ing of the surface generally follows, a second application of the ointment is made, and the patient sent home. This is often found sufficient to effect the cure, but the treatment can, if necessary, be repeated.

The name "Exophthalmic Goitre" is applied to another form of the enlargement of the thyroid gland, differing entirely in its pathological connexions from that above described. In this affection the bronchocele is but one of three phenomena, which together constitute the typical characteristics of the disease, viz., palpitation of the heart and great vessels, enlargement of the thyroid gland, and protrusion of the eyeballs. This group of symptoms is generally known by the names of Graves's disease or Von Basedow's disease, in reference to the physicians by whom the malady was originally recognized and described. Although occasionally observed in men, this affection occurs much more commonly in females and in comparatively early life. It is generally preceded by ill health in some form, more particularly impoverishment of blood, and nervous or hysterical disorders, and is occasionally seen in cases of organic heart-disease. It has sometimes been suddenly developed as the effect of fright or violent mental emotion. The first of the symptoms to appear is usually the palpitation of the heart which is aggravated by the slightest exertion, and may be so severe as not only to shake the whole frame but even to be audible at some distance from the patient. An uncomfortable sensation of throbbing is felt throughout the body, and many of the larger blood-vessels are seen to pulsate strongly like the heart. The enlargement of the thyroid gland generally comes on gradually, and rarely increases to any great size, thus differing from true goitre, as originally noticed by Dr Graves. The enlarged gland is of soft consistence, and communicates a thrill to touch from its dilated and pulsating blood-vessels.

Accompanying the goitre a remarkable change is observed in the appearance of the eyes, which attact attention by their prominence and the startled expression thus given to the countenance. In extreme cases the eyes protrude from their sockets to such a degree that the eyelids cannot be closed, and injury may thus arise to the constantly exposed eyeballs. Apart from such risk, however, the vision is rarely affected in this disease. Much difference of opinion prevails as to the immediate cause of the protrusion of the eyes, but it is generally ascribed to the increase of the fatty tissue and distension of the blood-vessels of the orbits. It occasionally happens that in undoubted cases of the disease one or other of the three above-named phenomena is absent, generally either the goitre or the exophthalmos. The palpitation of the heart is the most constant symptom. Sleeplessness, irritability, disorders of digestion, diarrhœa, and uterine derangements are common accompaniments.

The pathology of exophthalmic goitre is still somewhat uncertain, but there are strong reasons to believe that it is essentially a nervous ailment, and that the symptoms depend on a morbid state of the sympathetic nerve in the neck, which is well known to play an important part in the vaso-motor functions—that is, in controlling the action of the heart and regulating the calibre of the blood-vessels. In numerous instances of exophthalmic goitre a diseased state of this nerve has been found *post mortem*, although it must be admitted that in some cases no morbid change could be detected. The experiments of Bernard, Brown-Sequard, Schiff, and others upon the functions of the sympathetic nerve lend strong support to this view of the pathology of the disease. Exophthalmic goitre is not directly a fatal malady, but, on the other hand, complete recovery is a less frequent result than partial improvement, the patient continuing to suffer from chronic ill-health. The disturbed condition of the heart's action leads in some instances to permanent disease of that organ in the form of dilatation of its cavities. In the treatment of exophthalmic goitre the most successful results have been attained by the use of digitalis, which has the effect of giving tone to the heart and contracting the dilated blood-vessels. The tincture of digitalis, in doses of 5 to 10 drops twice or thrice daily, is perhaps the best form of administration. Where anæmia is present iron is indicated, and may be combined with the digitalis, although in some cases it is found to be unsuitable. In allaying the palpitation benefit is said to have frequently followed the application of ice to the cardiac region as well as to the thyroid gland. Iodine, which is so valuable in cases of true goitre, is generally admitted to be of no service in this disease, and is rather held to be injurious. (J. O. A.)

GOLCONDA, a fortress and ruined city, situated in the Nizám's Dominions, 7 miles west of Hyderabad city. In former times Golconda was a large and powerful kingdom of the Deccan, which arose on the downfall of the Báhmani dynasty, but was subdued by Aurungzebe in 1687, and annexed to the dominions of the Delhi empire. The fortress of Golconda, situated on a rocky ridge of granite, is extensive, and contains many enclosures. It is strong and in good repair, but is commanded by the summits of the enormous and massive mausolea of the ancient kings about 600 yards distant. These buildings, which are now the chief characteristics of the place, form a vast group, situated in an arid, rocky desert. They have suffered considerably from the ravages of time, but more from the hand of man, and nothing but the great solidity of their walls has preserved them from utter ruin. These tombs were erected at a great expense, some of them being said to have cost as much as £150,000. Golconda fort is now used as the nizám's treasury, and also as the state prison. The diamonds of Golconda have obtained great celebrity throughout the world; but they were merely cut and polished here, being generally found at Partial, near the south-eastern frontier of the nizám's territory.

GOLD

THE colour, lustre, and power of resisting oxidation, which this metal possesses, have caused it to be valued from the earliest ages. Allusions to gold are frequent in the Old Testament, and the refining of the precious metals by cupellation seems to have been a favourite illustration with the Jewish poets.[1] Jewellery and vessels found in Egyptian tombs afford evidence of the perfection attained in working gold at a period earlier than the government of Joseph,[2] and drawings on tombs of about this epoch clearly indicate the method of conducting the operations of washing, fusing, and weighing the metal. Excavations in Etruria have brought to light beautiful ornaments of gold, enriched with minute grains of the metal, the workmanship of which was unrivalled until Castellani studied and revived the methods employed by Etruscan artists.[3] The Greeks were familiar with natural alloys of silver and gold named *electrum*, rough nuggets of which were frequently stamped, and formed the earliest coins in Lydia.[4] The colour of this electrum is pale yellow to yellowish white, and it contains from 20 to 40 per cent. of silver.

[1] Percy's *Metallurgy of Lead*, p. 177.
[2] Jacquemart, *History of Furniture*, translation, p. 331.
[3] *Archæological Journal*, 1861, p. 365.
[4] "Notes on the Ancient Electrum Coins," by Barclay V. Head, *Numismatic Chronicle*, part iv., 1875, p. 245.

With regard to the history of the metallurgy of gold, it may be mentioned that, according to Pliny, mercury was employed in his time both as a means of separating the precious metals and for the purposes of gilding. Vitruvius also gives a detailed account of the means of recovering gold, by amalgamation, from cloth into which it had been woven.

