ployed to do the work. The variety and sizes of the twine and mesh were very small. The fishing industry was attaining considerable proportions, however, and the use of cotton twines stimulated a demand for them which induced other yarn manufacturers to engage in their production.

In the year 1858 the net and twine company referred to imported the first netting machine used in the country. It was a hand power Scotch machine, the only kind then in existence. The Scotch machine was not, and we believe it never has been, adapted to the manufacture of heavy netting, so that after its importation all netting, except that composed of fine twines, continued to be made by hand. For light netting, however, the company built in their own factory several machines of the Scotch pattern.

The limitations of this netting machine led the Net and Twine Company to expend a considerable sum of their money in attempting to develop two or three inventions designed to overcome the difficulty of knitting heavy twines, but none of them proved satisfactory. In 1862 a newly invented machine, quite different in principle and well adapted to heavy work, was put in operation. Some years afterward an ingenious native of the State of Connecticut, Mr. Squire, invented a machine for knitting fine threads which possesses many advantages over the Scotch machine.

The larger netting companies are using the Scotch machine, which has been improved somewhat in construction, and the one hundred and sixty-two power machine, and the company we have spoken of use also the machine of American invention in the manufacture of fine thread netting. They have purchased the rights of the inventor.

The extensive introduction of these different machines was, of course, a process of gradual accomplishment, and while it was taking place the fisheries were undergoing that wonderful expansion which we have little more than indicated in this paper. Without the machines it would not be possible to produce the great variety of twine and netting used, and it is true, no doubt, that the ability of the netting factories to supply everything imaginable has induced the fishermen to adopt a great many sizes of mesh and twine which would not otherwise be considered necessary. — The Fishing Gazette.

GOLD EXTRACTION PROCESSES.

By T. K. ROSE, in Science Progress.

FROM very early times the ancients were attracted by the beautiful color, the brilliant luster and the indestructibility of gold, and spared no pains in the endeavor to acquire it. In the code of Menes, who reigned in Egypt some 2,000 years before the time of Moses, the ratio of value between gold and silver is mentioned, one part of gold being declared equal in value to two and a half parts of silver, and it is, therefore, clear that the extraction of both metals from the deposits containing them must have been carried on before that time. It is indeed probable that gold was the first metal observed and collected, since it occurs in fragments of all sizes in loose sand, and the operations of collecting the larger pieces and melting them together are so simple. Among the rock carvings of Upper Egypt there are several illustrative of the art of washing auriferous sands by stirring and working them up by the hand in hollowed-out stone basins, and subsequently melting the gold in simple furnaces with the aid of mouth blowpipes. The earliest of these carvings is supposed to date back to about 2,500 B. C. However, in ancient times, gold appears to have been mainly derived from India, and that country continued to supply most of the gold used in Europe until the discovery of America by Columbus.

In order to collect alluvial gold, the sands were washed down over smooth sloping rocks by means of running water, and the particles of gold, sinking to the bottom of the stream by reason of their high density, were entangled and caught by the hair on raw hides spread on the rocks. Among the hides used were sheepskins, and hence originated the form of the legend of the Golden Fleece. Stripped of its heroic dress this legend of course described a piratical expedition to win gold which was being obtained from streams with the help of sheepskins by the inhabitants of what is now Armenia. Similar expeditions have not been unknown in much later times, and the method of obtaining gold by washing river sands is still practiced with improvements in matters of detail in many parts of the world. Hides are even now occasionally employed to catch the gold, but sheep's wool when used is generally in the form of blankets.

The use of mercury as an aid in the collection of gold contained in river sands or in crushed rock is also of great antiquity. The earliest mention of quicksilver itself appears to occur in the works of Theophrastus, about B. C. 300; but Diodorus of Sicily, who saw gold being extracted from quartz in Upper Egypt in the time of Julius Caesar, does not refer to its use.* Only a few years later, however, Vitruvius,† about B. C. 13, described the manner in which, by the help of quicksilver, gold was recovered from cloth in which it had been interwoven, and in Pliny's time the separation of gold from its impurities generally by the same means was well known.‡ It is probable that this knowledge was never afterward entirely lost, although the references to it in the middle ages are very scanty. For example, Geber§ in the eighth century was aware that mercury would dissolve considerable quantities of gold and silver, but not earthy materials, and Theophilus the monk,|| in the eleventh century, carefully described the method of washing the sands of the Rhine on wooden tables, the final operation consisting in treating the concentrates with quicksilver for the removal of the gold. Biringuccio¶ was taught the secret of this use of mercury in Italy some time before 1540 in return for the present of a valuable diamond ring, and it is clear that the so-called invention of the amalga-

mation process in Mexico by the Spaniards in 1557 was only the introduction or adaptation of a process already well known in Europe.

