shall bind themselves to employ not less than forty persons for such undertaking during the period of their occupation, and take out a license for every person so employed; and such claim shall be voided by the withdrawal of such number of persons from the work, unless in case of interruption by flood or other unforeseen accident.

10. Where more than one application shall have been made for any pond or waterhole previously to the publication of these regulations, or shall hereafter be made on the same day, such pond or waterhole shall be put up to tender, the advance being on the existing rate of the license fee. And it will be understood that such advance shall be paid on any number of persons employed in addition to the forty above determined.

The Commissioner or Assistant Commissioner is empowered to make such temporary regulations as may be necessary to prevent inconvenience to other licensed persons from the carrying on operations of the above nature.

By his Excellency's command,

E. Deas Thomson.

Colonial Secretary's Office, Sydney,
Oct. 21, 1851.

Gold Regulations.

His Excellency the Governor-General, with the advice of the Executive Council, has been pleased to make the following modifications in the provisional regulations of the 7th instant, having reference to the draining of ponds or watercourses, for the purpose of searching for gold.

1. In lieu of uniformly fixing at forty the number of persons to be employed on any such undertaking, the Government will, on the report of the local Commissioner, determine in each case the number of persons for whom the working of the claim would properly afford employment.

2. The persons undertaking to drain any such pond or watercourse will not, however, be com-

pelled to employ that number of persons during their occupancy, as required by the notice of the 7th instant; it will be sufficient that during such occupancy they pay for licenses for the full number of persons so fixed.

By his Excellency's command,

E. DEAS THOMSON.

Colonial Secretary's Office, Sydney,
Oct. 21, 1851.

GOLD.

His Excellency the Governor-General, with the advice of the Executive Council, has been pleased to direct, that from and after the 1st proximo, all alluvial gold, or matrix gold obtained by separation only, which may be tendered to the Government in payment of license fees, will be valued at three pounds per ounce, instead of three pounds four shillings, as determined by the notice of the 5th August last; and according to this value also (3*l.* per ounce) will be computed the royalty on matrix gold, and the commission on the conveyance by the Government of all gold, except such as may be procured by amalgamation.

2. It has not been found necessary to make any alteration in the value at which the Government

consents to receive gold obtained by amalgamation, namely:—Two pounds eight shillings per ounce; and the royalty on such gold, and the commission on its conveyance, will be regulated accordingly.

By his Excellency's command,

E. Deas Thomson.

Instructions to the Commissioner of Crown Lands for the Gold District.

Colonial Secretary's Office, Sydney,
May 23, 1851.

Sir,

In consequence of the discovery of gold in the western districts of the colony, and the collection in that quarter of a large number of persons, his Excellency the Governor has thought it expedient to take steps for the protection of the rights of the Crown, and for other purposes; and he has been further pleased to appoint you a commissioner of Crown lands, under the local Acts for protecting the Crown lands of the colony from encroachment, intrusion, and trespass, for the purposes and with the instructions following.

2. You will, in the first place, organize the force

of ten men, which will be placed under your orders, for the purpose of carrying out the duties for which you are appointed. You will at once arrange for their being armed, accoutred, and mounted, and for their being furnished with other indispensable articles as much as possible on the model of the late mounted police.

3. You will instruct the men composing such force as to the terms on which they are employed, as set forth in the memorandum* A annexed, more particularly explaining to them the probable want for the present of lodging, and of regular rations; and such men will sign an engagement in the form B* appended, and be sworn in as constables.

4. You will then proceed without delay to the Bathurst district, and establish yourself and your force in some locality that is central and otherwise suitable for your undertaking, providing rations for your party and forage for your horses as you may find practicable, and making such arrangements as you can for temporary shelter.

5. You will at once proceed to carry out the views published in the Proclamation of the 22d instant, and the regulations of this date. You are instructed to compel every individual at work at

* These Appendices were not furnished with the other documents.

the gold field to take out and pay for a license in the required form. You will be furnished with the necessary books, and it will be your duty to visit every person at work to receive the prescribed payments and to furnish the licenses properly filled up. It is probable that the only means of payment will be the gold collected; you will be furnished with scales and weights to enable you to take payment in gold, according to the scale following, namely, at the rate of 2*l.* 8*s.* per ounce for such as is obtained by amalgamation, and 3*l.* 4*s.* per ounce for such as is obtained by washing.