Properties.—Gold is the only metal of a yellow *colour*, which is, however, notably affected by small quantities of other metals; thus the tint is sensibly lowered by small quantities of silver, and heightened by copper. The surface colour of particles of gold is often apparently reddened by translucent films of brown iron ore. It is nearly as soft as lead. The *hardness* varies, however, with the composition. Crystallized specimens from Oregon and Fraser River, containing respectively 835 and 910 parts of gold in 1000, are slightly harder than calc spar but sensibly softer than fluor spar, or much harder than the pure metal. When pure, gold is the most *malleable* of all metals. One grain may be beaten into leaves which cover a surface of 56 square inches, and are only $\frac{1}{282000}$th of an inch thick. Faraday has shown that the thickness of gold leaves may be still further reduced by floating them on a dilute solution of cyanide of potassium. When very thin, leaf gold appears yellow by reflected and green by transmitted light. If, however, certain gold films are heated, the light transmitted is ruby red; the pressure of a hard substance on the film so changes its state of aggregation that green light is again transmitted.[1] The metal is extremely *ductile*; a single grain may be drawn into a wire 500 feet in length, and an ounce of gold covering a silver wire is capable of being extended more than 1300 miles. Gold can readily be welded cold, and thus the finely divided metal, in the state in which it is precipitated from solution, may be compressed between dies into discs or medals. According to G. Rose,[2] the *specific gravity* of gold in the finely divided state in which it is precipitated from solution by oxalic acid is 19·49. The specific gravity of cast gold varies from 18·29 to 19·37, and by compression[3] between dies the specific gravity may be raised from 19·37 to 19·41; by annealing, however, the previous density is to some extent recovered, as it then is found to be 19·40. Its *atomic weight* is variously given as follows:—196·67 (Berzelius), 196·3 (Levol), 196·5 (Wurtz), 196·0 (Watts). The number adopted in this work (CHEMISTRY, vol. v. p. 528) is 196·2. Different observers have given the following temperatures as its *melting point*:—1425° C. (Daniell), 1200° C. (Pouillet), 1380° C. (Guyton de Morveau). Riemsdijk,[4] after comparing the several results, concludes that it may be considered to be 1240° C. The *electric conductivity* is given by Matthiessen as 73·99 at 15·1° C., pure silver being 100; this depends greatly on its degree of purity,—the presence of a few thousandths of silver lowering its conductivity by 10 per cent. The *specific resistance* of the metal in electromagnetic measure, according to the centimetre-gramme-second system of units, is 2154. Its *conductivity for heat* is 53·2 (Wiedemann and Franz), pure silver being 100. Its *specific heat* is 0·324 (Regnault). Its *coefficient of expansion* for each degree between 0° and 100° C. is 0·000014661, or for gold which has been annealed 0·000015136 (Laplace and Lavoisier). The *specific magnetism* of the metal is 3·47 (Becquerel). Details as to its *tenacity* and *rigidity* are given in the article ELASTICITY. With regard to its *volatility*, Gasto Claveus[5] states that he placed an ounce of pure gold in an earthen vessel in that part of a glass-house where the glass is kept constantly melted, and retained it in a state of fusion for two months without the loss of the smallest portion of its weight. Kunkel describes a similar experiment, which was attended with the same result. Homberg,[6] however, observed that when a small portion of gold is kept at a violent heat, part of it is volatilized. Both Macquer and Lavoisier showed that when gold is strongly heated, fumes arise which gild a piece of silver held in them. Its volatility has also been studied by Elsher, and, in the presence of other metals by Napier.[7] Hellot affirms that when an alloy of 7 parts of zinc and 1 part of gold is heated in air, the whole of the gold rises in the fumes of oxide of zinc which are produced. Gold is dissipated by sending a powerful charge of electricity through it when in the form of leaf or thin wire. In the gold *spectrum* Huggins has observed twenty-three lines, and the wave lengths of the three most important of these are 5231, 5835, and 6276 respectively. Some preliminary observations on the spectrum of the vapour at the temperature of the oxy-hydrogen flame, made by Lockyer and Roberts,[8] showed that there was a distinct absorption both at the blue and at the red end.

The solvents for gold are given in the article CHEMISTRY, vol. v. p. 529. It may be added that finely-divided gold dissolves when heated with strong sulphuric acid and a little nitric acid. Dilution with water, however, precipitates the metal as a violet or brown powder from the solution so obtained. Gold is also attacked when strong sulphuric acid is submitted to electrolysis with a gold positive pole.[9] W. Skey has shown[10] that in substances which contain small quantities of gold, the precious metal may be removed by the solvent action of a tincture of iodine or bromine in water. Filter paper soaked with the clear solution is burnt, and the presence of gold is indicated by the colour of the ash.

Occlusion of Gas by Gold.—Graham has shown[11] that gold is capable of occluding 0·48 of its volume of hydrogen, and 0·20 of its volume of nitrogen. Varrentrapp has also pointed out that "cornets" from the assay of gold may retain gas if they are not strongly heated. Artificial crystals of gold may be formed when the molten metal is slowly cooled.

Occurrence and Distribution.—Gold is found in nature chiefly in the metallic state, or as native gold, and less frequently in combination with tellurium, lead, and silver, forming a peculiar group of minerals confined to a few localities in Europe and America. These are the only certain examples of natural combinations of the metal,—the minute although economically valuable quantity often found in pyrites and other sulphides being probably only present in mechanical suspension, although for practical purposes it may be spoken of as combined. The native metal occurs tolerably frequently in crystals belonging to the cubic system, the octahedron being the commonest form, but other and complex combinations have been observed. Owing to the softness of the metal, large crystals are rarely well defined, the points being commonly rounded. In the irregular crystalline aggregates branching and moss-like forms are most common, and in Transylvania thin plates or sheets with diagonal structures are characteristic These have recently been shown by Vom Rath to be repeated combinations of distorted tetrahexahedra. During the preparation of a mass of pure gold in the Mint at London, some fine crystals which appear to be aggregations of octahedra were obtained; and dendritic crystals of gold,

[1] *Phil. Trans.*, 1857, p. 145.
[2] *Pogg. Ann.*, vol. lxxiii. p. 1, and lxxv. p. 408.
[3] *Eighth Ann. Report of Deputy Master of the Mint*, 1877, p. 41.
[4] *Archives Néerlandaises*, t. iii., 1868.
[5] Quoted by Dr T. Thomson, *System of Chemistry*, 5th edition, 1817, vol. i. p. 484.
[6] *Mem. Paris Academy*, 1702, p. 147.
[7] *Chem. Soc. Journ.*, vol. x. p. 229, vol. xi. p. 168.
[8] *Proc. Roy. Soc.*, 1875, p. 344.
[9] Spiller, *Chem. News*, x. 173.
[10] *Ibid.*, xxii. 245.
[11] *Phil. Trans.*, 1866, 433.