The existing methods of washing auriferous sands all depend on two principles—the great density of gold when compared with that of the siliceous material with which it is associated and, as Baron Born expressed it over 100 years ago, the “elective affinity” of mercury for gold when mixed with impurities. The ease with which gold amalgam can be collected in spite of its being less dense than gold is of course due to the fact that it is miscible in all proportions with mercury, so that under proper conditions large globules of liquid alloy are formed by the running together of smaller particles, and the former are readily caught in suitable crevices.

A large number of implements of varied form and efficiency are used in different parts of the world to apply these principles. In operations on a small scale the batea, the trough and the miner's pan are chiefly used. In South America, in West Africa, and in parts of China, the batea is used, a wooden vessel having the shape of a very short reversed cone. When held in the hands and filled with gravel and water, a peculiar gyratory motion imparted to it results in the collection of the gold in the apex of the cone, and the light material can then be readily washed away.

A small wooden trough, twelve or fifteen inches long, is used for the same purpose in the far East by the Chinese, the Tonquins, the Annamites, the Malays and others, the water being made to flow up and down until the gold has settled to the bottom. The miner's pan, a flat-bottomed iron vessel with sloping sides, was first used by the California pioneers, but has now become the favorite implement of Europeans for prospecting in all parts of the world. In early days in Australia and California millions of ounces of gold were obtained from the river gravels by its use, but apart from its value in prospecting, it is at most a rough and ready means of treating small quantities of rich material, and is only suitable to individual effort.

In combined efforts to treat larger quantities of sand, the machines all consist essentially of a slightly inclined trough, through which a stream of water is made to convey the auriferous sand, mercury being usually sprinkled on at short intervals of time. If the trough is long enough, and the stream of water not too rapid, the gold and mercury sink, and, uniting, are swept along together, until arrested by some inequality of the bottom.

Crevices and “riffles” or obstructions of various kinds are arranged to catch the amalgam. The simplest contrivances are transverse slats of wood nailed to the bottom of the trough or sluice. In Siberia square “pigeonhole” depressions have been continuously used for more than fifty years. In California, the sluice is paved with square blocks of wood placed an inch or more apart, or with large rounded stones, or ordinary iron rails between which are plenty of crevices where the amalgam can lodge. To catch light spangles of gold, blankets are spread, the loose fibers of which become charged with pyrites and gold, and in New Zealand plush is a favorite gold catcher.

When a “clean up” is desired, a stream of clear water is run through the sluice, the riffles are taken up, the mercury and amalgam washed down and allowed to accumulate at some convenient spot, and then ladled out and squeezed in bags of canvas or leather as in the days of Pliny, who describes the process as follows: “Ut et ipsum [i. e., argentum vivum] ab auro discedat, in pellis subactas effunditur, per quas sudoris vice defluens purum relinquit aurum.” The excess of mercury being thus filtered off, the paste amalgam, containing about one-third of gold, is retorted.

The methods of conveying the auriferous material to the sluices vary with the scale of the operations and the other conditions. When rocking cradles or the smaller sluices are used, the gravel is shoveled into them. In Siberia, where the valleys are shallow and the inclination of the ground small, the gravel is carried in carts up an inclined plane to an elevated wooden platform whence the sluice starts. In California, where the gulches are deep, the fall of the ground rapid, and the auriferous deposits of great thickness, the banks of gravel are attacked by jets of water of tremendous power, and the earth washed down and carried through the sluices without being touched by hand, the so-called “hydraulic method.” When the gravel beds are below the general level of the country they are raised by the “hydraulic elevator,” a jet of water, under a head of as much as 400 or 500 feet, carrying water, sand, and boulders alike up a pipe inclined at some 60 degrees to the horizon, so as to deliver them all at the head of the sluice, the vertical lift being sometimes over 40 feet.

One of the main difficulties in the hydraulic process is in the disposal of the tailings, which are usually discharged into a river or into the sea. The enormous amount of loose sand and gravel delivered from the hydraulic mines into the Yuba and Feather rivers, California, prior to 1880, filled up their beds to such an extent that in rainy weather disastrous floods ensued, and much valuable agricultural land was buried beneath sterile drift deposits and rendered worthless. The farmers thereupon took action against the mining companies and obtained a perpetual injunction forbidding the discharge of tailings into these rivers. The result has been to stop the use of the hydraulic method in these important districts, and an apparently irreparable blow was inflicted on gold-winning industry in California.