6. You will be furnished, as I have stated, with books containing the form of license for each month in the year. You will on the delivery of each license enter the name and description, after the model here given, of the person taking out the license; you will observe that in the license the name only, but not the description, is inserted. In the butt however from which the license is separated the description is added to the name. The reason of this is, that if any person should leave the gold field and transfer his license to another person who will assume his name for the purpose, the imposition will be at once detected in most cases. You are, of course, only expected to approximate to a correct description, for it is probable that much offence might be given by attempting perfect exactness. You will, moreover, before

granting licenses, require from each applicant a discharge from his last service, unless you have reason to believe such person was not at a time shortly preceding in service. It is, however, impossible for you to ascertain these points in many cases that may arise, but you will at least refuse a license to any one whom you may have sufficient reason to believe to be improperly absent from hired service.

7. You will be required to give security to the Government by two sureties severally and respectively bound with yourself in the sum of £2,000, for the faithful discharge of your duty as Commissioner, and for the payment to the Government of all monies and gold you may receive for licenses; such monies and gold are to be sent in the first week of each month to the Colonial Treasury at Sydney, under a sufficient and properly armed escort. You will advise the Colonial Treasurer by post of all such remittances, and transmit to him an account of your receipts during the month in which they have been collected, together with such vouchers in support thereof as shall be required by the Auditor-General, and the correctness of every such account shall be attested by the declaration required by law.

8. With respect to such persons as shall refuse to pay the moderate fee demanded by the Government, you will, I doubt not, act with vigour and

determination, remembering that the very object of your being furnished with an efficient force is to enable you to cause the Government regulations to be invariably respected; and for this purpose his Excellency the Governor has been pleased by the accompanying document to give you full authority to remove all unlicensed persons.

9. These are the instructions the Government has deemed it proper to give you at present; it may probably be necessary soon to extend them, and for that purpose it will be requisite for you to give as full and frequent information to the Governor, through this office, as may be practicable. It is impossible to mark out for you an exact path, something must at this early stage be left to your discretion, and in using, either in acting or in forbearing, you will lose no time in reporting your proceedings for approval.

10. And in conclusion, though your chief business will be to protect the interests of the Crown in matters of revenue, it will be an essential part of your duty to preserve the peace, to put down outrage and violence, and to protect the community generally. In this portion of your duties you will, I have no doubt, co-operate zealously with the local police, and as a ready and convenient accessory to your force, you will, with as little delay as possible, select from the respectable portions of the licensed persons employed in the locality, such and

so many as you may find necessary to be sworn in as special constables.

I have, &c.

(Signed) E. DEAS THOMSON.

John Richard Hardy, Esq.,
Commissioner of Crown Lands for the
Gold District.

INSTRUCTIONS TO ASSISTANT GOLD COMMISSIONERS.

1. You will, on the first and following days of each month, commence issuing licenses in your district, receiving payment for the same in money or gold dust. You will commence at the portion of the diggings which is most convenient, marking out at the time of giving the licenses the boundaries of each party on the following scale, namely,—

On every river or main creek, fifteen feet frontage to either side of the stream to each person licensed.

On every tributary to a river or main creek, twenty feet to each person licensed.

In every ravine or dry watercourse running into a creek or river, sixty feet of the bed to each person licensed.

On table land or river flats, constituting dry diggings, twenty feet square to each person licensed.

These allotments are to be marked consecutively, where practicable; and you will, with the assistance of your clerk, who will accompany you at suitable times, enter in a book, in the form annexed (B.) the description of the localities allotted, with the names of the parties. You will append to such book a rough chart of the ground, giving names for the convenience of reference to the more prominent portions of the ground.

2. You will be furnished with books of blank licenses, with butts like a cheque book; and monthly requisitions are to be made by you, on the colonial storekeeper, for such further books as may be necessary, care being taken that your demand is made sufficiently early to enable that officer to forward them to you by the time they are required.

You will fill up and deliver the licenses to the parties at the gold fields, entering their names in the butts, and receiving the prescribed fees; and you will make half-monthly payments direct to the Colonial Treasurer in Sydney of the amount collected by you for licenses, accompanied by statements in duplicate of the particulars. You will also make a return to me of the number of licenses issued, and the amount received, as well as of the number remaining of the blank license forms. At the commencement of each month you are to furnish to the Auditor-General a return of sums re eived by you during the previous month, and of

the number of licenses issued, transmitting to him, at the same time, the butts and blank licenses for the month remaining unexpended; and you are clearly to understand, that no deduction is to be made from the amount of your collections, but that the whole is to be paid in gross into the Treasury.