prepared artificially, have been described by Chester. It is possible also to obtain gold in crystals by heating its amalgam; according to Knaffl, an amalgam of 1 part of gold with 20 parts of mercury is maintained at a temperature of 80° C. for eight days. It is then heated to 80° C. with nitric acid of specific gravity 1·35, when dull crystals will be left, which become brilliant when more strongly heated. More characteristic, however, than the crystallized are the irregular forms, which, when large, are known as "nuggets" or "pepites," and when in pieces below $\frac{1}{4}$ to $\frac{1}{2}$ ounce weight as gold dust, the larger sizes being distinguished as coarse or nuggety gold, and the smaller as gold dust proper. Except the larger nuggets, which may be more or less angular, or at times even masses of crystals, with or without associated quartz or other rock, gold is generally found bean-shaped or in some other flattened form, the smallest particles being scales of scarcely appreciable thickness, which, from their small bulk as compared with their surface, subside very slowly when suspended in water, and are therefore readily carried away by a rapid current. These form the "float gold" of the miner. The physical properties of native gold are generally similar to that of the melted metal and its alloys as described above. The composition varies considerably in different localities, as shown in the following table:—

Analyses of Native Gold from various localities.

Locality.	Gold.	Silver.	Iron.	Copper.	Authority.
EUROPE.					
British Isles—					
Vigra & Clogau...	90·16	9·26	trace	trace	Forbes.
Wicklow(river)...	92·32	6·17	·78	...	Mallet.
Transylvania	60·49	38·74	...	0·77	G. Rose.
ASIA.					
Russian Empire—					
Brezovsk	91·88	8·03	trace	·09	G. Rose.
Ekaterinburg.....	98·96	0·16	·05	·35	...
AFRICA.					
Ashantee	90·05	9·94	...	...	...
AMERICA.					
Brazil	94·0	5·85	...	...	D'Arcet.
Central America ...	88 05	11·96	...	...	Fremy and Pelouze.
Titiribi	76·41	23·12	...	0·87	Rose.
Californa	90 12	9·01	...	...	...
Mariposa	81·00	18·70	...	...	F. Claudet.
Cariboo	84·25	14·90	...	·03	Claudet.
AUSTRALIA.					
South Australia ...	87·78	6·07	6·15	...	A. S. Thomas.
Ballarat..............	99·25	0·65	...	...	Claudet.

Of the minerals containing gold the most important are sylvanite or graphic tellurium, of composition $(AgAu)Te_2$, with 24 to 26 per cent.; calaverite, $AuTe_2$, with 42 per cent.; and nagyagite or foliate tellurium, of a complex and rather indefinite composition, with 5 to 9 per cent. of gold. These are confined to a few localities, the oldest and best known being those of Nagyag and Ofenbanya in Transylvania; but latterly they have been found in some quantity at Red Cloud, Colorado, and in Calaveras county, California—the nearly pure telluride of gold, calaverite, being confined to these places.

The minerals of the second class, usually spoken of as auriferous, or containing gold in sensible quantity, though not to a sufficient amount to form an essential in the chemical formulæ, or even in many instances to be found in the quantities ordinarily operated upon in analyses, are comparatively numerous, including many of the metallic sulphides. Prominent among these are galena and iron pyrites,—the former, according to the observations of Percy and Smith, being almost invariably gold-bearing to an extent that can be recognized in operating upon a pound weight of the lead smelted from it, the proportion increasing to some extent with the amount of silver.[1] The second is of greater practical importance, being in some districts exceedingly rich, and, next to the native metal, is the most prolific source of gold. Magnetic pyrites, copper pyrites, zinc blende, and arsenical pyrites are other and less important examples,—the last constituting the gold ore formerly worked in Silesia. A native gold amalgam is found as a rarity in California, and bismuth from South America is sometimes rich in gold. Native arsenic and antimony are also very frequently found to contain gold and silver.

The association and distribution of gold may be considered under two different heads, namely, as it occurs in mineral veins, and in alluvial or other superficial deposits which are derived from the waste of the former. As regards the first, it is chiefly found in quartz veins or reefs traversing slaty or crystalline rocks, usually talcose or chloritic schists, either alone, or in association with iron, copper, magnetic and arsenical pyrites, galena, specular iron ore, and silver ores, and more rarely with sulphide of molybdenum, tungstate of calcium, bismuth, and tellurium minerals. Another more exceptional association, that with bismuth in calcite from Queensland, was described by the late Mr Daintree. In Hungary, the Urals, and northern Peru, silicates and carbonates of manganese are not uncommonly found in the gold and silver bearing veins. In the second or alluvial class of deposits the associated minerals are chiefly those of great density and hardness, such as platinum, osmiridum, and other metals of the platinum group, tinstone, chromic, magnetic, and brown iron ores, diamond, ruby, and sapphire, zircon, topaz, garnet, &c., which represent the more durable original constituents of the rocks whose disintegration has furnished the detritus. Native lead and zinc have also been reported among such minerals, but their authenticity is somewhat doubtful.

The distribution of gold-bearing deposits is world-wide; although the relative importance of different localities is very different, their geological range is also very extensive. In Europe the principal groups of veins are in slaty or crystalline schists, whose age, when it can be determined, is usually Palæozoic, Silurian, Devonian, or Carboniferous, and less commonly in volcanic formations of Tertiary age. The alluvial deposits, being more extensive, are less intimately connected with any particular series of rocks. Few of either are, however, of much importance as compared with the more productive deposits of America and Australia. In the United Kingdom gold-bearing quartz veins were worked during the Roman occupation at Ogofau, near Llanpumpsant, in Carmarthenshire; and in the year 1863 as much as 5300 oz. was produced from similar veins in Lower Silurian slates at Vigra and Clogau mines, near Dolgelly. In 1875 the mine was reopened, and in 1878 it produced 720 oz. Tetradymite, native bismuth, and several other characteristic associates of gold were also found in small quantity. In Cornwall small pieces of native gold have at intervals been found in alluvial or stream tin works; and similar but more important finds have been made in the granite district of Wicklow, and more recently at Helmsdale, in Sutherlandshire. The largest nugget of British origin weighs under 3 oz.