In every country as soon as the richest of the placer beds have been worked out, efforts are made to extract the gold from quartz veins. The quartz must of course be crushed, and the crushed material has in the past been generally treated similarly to the auriferous sands occurring naturally. Thus, according to the account given by Diodorus Siculus, already referred to, the quartz was reduced to coarse powder by pounding it in stone mortars, then finely ground in handmills resembling the flour mills of the present day, and finally washed down over inclined planks with water, when the lighter material was carried away and the heavy gold retained on the wood. Hollowed out stone mortars suitable for the first of these operations have been found in many parts of the world, including Wales, Central America, the Pyrenees, and Transylvania. The stamp mill has no doubt been evolved from the pestle and mortar, but was not used for crushing ores

until about the year 1519, when the process of wet stamping and sifting was introduced by Paul Grommestetter, in Joachimsthal, the two operations, however, being at first kept distinct.

Agricola has given an exact description of the treatment of auriferous quartz in Germany in 1556,* from which it appears that the methods in use at that time were strikingly similar to those still employed in Transylvania and the Tyrol, which were among the districts of which he wrote. Doubtless in these districts the methods have been handed down from generation to generation with little change, while in other countries where they were introduced hundreds of years later the changes have been rapid and striking. In those points in which the older Tyrolean practice differed from the modern one it resembled the procedure of the old Egyptians. The wooden stamps, shod with hard stone or iron, were arranged in sets of three, and raised by cams to fall by gravity when released. The rock was shoveled dry into the mortar, and coarsely crushed by the blows of the stamps.

Next it was ground as fine as flour in a stone mill supplied with water, and carried by the stream of water into the uppermost of three wooden tubs, whence it overflowed in succession into the other two. Revolving mechanical stirrers furnished with six paddles kept in agitation the contents of the tubs, and “separate even very minute flakes of gold from the crushed ore. These flakes, settling to the bottom, are drawn to itself and cleansed by the quicksilver (lying in the tubs), but the water carries off the dross.”† Agricola here expounds the theory of amalgamation still adhered to in Austria, where mercury is regarded merely as a useful means of collecting particles of gold which have already been separated from the crushed ore by their great density. The Tyrolean bowls still in use at Vorospatack in Hungary and in a few retired valleys in the Eastern Alps do not differ essentially from the tubs drawn and described by Agricola; and, although wet crushing by the stamps has been introduced, the mortar is not usually furnished with screens.

Elsewhere, the changes in stamp battery amalgamation since Agricola wrote his treatise have been many and great. One of the first was the addition of screens in the side of the mortar, so that the two operations of crushing and sifting were united. In 1767 M. Jars saw these in use in the Hartz,‡ though even then only a single screen of brass wire twelve inches square delivered the product of three stamps, and in several other districts of Germany screens had not been adopted. The most important improvement however has undoubtedly been the introduction of the amalgamated copper plate for catching gold, the complement of the practice of charging mercury with the ore into the battery and so combining the operations of crushing and amalgamation. No mention of either this practice or the use of copper plates appears to have been made before stamp batteries began to work in California in 1850, although they had very likely been used in Georgia for some time previously.

The use of the copper plate was probably suggested by the experience in Mexico and South America of the working of the Cazo process, in which it is well known that amalgam tended to adhere to the copper sides of the vessel unless the proportion of mercury to gold and silver present was less than four to one. Thus Baron Born wrote in 1786:§ “In new kettles . . . the inside becomes wholly and so perfectly silvered that it never can be cleaned. . . . The silvery coat is daily increased by slow and gradual apposition, and the crusts of amalgama, accumulating on the bottom and sides of the vessels, become gradually so thick that on emptying them they often fall off by their own weight as silver plates, which, when dry, show the laminated texture of their daily augmentation.”

The knowledge of this behavior of amalgam in the Cazo process must have been common to many who were engaged in exploiting the quartz veins of the West soon after their discovery, and the speedy application of this knowledge is exactly what might be expected from those sturdy pioneers. Nevertheless, the exact date and locality of the introduction of the copper plate remains a matter for conjecture.

The copper plates fixed on the battery in the early fifties were about four inches wide and as long as the mortar, and were placed one on the “feed” side and one on the discharge side just underneath the screens. It was soon found that the plates worked better from the start if mercury was rubbed on them before they were placed in position, and this has now been invariably done for many years. Crushed ore, stones, water, and amalgam are flung violently against the plates and the amalgam is retained in great part.