For any expenses which you may be authorized to incur, accounts should be rendered as early as practicable to the Auditor-General, who, if he finds them correct, will prepare a warrant authorizing payment of them to be made from the Treasury to the parties or their agents.

In such cases as it may be deemed expedient to make payment for any supplies earlier than can be done in this way, an advance will be made to you from the Treasury for the purpose, with the understanding that it will be adjusted by a certain time to be named in your application for it, which is to be made to the Auditor-General, specifying the general objects for which it is required, and that you will be held responsible for the amount until this has been done by the passing of the accounts for the expenditure at the Audit Office.

3. You will at the same time forward to the Auditor-General the monthly abstracts of the salaries of your establishment, including authorized accounts for forage and rations.

4. You will, in all respects, carry out the gene-

ral regulations, of which copies are annexed, reporting any temporary deviation which circumstances may render inevitable. You will especially report upon the applications made to you by companies or individuals under the 4th, 8th, and 9th clauses of the regulations of the 7th October, 1851, that the necessary steps may be at once taken to carry out their objects.

5. You will be furnished with an iron safe for the security of gold and money received by you, and it is desirable that in your temporary absence the same should be given to the care of the serjeant of your party. You will take care that the barracks or tents are not at any time left without a sufficient guard, and you will keep a sentry on the ground at all hours day and night.

6. You will settle all disputes between licensed occupiers of the gold field, visiting the spot in dispute with as little delay as possible. It is most desirable that every dispute should be instantly investigated and settled, that disputants may not have the temptation to redress their grievances themselves.

7. You will keep copies of all correspondence and accounts, reporting to the Colonial Treasurer the particulars of the gold received by you, and sent by escort to Sydney or elsewhere.

8. You will keep me informed at all times with the particulars of the gold field in your district,

including the number of persons, the number licensed, and the general prospects of the place.

9. As soon as practicable, you will divide your district into separate beats, assigning to each trooper a particular locality. By this means he will soon become acquainted with every person on his beat, and more readily detect unlicensed diggers.

B.

(Form referred to p. 154.)

UPPER TURON.—NAMES AND DESCRIPTIONS.

Maitland Point.

No. 1.—Henry Smith, Thomas Smith, John Paton.

No. 2.—W. H. Moore, J. Hindes.

No. 3.—Henry Thomas, William Pollard, Henry Pollard, Thomas Snow, William Moore.

No. 4.—&c., &c., &c.

Sofala Point.

No. 9.—William Smith, Henry Smith, Thomas Erskine.

No. 10.—Thomas Rowe, &c.

Erskine Point.

No. 22.—Henry Smith, William Smith, Thomas Jones, &c.

No. 23.—&c., &c., &c.

Trooper's Point.

No. 29.—Henry Smith.

Referring to my previous instructions of the I have the honour to forward to you a few general instructions for your guidance in matters of police.

Your establishment will consist of a clerk, of five mounted and five dismounted troopers; namely, a serjeant, at three shillings and ninepence, and the remainder at three shillings and threepence per diem each, with the old mounted police rations, and with clothing.

You will hold courts of Petty Sessions at the place, near to your head quarters, which may be proclaimed for that purpose, on such days as shall be most convenient, giving sufficient publicity to the same. You will carry out the general police business of your district, taking especial care that sly grog-selling and gambling and other disorders are, as much as possible, put down. Your clerk will also act as clerk of Petty Sessions, and the serjeant of your party as chief constable, and their

duties will be those ordinarily belonging to such officers.

You will provide for the escort of prisoners to Bathurst or elsewhere, as well as for their safe custody and support while in detention.

You will further furnish me, monthly, with an account of the number of days on which courts of Petty Sessions are held, and of the number of cases, and their result, distinguishing their several characters.

You will assign to each trooper a particular horse, for the care and good order of which he will be responsible, and you will have the power of dismissing any of your party for drunkenness or other misconduct, reporting to me the circumstances.

*** Similar regulations have been issued for the other gold-bearing districts.

THE END.

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A

MANUAL

OF

METALLURGY,

OR

Practical Treatise

ON THE

CHEMISTRY OF THE METALS.

BY

JOHN ARTHUR PHILLIPS, F.C.S.