On the continent of Europe the great rivers originating in the crystalline rocks of the Alpine region, such as the Rhine and Danube, are slightly auriferous in their alluvial deposits in several places; but the proportion of gold is extraordinarily minute, so that the working is only carried on by gipsies, or by the local peasantry at irregular intervals, the return for the labour expended being very small. The same remark applies to the Rhone and its

[1] *Phil. Mag.*, vii., 1854, p. 126.

affluents, and the rivers of the central granitic mass of France. In the Austrian Alps the gold quartz mines at the Rathausberg, near Gastein, at a height of about 9000 feet above the sea-level, and at Zell, in Tyrol, are of interest historically as having developed the system of amalgamation in mills, although they are economically of small importance at present. On the Italian side, in the Valanzasca and Val Toppa above Lago Maggiore, a group known as the Pestarena mines have yielded from 2000 to 3000 ounces annually for several years past; and more recently a discovery of great interest of a highly auriferous copper ore has been made at Ollomont in the Val d'Aosta. In Hungary the gold-bearing veins of Schemnitz occur in greenstones and trachytes of Tertiary age, the most powerful example, the *Spitaler-gang*, being filled with a mixture of quartz and brown iron ore known as zinnopal, and containing gold associated with silver ores, galena, and pyrites. In Transylvania, at Nagyag, the gold-bearing tellurium minerals previously noticed are found in small veins traversing greenstone trachyte. These are often very thin, as low as $\frac{1}{8}$th to $\frac{1}{16}$th of an inch, but each is carefully traced out, the rock being impregnated with gold and silver to a certain depth on each side. At Vörospatak, another Transylvanian locality, gold with a very large proportion of silver and associated with gypsum is worked in veins traversing a Tertiary sandstone, being almost the only known instance of such a mode of occurrence.

The Russian empire has the largest gold production among the countries of the Old World, most of the produce, however, being derived from its Asiatic territories. The more important localities are situated on the eastern slope of the Ural chain, extending in a nearly north and south line for more than 600 miles from 51° to 60° N. lat. The chief centres are Miask (55° N.), Kamensk (56° 30′ N.), Berezovsk (57° N.), Nijne Tagilsk (58° N.), and Bogoslowsk (60° N.), the known deposits, which include both veins and alluvial mines, extending for about one degree farther north. The geological age of the Ural veins is not very well defined—strata of the Silurian, Devonian, and Carboniferous periods, which form regular parallel alternations on the European slope, being present on the Asiatic side, but in much disturbed and contorted positions, in association with plutonic rocks, diorite, diabase, and granite, with which the gold veins are intimately connected. The latter are therefore of post-Carboniferous and probably of Permian date. At Berezovsk the mines cover an area of about 25 square miles, mainly composed of talcose, chloritic, and clay slates, vertical or sloping at high angles, and penetrated by dykes of beresite, a fine grained rock made up of quartz and white mica with some felspar and pyrites, the latter usually transformed into brown iron ore. These dykes, which have a general north-and-south direction are vertical, and are from 20 to 70 feet and upwards in thickness, are traversed perpendicularly to their direction by veins of quartz from the thinnest string to a maximum of $3\frac{1}{2}$ or 4 feet thick, in which gold is associated with brown iron ore or ochres, resulting from the decomposition of pyrites. The workings being essentially shallow, none of the associated sulphides, galena, disulphide of copper, &c., have as yet been found, as a rule, to be gold-bearing. The valuable parts of the veins are almost entirely restricted to the beresite dykes. The richest of the Ural mines are those of Smolensk, near Miask, and Ouspensk, near the village of Katchkar, in 52° N. The alluvial deposits which, though called sands, are but very slightly sandy clays, extend to the north beyond the inhabited regions, and to the south into the Cossack and Bashkir countries. The most valuable diggings are in the district of Miask, where the largest nuggets have been found, and in the Katchkar, which are remarkable for the great number of gems, pink topazes, emeralds, &c., found in connexion with the gold. Magnetite, quartz, and platinum are very common in all the Ural gold sands; less common are hematite, titaniferous and chromic iron, pyrites, garnet, and, least of all, zircon, kyanite, and diamond. These alluvial deposits are of later Tertiary age, some of them containing traces of prehistoric human work; others are post-Pliocene, with the remains of the mammoth, tichorrhine, rhinoceros, and other mammalian fossils. Somewhat similar conditions prevail in the alluvial gold region of the Altai. Besides the veins and alluvial deposits, the Ural rocks, such as serpentine, diorite, beresite, agrairite, &c., are at times auriferous.

The gold deposits of the Caucasus, though immortalized in the tradition of Jason and the Argonauts, are now entirely abandoned, the last attempt at working them having been suspended in 1875.

In India gold is obtained in small quantities by native gold washers in various parts of the highlands of southern Bengal, and more recently quartz veins and alluvial deposits of considerable promise have been discovered in the district of Wynaad, in the southern part of the Madras presidency.

On the Atlantic slopes of North America the chief gold-bearing localities are on the Chaudière river, near Quebec, and in Nova Scotia. In both instances the quartz veins worked are contained in slates belonging to the Quebec group of the Lower Silurian period, those of the latter province being specially remarkable for their quasi-stratified character, as they penetrate the slates at a very low angle of inclination, and have been folded and corrugated together with the containing rocks by subsequent disturbances. Other deposits of old geological periods are found in Tennessee and North Carolina.

On the Pacific side of America gold is found under very different conditions, and on a much larger scale than on the Atlantic side. The whole distance from Mexico to Alaska may be said to be more or less auriferous, the most extensive deposits being in the great north-and-south valley of the Sacramento, which runs parallel to the coast, between the so-called Coast Mountains and the Sierra Nevada, the latter being distinguished further to the north in the Cascade range. Others of less extent are known in the Klamath, Columbia, and Fraser river basins; they extend in the last two far back into the interior, to the region between the Cascade range and the Rocky Mountains. In many of these valleys alluvial deposits are developed to an extent unparalleled elsewhere, the river channels being bordered by banks or benches of gravel and sand, rising in terraces to considerable heights on the flanks of the hills. For example, at the Methow a tributary of the Columbia, there are sixteen lines of such terraces, the highest about 1200 feet above the river; and at Colville, on the Columbia, traces of old terraces, much degraded by frost and rain, are seen at 1500 feet above the river. These gravels, which are of Pliocene and more recent origin, are in many places, though very unequally, auriferous, the richest points being found in the bars or shingle banks of the river after the summer floods, and in the channels of the smaller tributary streams, where the poorer material has been partially enriched by a process of natural washing. The most extensive, or rather the best known because most completely explored, deposits of this class are those of the Upper Sacramento valley, in California (see vol. iv. p. 701).[1] Others of considerable importance are worked in the Cariboo district on the Upper Fraser river, yielding very coarse gold. Another discovery of a singular character, the produce being a regular gold gravel, was made some years back at Salmon river in Oregon, but the deposit, though exceedingly rich, was soon exhausted. Gold-