The scouring action of the pulp on the plates is, however, always great, and becomes more violent in proportion as the stamps are larger. These are now as much as 1,100 and even 1,250 lb. in weight in the Transvaal—an enormous mass when compared with the 750 lb. stamp of a few years ago and the 120 lb. stamp of the last century. With this increase in weight, it has become desirable to modify the use of the copper plate. The plate on the feed side, long ago condemned by many, is accordingly being discarded more and more, and that below the screens is curved away in such a manner that it cannot be struck directly by the splash from the stamp, while slots in cast steel plates lining the mortar have been devised for the purpose of catching amalgam.

After leaving the mortar the pulp was treated forty years ago mainly by passing it over inclined tables covered with blankets, much in the same way as Jason may have seen the golden sands worked in Asia Minor. The sands accumulating on the blankets were washed off at intervals and ground in mills with mercury. In addition, the ore was frequently passed over or through baths of mercury (as is still done in many Australian mills) and concentrated in various ways. Amalgamated copper plates over which the pulp flowed were tried, but in Western America were at first almost everywhere rejected,|| probably owing to the great depth of the stream of ore and water made to flow over them. When this mistake began to be rectified, some twenty-

* Agricola. De Re Metallica, p. 233. Basel, 1556.

† Agricola, loc. cit.

‡ Voyages Metallurgiques, vol. ii, p. 309. Paris, 1780.

§ Baron Inigo Born's New Process of Amalgamation, p. 122, translated by Raspe. London, 1791.

|| See Nevada and California Processes of Silver and Gold Extraction, p. 61, by G. Kustel. San Francisco, 1863.

* Diodor., iii, 13. A full translation is given by B. H. Brough in his Cantor Lectures on Mine Surveying. Jour. Soc. Arts, 1892.

† Vit., lib. vii, cap. 8.

‡ Nat. Hist., lib. xxx, cap. vi, sect. 32. Quoted in full in Percy's Metallurgy of Silver and Gold, p. 559.

§ Salmon's Geber, cap. 47.

|| Theophilus, lib. iii, cap. 49.

¶ De la Pirotechnia. Venetia, 1540. Lib. ix, cap. xi, fol. 142.

five years ago, the value of the plates was soon recognized in California.

In the extraction of gold from crushed ore by means of amalgamated copper plates, the pulp is led over their surface in a very thin stream, not more than a quarter of an inch deep. The plates are slightly inclined, wider than the screens from which the pulp issues, and from six to twelve feet long. The pulp does not run down in a regular stream, but in a series of little wavelets which tumble over and over and are supposed to bring every part of the pulp in succession in contact with the amalgamated surface. The catching powers of the plates are thus supposed to be practically independent of the tendency of the particles of gold or amalgam to sink to the bottom of the stream. This theory is not accepted by the Austrian school, and it is certain that native gold is caught more easily in proportion as it contains less silver, so that when the particles of metal consist of an alloy largely consisting of silver, and are therefore of comparatively low density, the yield on the plates is generally poor. In any case, however, the amalgamated plate should theoretically be better adapted for its work than the Tyrolean mill and other machines using mercury baths, owing to the slight depth of the pulp on the plates and the short distance through which the gold particles are compelled to settle before reaching a catching surface. The plates are wiped down with rubber or brushes about once a day and the gold separated in the usual way from the excess amalgam thus collected.

Admirable as is the amalgamation process in many respects, it has always been recognized that the extraction of gold by its use is generally far from complete. Besides the comparatively large particles of free gold which are readily saved by amalgamation, all ores contain more or less gold in an excessively fine state of division (the aurum larvatum or "disguised" gold of the last century) as well as gold contained in sulphides (aurum mineralisatum), and these particles cannot be extracted by the copper plates.

In an investigation on the dimensions of gold particles in ores J. A. Edman* observed a single chip of quartz $\frac{1}{16}$ inch in diameter, which when magnified 50 diameters, showed over 300 particles of gold varying in size from $\frac{1}{1000}$ to $\frac{1}{100}$ inch, not only on the surface of the stone, but scattered though the transparent mass. Higher powers showed still greater numbers of smaller particles. The gold contained in pyrites, if, as seems likely, it is generally free, must be often still finer. It has been likened to the mortar in a brick wall, and is almost as difficult to catch as the motes in a sunbeam. Prolonged grinding with mercury no doubt increases the chances of such gold being amalgamated, and hence the success which has frequently attended the use of the Mexican arrastra, where the grinding surfaces are of stone, and of its successor the iron amalgamating pan.