PUBLISHED BY

JOHN JOSEPH GRIFFIN AND CO.

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AND RICHARD GRIFFIN & CO. GLASGOW.

1852

[*Prospectus.*

PHILLIPS'S MANUAL OF METALLURGY.

Prospectus.

THIS work forms Volume XXI. of the CABINET EDITION of the *Encyclopædia Metropolitana*, and treats of that important branch of Chemistry which relates to the EXTRACTION OF METALS FROM THEIR ORES. The following is a brief sketch of its contents:—

Physical and Chemical Properties of the Metals, their Alloys, Salts, and other Compounds. State in which the Metals are found in nature. Properties by which Minerals are discriminated. Crystallography. Constitution of the external Crust of the Earth. Principal kinds of Rocks. Strata that contain Ores. Localities in which the principal Ores are found. Description of the most important Ores of each Metal. Chief Operations of Mining. The mechanical Preparation of Ores previous to Smelting, by Crushing, Washing, Sifting, &c. *Fuel and its Economy*—Wood, Peat, Lignite, Coal, and Anthracite. *Prepared Fuels*—Charcoal, Peat-Charcoal, Coke. The Assay of Fuels. Estimation of their comparative Value. Furnace Materials. *Metallurgy Proper*—Iron, Copper, Cobalt, Nickel, Tin, Zinc, Antimony, Bismuth, Mercury, Lead, Silver, Gold, Platinum. In addition to the operations of Smelting, the work describes many important Manufactures in Metal; such as the Rolling of Sheet and Bar Iron, Iron Casting, and the Manufacture of Steel, of Sheet-Lead, and Lead-Pipes. The Processes which relate to the useful Metals smelted in Great Britain, and those regarding the Crushing, Washing, and Amalgamation of Gold and Silver Ores, are given in considerable detail.

The important subject of ASSAYING is treated of fully and practically. Assaying by Furnace Operations. Chemical Analysis in the wet way. Cupellation and Parting of Gold and Silver. Centigrade Processes for Testing Solutions of Silver and Copper, by graduated Test Liquors.

The work is illustrated by Two Hundred and Sixteen Wood Engravings, which exhibit the most approved Furnaces, Machinery, Implements, Apparatus, &c.

CRITICAL NOTICES
OF
PHILLIPS'S MANUAL OF METALLURGY.

"THE mineral wealth of the British islands has been fairly estimated to be nearly equal to that of the whole of the rest of Europe. Many years since twenty millions was regarded as the annual value of the mining produce of Great Britain and Ireland:—it is now considerably more. In every branch of metallurgy there has been an extension of the operations of smelting and refining, to meet the rapidly increasing demands for home consumption and for the foreign markets. Important as this branch of national industry is to this country—forming the source from which thousands draw their existence, and being in reality one of the most considerable elements in determining the position of the British empire among nations,—there are but few works to which reference can be made for information as to the statistics of production,—and still fewer which treat with any thing like accuracy of the methods employed in this country to render the productions which Nature has lavished on us available to the purposes of manufacture. The English language is exceedingly poor in works of a technical character. Although the English are essentially a practical people, when we have counted some half a dozen books (some of these being very old, and merely local in their bearing), we shall find that the literature of metallurgical art and of mining is exhausted. A work devoted to metallurgy, in its varied details, did not exist in England previously to the publication of the 'Manual' which stands as the heading to the present notice. The consequences of this have been, that the metallurgical operations of different localities have rarely been extended; since the busy manufacturers of another district, satisfied with their own methods, did not care to examine the results of their neighbours or to communicate their own. Proceeding for the most part empirically—the smelters having but the smallest possible amount of scientific knowledge to guide them,—it is really surprising that the characters of the British metals have reached so high a standard as they are now found to obtain. There was no more instructive section of the Great Exhibition than that which was devoted to the Mineral kingdom,—and it afforded for the first time to the British workman the means of comparing the metals produced from the minerals of other countries with those obtained from the metalliferous ores of our own. We are informed that, in many departments of metallurgy, a marked improvement has already been the result of that grand industrial competition. From the absence of any work in the language devoted to metallurgy, it was with difficulty that information had hitherto been obtained of the processes practised on the Continent, although many of them were known to be superior to our own.