[1] See also Whitney, *On the Auriferous Gravels of the Sierra Nevada*, Cambridge, U.S., 1879

bearing quartz veins are also common over a large part of California, notably in Grass Valley (vol. iv. p. 702), in strata that are supposed to be of Triassic age, the associated minerals being iron and arsenical pyrites, galena, &c. In Calaveras county, tellurium ores like that of Transylvania are characteristic of the gold veins. In the adjacent States of Nevada and Colorado, gold is so intimately associated with silver ores that it is for the most part only obtained from the ultimate process of refining the reduced silver. The same remark applies to the most of the mines of Mexico, and on the south-west coast of America, in Peru, Bolivia, and Chili. See SILVER.

Very rich gold quartz has been brought from Carabaya on Lake Titicaca; and recently considerable deposits both alluvial and in veins have been opened at Caratal in Venezuela and at St Elie in French Guiana, which are interesting as proving the actual existence of Raleigh's Eldorado.

In Brazil the principal gold mines are upon veins in clay slate, and a peculiar class of rocks known as Jacotinga or Itabirite, and which are mixtures of quartz, chlorite, and specular iron ore, the latter often occurring in large mirror-like crystals several inches across. The gold occurs almost entirely in pyritic minerals, being most abundant in ordinary iron pyrites, and less so in magnetic and arsenical pyrites, free gold being rarely seen. See BRAZIL, vol. iv. p. 224.

In Africa the chief gold-bearing localities are on the west coast—gold dust derived from alluvial washings forming an article of export from many of the trading stations along the Guinea coast. Latterly, alluvial deposits have been worked in the mountains of Transvaal, in the Leydenburg district (25° S. lat., 31° E. long.), producing coarse nuggetty gold in masses up to 11 lb weight, and in a few cases gold-bearing quartz has been found in veins in talcose schist and quartzite, closely associated with eruptive masses of diorite. The age of these rocks is considered by Dunn[1] to be Silurian or Devonian, and the observed phenomena to be similar to those generally observed in Australia. The upper valley of the Nile produces a little gold in Abyssinia and Nubia, the latter being the land of gold of the old Egyptians. Very extensive ancient mines have been described by Linant Bey in the district known as Attaki or Allaki on the Red Sea, situated about 120 miles back from Ras Elba, the headland midway between Berenice and Sauwakin. These are probably the same mines that were described by Diodorus Siculus, and one of the oldest topographical documents known, a map or itinerary of the route to them from the Nile, is preserved at Turin. In the reign of Setee I., of the 19th dynasty, wells were opened along this route, in order that the mines, that were then of very great antiquity, might be reopened.[2] Similar ancient gold mines have recently been discovered by Burton in the land of Midian, on the east coast of the Gulf of Akaba.

The gold districts of Australia cover a very considerable area, extending from the east side of the continent for about 20° of latitude (18° to 38° S.), the more important deposits being those of Victoria in the south. The principal districts are in Victoria,—Ballarat, Castlemaine, and Sandhurst, lying west and north from Melbourne, and Beechworth near the Murray river to the north-east. In New South Wales the gold fields are scattered over the entire length of the colony from north to south, the more important districts lying between the 32d and 36th parallels of S. lat. on the western side of the Australian cordillera, on the upper tributaries of the Macquarie and Lachlan rivers, the centre being about the town of Bathurst. This is known as the western district. Another group, known as the northern district, is on the eastern side of the mountains near the Queensland boundary, in 29° S., Rocky River being the principal locality; while the southern district includes Braidwood, Adelaide, Tumbarumba, and other localities near the Murray river. In Queensland the chief localities are, commencing on the south, Gympie and Kilkevan near Maryborough, 26° S. lat.; a group extending about 50 miles north and south of Rockhampton, in 24° 30′ S. lat., all near the coast; Eastern River, Hurley, and Peak Downs, about 300 miles inland on the 23d parallel; and Clomenny and Gilbert on a stream running into the Gulf of Carpentaria, besides numerous others. In all those localities two principal kinds of deposits are observed, namely, auriferous quartz veins traversing slates of Silurian and Devonian age, which are in intimate relation with masses of diorite and other eruptive rocks; and gold-bearing drifts of Miocene or even newer Tertiary date, derived from the degradation of the older strata. According to Daintree,[3] no auriferous vein of any kind has been found in any Secondary or Tertiary strata, or in the igneous rocks erupted through any such newer formations; and as a result of his experience the same observer gives the following as the modes of occurrence of gold in Australia:—(1) In pyritic diorites and felstones in Queensland, and their alluvial drifts; (2) in pyritic granites in New South Wales; (3) in drifts from auriferous serpentine in Queensland, also in the two northern colonies; (4) in more or less regular veins with quartz and calcspar in the preceding rocks; (5) in quartz and other veins in Devonian and Upper Silurian strata in proximity to similar igneous rocks, which is the general character of the Victoria quartz veins; (6) in veins of metamorphic rocks of unknown age in Queensland; and (7) in quartz veins in Lower Silurian strata, without any apparent connexion with igneous masses. The latter occur only in Victoria, and are of comparatively minor importance. In the northern territory of South Australia, alluvial gold mining has recently been developed to a considerable extent in the neighbourhood of Port Darwin in the Gulf of Carpentaria, the export being from 2000 to 3000 oz. monthly.

Statistics.—There are no means of stating exactly the total gold produce of the world for any particular year, as in many of the larger producing countries no systematic returns are obtained, and in others where such returns are collected their publication is often delayed for a considerable time. The following figures, mostly derived from a recent statistical work, A. Soetbeer, *Edelmetall-Produktion*, 1879, with some additions from late official sources, will give some idea of the relative importance of the different countries. Previous to 1837 the first place was held by Russia, and the estimated average annual yield from all sources was, in the decennial period 1841-50, 1,760,500 ounces.