Nevertheless, the yield of gold, mainly owing to the "flouring" and "sickening" of the mercury, is not always good even in these slow working and therefore costly machines. Mercury, when triturated with ore for a long time, tends to break up into very fine particles which, although apparently clean and bright under the microscope, refuse to run together, and are carried away by the stream of water and lost, together with the gold already taken up by them. Such mercury appears grayish white, and is said to be "floured." Moreover, when base metals are present in the ore they become amalgamated, and then, oxidizing, coat the surfaces of the globules of mercury with black scum, which effectually prevents the amalgam from adhering either to gold or to amalgamated plates. This "sickening" is doubtless also caused by the formation of compounds of the mercury itself. Ores containing sulphides of arsenic or antimony (which are reduced by mercury) are particularly apt to cause "sickening," but manganese dioxide, partly decomposed copper pyrites, zinc blende, and galena are also harmful.

It has been well known ever since the time of Agricola that the gold contained in these minerals, although not easy to extract by mercury, may be readily obtained by concentrating the ore (all finely divided free gold being, of course, lost in the process); the concentrates are then smelted, the gold accumulated in a reduced metal, such as lead or copper, and subsequently separated by cupellation or other means. The impossibility of applying this method of procedure to individual mines far distant from coal beds, and in places where a mixture of different kinds of ore cannot be obtained, prevents the universal application of the method, although in the neighborhood of such smelting centers as Freiberg and Denver nothing better is required.

The chlorination process, now nearly fifty years old, is of more general value for treating concentrates. Chlorine is a somewhat slow solvent for gold, any particle occurring native which is visible to the unassisted vision requiring many hours for its complete dissolution; but it is well adapted to dissolve the fine flakes existing in pyrites. Unfortunately, chlorine has a strongly preferential action on sulphides, and to avoid the enormous waste of gas which a small percentage of these substances cause it is necessary to precede chlorination by careful and complete roasting. After this there is little difficulty in the process. Oxides of the metals, except the alkaline earths, are very slowly attacked by chlorine; and when the alkaline earths are present salt is added in the roasting furnace. Chlorine is applied to the slightly clamped ore in the form of gas, or, in more modern practice, as a strong aqueous solution. After a day or two the liquid is filtered off, and the gold precipitated by ferrous sulphate or sulphureted hydrogen.

The problem of the extraction of gold contained in pyrites and complex minerals was partially solved by the chlorination process, but the cost of roasting is a stumbling block in many cases, and it was the desirability of avoiding this which led to the introduction of the use of cyanide solutions for leaching, probably the most important event in the history of the metallurgy of gold since the first application of mercury to gold extraction. The extraordinary properties of very dilute solutions of cyanide of potassium were unmarked and in great part unknown until quite recently. That metallic gold is soluble in alkaline cyanides unaided by an electric current remained an interesting but useless fact until it was found that a solution containing only

one per cent. of potassium cyanide dissolves gold at least as rapidly as much stronger solutions, although it has a very slow and partial action on most sulphides and other minerals occurring in gold ores. The presence of free oxygen is necessary for the dissolution of the gold, which takes place according to the equation

The oxygen is supplied from the air entangled in the porous ore, or dissolved in the solutions, in which MacLaurin* has shown that it can be retained in the presence of alkaline cyanides in spite of its rapid absorption by the latter with the formation of cyanates. The gold can be recovered by precipitation on zinc and subsequent melting, or by electrodeposition on suitable cathodes, of which lead only has been largely used.

The development of the cyanide process proceeded apace as soon as it had been introduced. The mechanical improvements devised were numerous, the most important being the enlargement of the size of the leaching vats, until the largest now hold 600 tons of ore. The chief chemical improvements have been the introduction of the use of caustic soda or lime to neutralize the acids and acid salts in "weathered" pyritic ores, and the reduction in the strength of solutions, the favorite "strong" solution now containing from 0.25 to 0.30 per cent. of available KCy, while solutions as weak as 0.01 per cent. are found in many cases to be equally efficacious if a somewhat longer time is allowed. In accordance with the experience in the extraction mills, MacLaurin† has found that gold and silver in the form of plates are most rapidly dissolved by solutions containing from 0.1 to 0.4 per cent. of cyanide, the maximum rate being observed with solutions containing about 0.25 per cent. of cyanide of potassium. A fairly rapid rate of dissolution, however, is still observable when only 0.005 per cent. of KCy is present.

