Messrs. Mack and Emden proved by means of photographs the presence of regular successive light and dark lines in a steam flowing from an orifice, which cannot be said to be anything else but acoustic waves; but as to the value of the existing pressures in this stream we were totally in the dark. Emden assumed that at places of compression the same condition exists as in the orifices, but he further said in contradiction to himself that there exists the same pressure at every place in the steam as exists in the surrounding atmosphere, and claims that there is a change of density. According to this, for instance, for air, places of smallest velocity, that is smallest energy, must coincide with places of smallest temperature, that is, smallest potential energy, which, Prof. Loewenstein says, is obviously impossible. By his calculation he further believed to have proved that the difference between the initial and the orifice pressures can only be used to produce the additional velocity of flow; the remainder of the available work is transformed into acoustic energy. The experiments lately made by Prof. Stodola contradict these opinions; they prove that the steam first expands to the existing pressure before the orifice, that therefore the first rush (as in the case with suddenly releasing a compressed spring) too much potential energy is changed into kinetic energy. Only this excess changes into acoustic vibrations and is recharged into heat at the rim of the stream by friction and eddy currents. The oscillations occur in the axial direction as well as in the radial. The stream flows at the pressure of the orifice into a region of much smaller pressure, and begins to expand in a radial direction. The resulting drop of pressure accelerates the particles also in the axial direction. Steam flowing from a diverging nozzle shows the same phenomena as from a simple orifice. With varying back pressure it was found that the steam on leaving the nozzle gave very regular acoustic vibrations, but it was possible to so fix the back pressure that every trace of a vibration disappeared.

From these experiments it is finally determined that the steam in a nozzle expands nearly adiabatically independent of the back pressure. If the steam flows into a place in which a back pressure exists exactly equal to the final pressure of expansion then the pressure in the stream is not changed at all. If the pressure is lower, acoustic vibrations occur, as with a simple orifice; if the back pressure is too high, a steam shock occurs with more or less drawn-out oscillations. By entirely filling out the cross-section of a diverging nozzle, a vibration is made difficult, if not entirely impossible. Prof. Loewenstein believes we can hardly go wrong if we say that the drawn-out vibrations occurring in a simple orifice are caused primarily by the sudden difference of pressures at the stream's rim and the surrounding atmosphere, which the stream quickly spreads. There is, therefore, the possible assumption that when vibrations still occur in the interior of the nozzle, the stream has detached itself at such places from the wall.

If the nozzle is constructed according to the formula of Zeuner, the final pressure will be greater than the prescribed back pressure, because friction transposes the kinetic energy into heat, and the expansion line will rise above the adiabatic. A nozzle calculated, therefore, according to Zeuner would actually be somewhat too long. This fact was soon recognized. To correct this Rateau, and after him Delaporte, proved by experiments that the pressure of a stream on blades or suitable plates decreased very little if the nozzles were made shorter—that is, the stream is allowed to flow out at a slight over-pressure—and recommended that this be done. It remained for Stodola to prove by his experiments just mentioned that violent acoustic vibrations would then take place in the stream, and that these must be avoided. It is important to make the nozzle dimensions suitable to the assumed back pressure. Before correct nozzle dimensions can be determined we must know from experiments the probable steam friction loss in the nozzle and then the design of the nozzle is easily accomplished.

In conclusion, Prof. Loewenstein pointed out that in the steam turbine we are confronted with an entirely new series of phenomena. The knowledge of steam accumulated by familiarity with the reciprocating engine is of little use in designing this newest yet oldest of prime movers. Nor can the cut-and-dry methods that have brought the reciprocating engine to its present stage of excellence be employed in the steam turbine. Modern commercial conditions are such that design must be based on ascertaining physical laws. This rapid advance has necessitated the re-investigation of steam from the point of view of velocity instead of pressure, of kinetic energy instead of potential, and the friction of rapidly moving bodies against a vapor instead of a lubricated surface, of the balancing of parts so that they shall revolve about their center of gravity, and of numerous other questions which are but beginning to make themselves felt. The available data are few, and practically all of the information is scattered through the pages of German and French scientific periodicals and a few books.—Eng. Record.

ELECTRIC POWER FROM BLAST FURNACES.*

By P. EYERMANN.

ADVANTAGES OF ENGINES DRIVEN BY BLAST FURNACE GAS.