The contributions of the different countries are as follows:—

		oz.		oz.		oz.
United States	1876,	2,050,000[4]				
Russia	1876,	1,072,920	1877,	1,281,260		
New South Wales	1876,	126,789	1877,	97,582		
Victoria	1876,	963,760	1877,	809,653	1878,	758,039
Queensland	1876,	410,330	1877,	468,418		
New Zealand	1876,	322,016	1877,	371,685	1878,	311,438
Venezuela					1878,	150.000
New Granada	1876,	112,500				
Africa	1875,	110,100				
Mexico	1875,	65,950				
Bolivia	1875,	64,300				
Austria-Hungary	1876,	61,214				
Brazil	1875,	55,300				
Japan	1876,	21,660				
Chili	1876,	12,860				
Nova Scotia	1876,	12,039				
Peru	1876,	11,570				

[1] *Quarterly Journal of the Geological Society*, xxxiii. p. 882.

[2] Mariette Bey, *Histoire Ancienne d'Egypt*, 1867, p. 96. The oldest notice of the mines goes back to the 12th dynasty.

[3] *Quarterly Journal of the Geological Society*, vol. xxxiv. p. 435.

[4] The two principal mines, on the Comstock lode, the Consolidated Virginia and California, produced, apart from silver, gold of the value in United States currency as follows:—

	1876.	1877.	1878.
Consolidated Virginia	$7,378,145	$6,270,000	$3,770,000
California	6 648,641	9,386,745	5,553,400

Since 1851 the yield has been very largely increased by the discovery of the Australian and Californian sources, the annual averages being—

In 1851-1855	6,350,180	ounces
,, 1856-1860	6,624,850	,,
,, 1861-1866	5,951,770	,,
,, 1866-1870	6,169,660	,,
,, 1871-1875	5,487,400	,,

Proportion of Gold in Deposits.—A rich gold-bearing deposit is quantitatively very different from one to which the same term is applied when containing ores of other metals. In the latter the useful material must as a rule form a considerable proportion—one or more parts in a hundred—of the mass; while in the former, owing to the superior value of the product, it rarely attains as much as 1 per cent., and is generally very much less, the amount of gold contained in easily worked alluvial deposits being often extremely small. For example, the yield of the Siberian gold washings ranges from 12 grains to 1 dwt. 12 grains per ton;[1] while in the lodes, which are more difficult and expensive to work, the proportion is about 8 dwts. per ton. In the alluvial washings of California it is estimated at about two shillings worth, equal to about $\frac{1}{40}$th of an ounce, per ton of gravel. In Australia the alluvial ground worked in the colony of Victoria in 1878 is returned as averaging 25 grains (1 dwt. 1 gr.) per ton, or about double the above quantity.

In vein mining, which is more difficult and costly, a larger yield is necessary, but probably 5 dwts., or about £1 in value per ton, will in most places represent paying quantities from quartz containing free gold, *i.e.*, not associated with pyrites. The proportional yield and quantities of the different kinds of auriferous materials treated in the colony of Victoria during the last three months of 1878 were—

	Tons.	Yield per ton. oz.	dwt	gr.
Alluvial sand "washdirt"	173·379	1	1	59·6
Cement (gravel) requiring crushing	5871	...	4	21·4
Quartz	222 775	...	9	21
Quartz tailings	11·139	...	1	18
Pyrites and blanketing (ore collected on blanket tables)	1·599	2	6	13·7

In the less tractable minerals, such as arsenical pyrites occurring in the lower portions of the veins, as much as $1\frac{1}{2}$ to 3 oz. may be required for profitable working. When associated with the ores of other metals, such as silver, lead, and copper, the extraction of the gold is in most cases an incidental and final operation in their metallurgical treatment, and may therefore be best considered in the articles on these metals.

Mining.—The various deposits of gold may be divided into two classes—"veins" and "placers." The vein mining of gold does not greatly differ from that of similar deposits of metals. It will only be necessary to refer here to certain details of the extraction of gold in such cases. In the placer or alluvial deposits, the precious metal is found usually in a water-worn condition imbedded in earthy matter, and the method of working all such deposits is based on the disintegration of the earthy matter by the action of a stream of water, which washes away the lighter portions and leaves the denser gold. In alluvial deposits the richest ground is usually found in contact with the "bed rock"; and, when the overlying cover of gravel is very thick, or, as sometimes happens, when the older gravel is covered with a flow of basalt, regular mining by shafts and levels, as in what are known as tunnel-claims, may be required to reach the auriferous ground. In the early days of gold washing in California and Australia, when rich alluvial deposits were common at the surface, the most simple appliances sufficed; the most characteristic being the "pan," a circular dish of sheet-iron with sloping sides about 13 or 14 inches in diameter. The pan, about two-thirds filled with the "pay dirt" to be washed, is held in the stream or in a hole filled with water. The miner, after separating the larger stones by hand, imparts a gyratory motion to the pan by a combination of shaking and twisting movements which it is impossible to describe exactly, so as to keep its contents suspended in the stream of water, which carries away the bulk of the lighter material, leaving a black residue consisting of magnetic iron ore and other heavy minerals, together with any gold which may originally have been present in the mass. The washing is repeated until enough of the enriched sand is collected, when the gold is finally recovered by careful washing or "panning out" in a smaller pan. In Mexico and South America, instead of the pan, a wooden dish or trough, variously shaped in different districts, and known as "batea," is used.

The "cradle," a simple appliance for treating somewhat larger quantities, varies in length from 3 feet 6 inches to 7 feet, but the shorter length is that usually adopted. Its nature will be evident from fig. 1, in which *a* is a movable hopper with a perforated bottom of sheet-iron in which the "pay dirt" is placed. Water is poured on the dirt, and the rocking motion imparted to the cradle causes the finer particles to pass through the holes in the hopper on to the screen *b*, which is of canvas, and thence to the base of the cradle, where the auriferous particles accumulate on the transverse bars of wood *c*, called "riffles." Washing by the cradle, which is now but little used except in preliminary workings, is tedious and expensive.

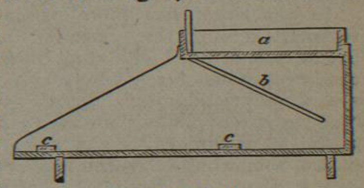

FIG. 1.—Cradle.

The "tom" is a sort of cradle with an extended sluice placed on an incline of about 1 foot in 12. The upper end contains a perforated riddle plate which is placed directly over the riffle box, and under certain circumstances mercury may be placed behind the riffles. Copper plates amalgamated with mercury are also used when the gold is very fine, and even in some instances amalgamated silver coins have been used for the same purpose. Sometimes the stuff is disintegrated with water in a "puddling machine," which is used, especially in Australia, when the earthy matters are tenacious and water scarce. The machine frequently resembles a brickmaker's wash-mill, and is worked by horse or steam power.