Cyanide of potassium acts rapidly when free oxygen is present in large quantities, as for example when gold floats on the solution, with its upper side dry. Under such conditions, cyanide is at least as rapid in action as chlorine, but in proportion to the supply of free oxygen falls off, the rate of dissolution of gold in cyanide becomes slower, and when air is excluded as rigidly as possible, hardly any action can be observed. In practice, these facts are of importance. Finely divided gold in ordinary ores is dissolved in two or three days. When concentrates containing a large proportion of sulphides are being treated, however, free oxygen is absorbed by the pyrites as well as by the solution, and the treatment lasts as much as two or three weeks with a corresponding increase in the destruction of the cyanide by the minerals in the ore. An artificial supply of oxygen or of oxidizing agents shortens the time required but increases the waste of cyanide. Moreover, when pyritic ores or concentrates contain much marcasite, and, in many cases, when copper sulphides or some other minerals are present, the process is useless, enormous quantities of cyanide being converted into other compounds before any gold is dissolved.

The process is therefore of limited application to complex ores and concentrates generally, although of wide applicability to ores comparatively free from sulphides, especially after the coarser particles of gold have been removed by amalgamation. Certain deposits of complex ores, above the average in richness, are at present left untouched for want of a process by which they can be treated.

The cost of treatment of gold ores by the processes described above of course varies enormously with the locality and the special conditions of the case. Under favorable conditions the following may indicate approximately the minimum amount of gold which must be present in an ore, in order that it may be treated at a profit by the most suitable process. Auriferous sand, washed in the miner's pan, must contain about one part of gold in 100,000 or say six pennyweights per ton of ore. When the sluice is used, the sand being excavated and carried to the sluice by hand labor, as in Siberia, there must be at least one part of gold in 2,500,000 parts of sand, or six grains to the ton. When the hydraulic method is possible, only one part in 18,000,000 may be enough, or three-fourths of a grain of gold per ton, a proportion about equal to that which Liversedge‡ found to exist in the sea water off the east coast of Australia. If the gold is contained in quartz, the cost of mining and of crushing the stuff makes the whole process of treatment far more expensive. Excluding the cost of mining, however, the cost of crushing and amalgamation requires the presence of at least one part of gold in 400,000, or say one and a half dwts. per ton. The cost of chlorination is equal to not less than one part of gold in 200,000 of ore or three dwts. per ton, although if only applied to concentrates, the cost per ton of the original ore may be trifling. Lastly, the cyanide process might be applied to the crushed tailings from the amalgamation process if they contain more than one part of gold in 600,000 or one dwt. per ton. If the ore has to be crushed, it must of course be richer. As stated above, these estimates apply only when the conditions are the most favorable. In general, such poor ores could not be worked at a profit.

At the present time the annual production of gold from all these sources is about £42,000,000 per annum, or double the output of seven years ago. It is greater than at any previous period in history, the nearest approach to it having been made in 1853, when the river gravels of California and Australia were at their best. The output was then estimated at £38,000,000.

Of the present output, washing processes, formerly instrumental in producing by far the larger proportion of the gold won, are now probably answerable for no more than 30 per cent. The amalgamation of crushed vein stuff, now the most important process, produces about 55 per cent. of the whole gold production. The two wet processes, chlorination and cyanide, account for some 11 per cent. of the output, of which about two-thirds are contributed by the cyanide process, and, lastly, smelting perhaps produces 3 or 4 per cent. of the total. In the future, as placer gravels become exhausted more and more, the proportion of the out-

put derived from them will continue to fall off, and the greatest increases will certainly take place in the production from stamp battery amalgamation and the cyanide process. The output from chlorination and from smelting has been for some years stationary or declining, and their proportion of the world's production will doubtless suffer a continued though gradual reduction. It is obvious that by new discoveries the whole direction and progress of the art might be modified. As the old deposits become exhausted the miner is compelled to go deeper into the earth and the metallurgist to treat poorer and more refractory ores. "Such is the vast labor expended on the extraction of gold. And from this description I think it is clear that gold is hard to get as it is difficult to keep; and though all men long to get it, yet when they have it they find as much pain as pleasure in the use of it."

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* Jour. Chem. Soc., vol. lxiii, p. 724 (1893).

† Jour. Chem. Soc., loc. cit. and vol. lxvii, p. 199, 1895.

‡ Proc. Roy. Soc. of N. S. W., 1895.

* Mining and Scientific Press, San Francisco, August 12, 1892.