"In the 'Manual of Metallurgy' an attempt has been made to

supply the want which we have shown to have so long existed. Mr. Phillips has rendered his work as interesting as was possible with a subject so purely technical, by commencing the main portion of his subject with a description of the geological conditions of the mineral-bearing districts, and of the mineralogical characters of the metal-liferous formations. Proceeding with a concise description of the operations of mining, he then details the processes of *dressing* the ores, by which they are rendered available for the furnace operations. Not only are our own methods of extracting the metals fully given,—but the most celebrated processes employed on the Continent are likewise described.

"A considerable section of the work is devoted to the various methods by which silver and gold are treated. These, as being of much interest at the present moment, will necessarily receive attention.

"In addition to the information given on Metallurgy, the work contains very full practical information on Assaying, and on the chemical processes by which the value of any particular ore may be readily ascertained.

"This 'Manual' is a highly valuable addition to our scientific literature, and will tend to increase the author's already extended reputation as a metallurgical chemist. The work consists of about 600 pages,—and is copiously illustrated with well-executed woodcuts, which materially aid in rendering the description of furnaces, &c. intelligible to all readers."—*Athenæum*, May 29, 1852.

"No publication has yet appeared in the English language taking so comprehensive a view of every detail connected with smelting and mining the various metallic minerals. It appears to us to fill up a long standing hiatus in the history of, and instruction in, mineralogical chemistry; and while it is sufficiently elementary to be understood by the young student, it is thoroughly practical, and erudite enough to form a standard work of reference for valuable information by the metallic chemical practitioner and assayer. The whole is admirably illustrated by well-executed diagrams. The type and paper are of the first order, and nothing appears to us to be wanting to render the work a *sine quâ non* to every metallurgist, whether practically engaged in the laboratory or at furnace operations, or the theoretic student and those attached to the applied sciences."—*Mining Journal.*

"We can confidently commend this volume to all whom its subject interests."—*Critic.*

"A most complete and practical Manual of metallurgic science and art."—*Literary Gazette.*

"Professor Phillips's treatise on the methods of extracting the metals from their ores is a technical book, addressed only to those who need practical instruction, of which its pages are full; but the curious reader will find useful information on several points connected with chemistry and chemical manufactures. The diagrams are numerous and excellent. An index is added."—*Leader.*

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HAMMER for flattening Gold, weight about 6 lb. bright face.

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Ditto, with Straight points, 4s. 6d.

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SMALL CRUCIBLE TONGS, 8 inches long, 2s.

GOLD-WASHING BASIN, of stout Zinc; form of figure 25, 26 inches in diameter, 14s.

SIEVES, of Hair and Brass Wire, of all diameters and degrees of fineness.

BOX SIEVE, with Three Divisions, size of gauze, 100, 50, and 20 to the inch, with cover, 7s. 6d.

MAGNIFYING LENS of Three Powers (for the Pocket), for examining Minerals, Crystals, Gold Dust, &c., fig. 4, 5s.

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1. Brass Beam, 12 inches long, in a Glass Case, with weights, £9 9s.

The beam has all the necessary adjustments. Will carry 1000 grains in each pan. Will turn with $\frac{1}{100}$ grain when thus loaded. The pans are suspended by platinum wire. The case is provided with adjusting screws to set it level. With a set of weights from 600 to $\frac{1}{100}$ grain.

2. Brass Beam, 15 inches long, in a Glass Case, with weights, £14. 14s.

BALANCES FOR ANALYTICAL PURPOSES—*continued.*

The beam is divided into ten parts, and has an apparatus placed over it by which the *rider* can be moved on the beam without opening the glass case. Will carry 1000 grains in each pan, and turn with $\frac{1}{100}$ grain when loaded. With a set of weights from 1000 grains to $\frac{1}{100}$ grain, including *riders* of $\frac{1}{10}$ grain each. There is a short pan cut out to receive the "potash apparatus," used in Organic Analysis. The glass case is provided with adjusting-screws.

3. ASSAY BALANCE, Brass Beam, 10 inches long, in a Glass Case, with a set of weights from 300 grains to $\frac{1}{1000}$ grain, £12 12s.

Will carry 500 grains in each pan, and turn with $\frac{1}{1000}$ grain when loaded.

4. PORTABLE BALANCE, in a mahogany box, brass beam 12 inches long, with a support adapted to the top of the box. The pans rest on the box, and are moved by a lever. Will carry 1000 grains in each pan, and turn with $\frac{1}{100}$ grain when loaded with 500 grains in each pan. The beam is divided into 10 parts from the fulcrum to the end, for a *rider*. With a set of square weights from 500 grains to $\frac{1}{10}$ grain. £5. 5s.