In workings on a larger scale, where the supply of water is abundant, as in California, sluices are generally employed. They are shallow troughs about 12 feet long, about 16 to 20 inches wide, and 1 foot in depth. The troughs taper

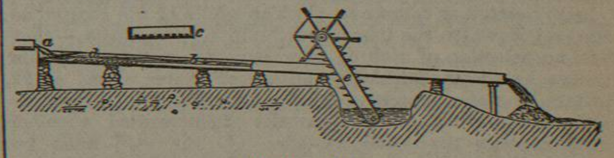

FIG. 2.—Sluice.

slightly so that they can be joined in series, the total length often reaching several hundred feet. The incline of the sluice varies with the conformation of the ground and the tenacity of the stuff to be washed, from 1 in 16 to 1 in 8. Fig. 2 represents one of the simplest forms of sluice as

[1] 1 dwt. per ton corresponds to 1 part in 653,333 by weight, and about 1 in 5 or 6 millions by volume.

used in river diggings in the north-west of America. A rectangular trough of boards, whose dimensions depend chiefly on the size of the planks available, is set up on the higher part of the ground at one side of the claim to be worked, upon trestles or piers of rough stone-work, at such an inclination that the stream may carry off all but the largest stones, which are kept back by a grating of boards about 2 inches apart at *a*. The gravel, which in this particular instance is from 12 to 16 feet thick, and with an average breadth to the river of 25 to 30 feet, is dug by hand and thrown in at the upper end, the stones kept back being removed at intervals by two men with four-pronged steel forks. The floor of the sluice is laid with riffles made of strips of wood 2 inches square laid parallel to the direction of the current (as at *b*, and in cross section at *c*), and at other points *d* with boards having transverse notches filled with mercury. These were known originally as Hungarian riffles. The bottom of the working, which is below the drainage level of the valley, is kept dry by a Chinese bucket pump *e*, attached to a rough undershot wheel driven by the current in the sluice. The sluice boxes are made in lengths, and united together spigot and faucet fashion, so that they may easily be removed and re-erected as the different parts of the claim are progressively exhausted.

In the larger and more permanent erections used in hydraulic mining, the upper ends of the sluices are often cut in rock or lined with stone blocks, the grating stopping the larger stones being known as a "grizzly." In order to save very fine and especially rusty particles of gold, so-called "under-current sluices" are used; these are shallow wooden tanks, 50 square yards and upwards in area, which are placed somewhat below the main sluice, and communicate with it above and below, the entry being protected by a grating so that only the finer material is admitted. These are paved with stone blocks or lined with mercury riffles, so that from the greatly reduced velocity of flow, due to the sudden increase of surface, the finer particles of gold may collect. In order to save finely-divided gold, amalgamated copper plates are sometimes placed in a nearly level position, at a considerable distance from the head of the sluice, the gold which is retained in it being removed from time to time. Sluices are often made double, and they are usually cleaned up,—that is, the deposit rich in gold is removed from them,—once a week. The gold is then recovered by "panning."

The application of a jet of water to the removal of auriferous gravels by the so-called hydraulic system of mining has already been noticed at vol. iv. p 701.[1] This method has for the most part been confined to the country of its invention, California, and the western territories of America, where the conditions favourable for its use are more fully developed than elsewhere,—notably the presence of thick banks of gravel that cannot be utilized by other methods, and abundance of water, even though considerable work may be required at times to make it available. The general conditions to be observed in such workings may be briefly stated as follows:—(1) The whole of the auriferous gravel, down to the "bed rock," must be removed,—that is, no selection of rich or poor parts is possible; (2) this must be accomplished by the aid of water alone, or at times by water supplemented by gunpowder; (3) the conglomerate must be mechanically disintegrated without interrupting the whole system; (4) the gold must be saved without interrupting the continuous flow of water; and (5) arrangements must be made for disposing of the vast masses of impoverished gravel.

[1] Much valuable information on this subject will also be found in the *Fifth Annual Report of the United States Commissioners of Mining Statistics*, Washington, 1873, p. 390.

The general appearance of an hydraulic gold working is seen in fig. 3, the water being brought from a ditch on the high ground, and through a line of pipes to the distributing box, whence the branch pipes supplying the

Fig. 3.—Hydraulic Gold Working.

three jets diverge. The stream issues through a nozzle resembling that of a fire engine (fig. 4), which is movable in a horizontal plane around the vertical axis *a*, and in a vertical plane on the spherical joint and centre *b*. so that the direction of the jet may be varied through considerable angles by simply moving a handle. The material of the bank, being loosened by the cutting action of the

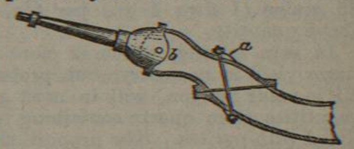

Fig. 4.

water, crumbles into holes, or "caves in," and the superincumbent mass, often with large trees and stones, falls into the lower ground. The stream, laden with stones and gravel, passes into the sluices, where the gold is recovered in the manner already described. Under the most advantageous conditions the loss of gold may be estimated at 15 or 20 per cent., the amount recovered representing a value of about two shillings per ton of gravel treated. The loss of mercury is about the same, from 5 to 6 cwt. being in constant use per mile of sluice. About 1 cwt. is added daily in at least two charges. The average half-yearly consumption is estimated at about one hundred flasks of 74 lb each, after allowing for the amount recovered in clearing up and distillation of the amalgam. The latter operation is performed at intervals of seven or fourteen days in the upper lengths of the sluice, and half-yearly in the lower parts.