Gas engines driven by blast furnace gas have now been in successful operation in Germany more than ten years. In the very first stages of this development many prominent engineers reached the opinion that ultimately this use of the blast furnace gas would re-

sult in the erection of auxiliary plants to take advantage of the power thus cheaply generated. There is no doubt that large cities such as New York, with the enormous amount of electric power they require, would offer opportunities for profit from the erection of such works. The writer has made a calculation for the purpose of demonstrating in detail why such a proposition has a good basis. Objections may of course be raised on the basis of experience obtained with existing furnaces of the old-fashioned type. The smoke from coal fires in operating boilers and the enormous quantities of dust escaping from blast furnace stacks, stoves, and chimneys may afford ground for serious objections. But these troubles are overcome with gas engines, and a modern blast furnace plant can be made to keep its surroundings thoroughly clean. Even if coal is supplied directly to a plant and not coke, there is no dangerous smoke or gas escaping from up-to-date coke ovens.

In cities with convenient harbor equipments like New York or Philadelphia a big coke-oven plant, blast furnaces, or a steel plant may become a desirable industry in the future, since it would be coupled with less dust and smoke troubles than any large city power and light plant, skyscraper building, or illuminating gas works.

The following improvements made in the last ten years constitute the most important reasons for a change in the iron industrial situation: No waste in coal, no waste in coke, no waste in water, no dust nuisance from iron ores, no nuisance from smoke, no escaping steam, no steam engine, no smokestack at all, no boiler explosion danger, no boilers.

A FURNACE PLANT CONSIDERED AS A GAS PRODUCER.

The main point in regard to the construction as well as concerning the management of such a big gas producer as a blast furnace plant may be considered as follows: The complete plant may be based to-day on selling electricity and obtaining as main by-products coke (with its auxiliary by-products, sulphate of ammonia, benzol, sal-ammoniac, tar, and naphtha), pig iron (with its auxiliary by-products, slag cement, bricks, and heating gas), and steel, if desired. As the installation of gas engines instead of steam motors is the most important matter, therefore the apparatus for gas manufacturing, such as the coke ovens and blast furnaces, must be constructed with reference to the most favorable conditions for the operation of the gas engines. The coke ovens as well as the blast furnaces should be provided with a charging mechanism which works as continuously as possible, because the thermal efficiency of the gas engine depends upon the regular and continuously uniform quality of the gas. The financial efficiency of the plant depends also upon the gas engine, as the latter produces the main product—namely, electricity.

There is also no doubt that a continuous charging of the blast furnace assures a better run and a better gas. Thus the main product is also obtained very regularly and the by-products can be drawn continuously in lieu of intermittently, as now. The pigs may be made by continuous casting on an improved pig iron casting machine, and the same can be said for the slag. If pigs of only 40 pounds each are cast (and this is convenient for cupolas) and the blast furnace should be of 576 tons daily capacity, then 20 such pigs are cast per minute, or one for each three seconds of casting time, which is just right for the machine.

NEW YORK AS A FURNACE LOCATION.

A blast furnace plant in New York would be based on a supply of iron ores shipped from the lake harbors to the plant by water from Buffalo. Other sources would be Canada, Spain, etc., by the Atlantic Ocean. The fuel supply may be based on direct coke contracts or on shipments of coal from Pennsylvania, Virginia, etc. The latter method may be preferred, as the power from the coke oven gas is secured and the other by-products are made right in the market. Thus, starting with the coke ovens, an approximate calculation is as follows:

Of coal, 11,000 tons yield 10,000 tons of dry coal or are converted into 7,850 tons of coke; the balance on an average consists of 120 tons of ash, 110 tons of sulphate of ammonia, 100 tons of tar, 30 tons of pitch, 60 tons of benzol, 5 tons of naphtha and 2 tons of sal-ammoniac, or about 8,250 tons of products out of 10,000 tons of dry coal. There is also produced 1,600 tons of coke oven gas from which it is desirable to earn profits. If such a complete plant belonged to the municipality the city would have its own required electricity free of cost.

Practice has proved that 1 ton of coal is equivalent to 10,000 cubic feet of such gas, or even more. The heating value is nearly the same as that of city gas, averaging, say, 600 British thermal units per cubic foot. Many gas engines will yield 1 horse-power for 10,000 British thermal units, but, conservatively, 12,000 British thermal units may be taken in this calculation, making each horse-power require only 20 cubic feet of coke oven gas per horse-power per hour. Of the gas made 50 per cent is used for heating the ovens, and if a further loss is allowed of 10 per cent of the gas for uncontrollable leakage, or for engines running under less favorable conditions, then 4,000 cubic feet of gas is available for power, or 200 horse-power for each ton of coal.