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4 inches diameter	.....	£0 1	6
5 — —	.....	0 2	6
7 — —	.....	0 6	0
10 — —	.....	0 12	0
12 — —	.....	0 18	0

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The principal Cabinet contains the most important Apparatus, arranged for convenient use in Trays and divided Boxes. The second Cabinet contains large articles for occasional use, Duplicates of Apparatus liable to be broken, extra stock of Acids and Chemicals, &c. Size of the Two Cabinets together, about 4 cubic feet. This Set contains Apparatus sufficient for the Complete Qualitative Analysis of Ores and Minerals, or the separation of the Components of a Mineral in quantities sufficient for an accurate Qualitative Analysis.

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SEFSTROEM'S BLAST FURNACE, fig. 5, page 48.

Outside Dimensions.		Dimensions of Fire Room.		
Height.	Width.	Depth.	Width.	Price.
9 inches ...	12 inches ...	6¼ inches ...	5 inches ...	£1 10 0
12 ...	16 ...	7¾ ...	6¾ ...	2 5 0
15 ...	18 ...	10¼ ...	7½ ...	2 15 0
18 ...	24 ...	12 ...	9½ ...	3 10 0

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Height.	Width.	Contents.	Price according to Weight, about
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$1\frac{1}{2}$	$1\frac{3}{8}$	1	35s.
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00	6d.	1	$1\frac{1}{4}$	$\frac{1}{3}$
0	8d.	$1\frac{1}{8}$	$1\frac{1}{2}$	$\frac{1}{2}$
1	9d.	$1\frac{1}{4}$	$1\frac{3}{4}$	$\frac{3}{4}$
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3 in. high, per doz.	0	1	4	$6\frac{1}{2}$ in. high, per doz.	0	6	9
4 — —	0	2	3	7 — —	0	8	6
$4\frac{1}{2}$ — —	0	2	6	8 — —	0	12	6
5 — —	0	3	0	9 — —	0	15	0
$5\frac{1}{2}$ — —	0	4	0	10 — —	1	1	0
6 — —	0	5	0				

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4 — —	0	2	6	10 — —	0	10	0
5 — —	0	3	0	11 — —	0	12	6
6 — —	0	3	6	12 — —	0	17	6
7 — —	0	4	6	13 — —	1	1	0
8 — —	0	5	6	14 — —	1	6	0

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3	0 6 6	0 4 3	30	4 0 0	2 2 0
4	0 8 6	0 5 9	35	4 10 0	2 10 0
5	0 10 0	0 7 0	40	5 5 0	2 17 6
6	0 12 6	0 8 6	50	6 10 0	3 10 0
7	0 15 0	0 10 0	60	7 15 0	4 5 0
8	0 17 6	0 11 6	70	9 0 0	5 0 0
10	1 1 0	0 14 0	80	11 0 0	5 10 0
12	1 6 0	0 17 0	90	12 10 0	6 10 0
15	1 17 6	1 1 0	100	13 0 0	7 0 0
18	2 5 0	1 6 0			

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1½ in. high, per gross	£0 4 6	3 in. high, per gross	£0 12 0
2 — —	0 6 0	4 — —	1 1 0
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2½	0 3	1¼	0 3	3	0 6
2¾	0 5	1½	0 3	3½	0 6
3½	0 7	2	0 4	4½	0 7
4½	0 8	2½	0 5	5½	0 8
5½	1 0	3	0 6	6½	1 0
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		6	1 2		
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0	0 0 7	3¼	2½	7	0 2 6	7¼	1 pint
1	0 0 9	3½	3	8	0 3 6	8½	2
2	0 1 0	3¾	4	9	0 5 0	10	4
3	0 1 2	4	6	10	0 8 0	12	7
4	0 1 4	4½	8	11	0 9 0	14	10
5	0 1 8	4¾	10	12	1 4 0	15½	18

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1000 grains — ..... 100 —
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— 8 —	6s. —	— 30 —	15s. —
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— 2.....	— 500 —	0	6	0
— 3.....	— 250 —	0	5	6

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Range from about −40 to +212°	£0	8	6
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Price.	Height.	Width at mouth.	Contents.
1s.	5½	1¼	¼ oz.
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Encyclopædia Metropolitana, *continued.*

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