The dressing or mechanical preparation of vein stuff containing gold is generally similar to that of other ores, except that the precious metal should be removed from the waste substances as quickly as possible, even although other minerals of value that are subsequently recovered may be present. This is usually done by amalgamation with mercury. In all cases the quartz or other vein stuff must be reduced to a very fine powder as a preliminary to further operations. This may be done in several ways, *e.g.*, either (1) by the Mexican crusher or *arrastra*, in which the grinding is effected upon a bed of stone, over which heavy blocks of stone attached to cross arms are dragged by the rotation of the arms about a central spindle, motion being furnished by mules or other power, or (2) by the Chilian mill or *trapiche*, also known as the edge-runner, where the grinding stones roll upon the floor, at the same time turning about a central upright,—contrivances which are mainly used for the preparation of silver ores; but by far the largest proportion of the gold quartz of California and Australia is reduced by (3) the stamp mill, which is similar in principle to that used in Europe for the preparation of tin and other ores, but has

received special modification in many details. Fig. C represents the ordinary Californian pattern of a stamp mill. The stamp is a cylindrical iron pestle faced with a chilled cast-iron shoe, removable so that it can be renewed when necessary, attached to a round iron rod or lifter, the whole weighing from 600 to 800 lb. The lift is effected by cams acting on the under surface of tappets *a*, and formed by cylindrical boxes keyed on to the stems of the lifter about one-fourth of their length from the top. As, however, the cams, unlike those of European stamp mills, are placed to one side of the stamp, the latter is not only lifted but turned partly round on its own axis, whereby the shoes are worn down uniformly. The bed or mortar A is of cast-iron. The height of lift may be between 8 and 10 inches, and the number of blows from 30 to 90 per minute. The stuff, previously broken to about 2 inch lumps in a Blake's rock-breaker, is fed in through the aperture *n* at the back of the "battery box," a constant supply of water being given from the channel *k*, and mercury in a finely divided state is added at frequent intervals. The discharge of the comminuted material takes place through the aperture *d*, which is covered by a thin steel plate perforated with numerous

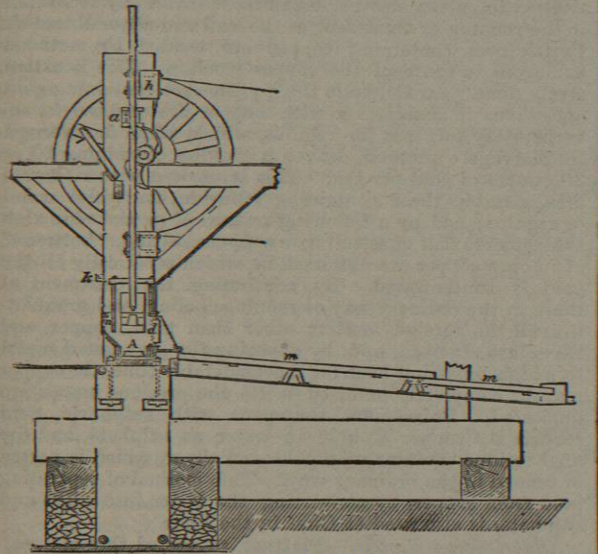

Fig. 5.—Stamp Mill.

slits about $\frac{1}{50}$th inch broad and $\frac{1}{10}$th to $\frac{1}{8}$th inch long, a certain volume being discharged at every blow and carried forward by the flushing water over the apron or table in front, *m*, covered by copper plates filled with mercury. Similar plates are often used to catch any particles of gold that may be thrown back, while the main operation is so conducted that the bulk of the gold may be reduced to the state of amalgam by bringing the two metals into intimate contact under the stamp head, and remain in the battery. The tables in front are laid at an incline of about 8 degrees, and are about 13 feet long; they collect from 10 to 15 per cent. of the whole gold; a further quantity is recovered by leading the sands through a gutter about 16 inches broad and 120 feet long, also lined with amalgamated copper plates, after the pyritic and other heavy minerals have been separated by depositing in catch pits and other similar contrivances.

When the ore does not contain any considerable amount of free gold, mercury is not, as a rule, used in the battery. The pulverized stuff is received upon blanket tables or sluices. These are inclined boards covered with coarse woolen cloth or sacking. The heavier particles become entangled in the fibres of the cloth, while the lighter deposits are carried forward by the current. At intervals of a quarter to half an hour the surface of the blanket is completely covered, when it is removed, and its contents are washed off in a tub of water and reserved for further treatment. This consists of amalgamation, in a contrivance analogous to the Hungarian mill subsequently described, and subsequent treatment in pan amalgamators somewhat similar to the *arrastra* in character, but with grinding surfaces of iron instead of stone.

At Schemnitz, in Hungary, quartz vein stuff containing a little gold, partly free and partly associated with pyrites and galena, is, after stamping in mills similar to those described above, but without rotating stamps, passed

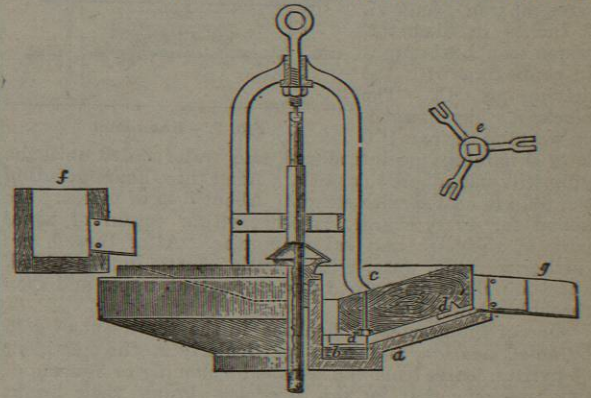

Fig. 6.—Hungarian Mill.

through the so-called Hungarian gold mill, fig. 6. This consists of a cast-iron pan *a*, having a shallow cylindrical bottom *b*, holding 50 lb. of mercury, in which a wooden runner *c*, nearly of the same shape as the inside of the pan, and armed below with several projecting blades, is made to revolve by gearing wheels placed either above, or, as in the figure, below. The connexion of the runner with the driving shaft is effected by the three-armed crutch shown in plan at *e*, which sits on the square part of the shaft. By means of set screws analogous to those of a flour mill, the runner is adjusted at such a height that the knives just clear the surface of the mercury. The stuff from the stamps arrive by the gutter *f*, and, falling through the hole in the middle of the runner, is distributed over the mercury, when the gold subsides in virtue of its superior density, while the quartz and lighter materials are guided by the blades to the circumference and are discharged at *g*, usually into a second similar mill, and sometimes to a third, placed at lower levels, and subsequently pass over blanket tables. The most advantageous speed is from 12 to 14 revolutions per minute. The action of this so-called mill is really more nearly analogous to that of a centrifugal pump, as no grinding action takes place in it. The amalgam is cleaned out about once a month. The average amount of gold collected from 50 tons of stuff stamped, is about 6 oz. in the mills, and in the subsequent dressing processes 1 lb of auriferous silver and 10 cwt. of lead. According to Rittinger, mercury that has been purified by distillation acts much more rapidly upon gold than such as has been saturated with the metal without losing its fluidity, although the amount that can be so dissolved is very small.

There are various forms of pan amalgamators of which space will not permit a description to be given. It may be stated, however, that experience of the great variety of pans that have from time to time been devised has led to