The same result may be checked in the following way: 1,600 tons of coke oven gas will yield approximately 112,000,000 cubic feet, as 1 ton of gas is equivalent to 70,000 cubic feet at normal temperature. Subtracting 10 per cent for loss and 50 per cent for heating purposes leaves 44,800,000 cubic feet, or 2,240,000 horse-power. Dividing this by 11,000 tons, the quantity of

coal, we reach an equivalent of 230 horse-power per ton of coal, or, referred to the coke, approximately, taking 216 horse-power as an average of the above two results per ton of coke, 200 horse-power, which is usually lost to-day.

DETAILS OF OPERATING SUCH A PLANT.

One ton of pig iron requires an average of 1 ton of coke and 2 tons of iron ore. With one furnace of 576 tons daily output especially designed as a gas producer for the subsequent generation of electricity through gas engines the calculation works out as follows:

With the object of obtaining somewhat richer blast furnace gas than may be obtained by using coke alone some coal may be charged into the furnace with the coke. It may be preferable also under certain conditions to mix the furnace gas with the gas from the coke ovens in order to secure a more uniform gas. For each ton of pig iron there would be obtained an average of 150,000 cubic feet of gas having a heating value of at least 100 British thermal units per cubic foot. As it may be also possible in the future to heat the required blast with the waste heat of the liquid cinder, thus doing away with the stoves, it is even conceivable to figure that for each ton of pig iron may be produced the following power: The gas has $150,000 \times 100 = 15,000,000$ British thermal units, and the gas engine requires 12,000 British thermal units per horse-power, thus making 1 ton of iron equivalent to 1,250 horse-power in a 576-ton plant, or 30,000 horse-power per hour.

At present, however, we must consider the following: From this $150,000 \times 24 = 3,600,000$ cubic feet of blast furnace gas 25 per cent is to be deducted for heating the stoves. In earlier days the amount was higher, but in a modern plant, equipped with improved cleaning apparatus, not more will be required. Therefore 900,000 cubic feet are set aside for heating gas for the blast.

For supplying air to the coke in the blast furnace by means of the blowing engines the latter are built on an average for, say, 80 to 100 cubic feet of air per pound of coke charged. For 24 tons of coke required per hour under these conditions $2,000 \times 24 \times 100 = 4,800,000$ cubic feet of air are required per hour. With a pressure of 20 to 25 pounds on an average, each 100 cubic feet per minute may require horse-power up to 5 per hour, or $4,800,000 \div 60 = 80,000$ cubic feet per minute, requiring an engine of 3,200 to 4,000 horse-power. Each horse-power of that engine would require 12,000 British thermal units, or 100 cubic feet, of blast furnace gas which would result in a further deduction of 400,000 cubic feet of gas for the blowing engines.

The uncontrollable leakages and losses in an up-to-date plant should not be more than 5 per cent or 180,000 cubic feet.

Mechanically operated cleaning plants have given the best results and are using from 0.4 to 0.7 horse-power for 1,000 cubic feet. If all the gas is cleaned this would take $3,600 \times 0.7 = 2,520$ horse-power, or another loss of 252,000 cubic feet of gas per hour, for cleaning purposes.

For auxiliary machinery, such as ore and coke handling appliances, electric light, power transmission, compressed air and water pumps, elevators and hoists, pig iron casting machines, etc., there would be required per ton of pig iron per day nearly 2 horse-power per hour, or another loss of $576 \times 2 = 1,152$ horse-power, or 115,200 cubic feet, of gas per hour.

Without further considering in this connection the possibility of heating open hearth furnaces, etc., with blast furnace gas, the power expressed in electricity which is daily obtainable is as follows:

	Cubic feet.	Cubic feet.
Blast furnace gas.....	3,600,000	
Less:		
Blast heating gas.....	900,000	
Blowing engine gas.....	400,000	
Furnace loss	180,000	
Cleaning gas	252,000	
Power gas (auxiliaries)	115,200	
		1,847,200
Remaining for further utilization.....	1,752,800	

The gas thus remaining when converted into electric power by gas engines gives 17,528 horse-power on the brake, and, allowing 10 per cent loss for efficiency in the electric generators and transformers, 17,528 — 1,752 = 15,776 electrical horse-power, equivalent to approximately 11,760 kilowatts.

It is now only a few years (1896-1897) since pig iron was placed on the New York market at \$10.50 to \$12 a ton. It is to be hoped that such times will not come again, but they should be remembered in considering the basic costs. The price of coke in large quantities delivered in the bins may be placed at \$3.50 per net ton. Iron ore under various conditions may be had at \$2.50 per ton; adding for lime, repairs, labor, etc., and maintenance another \$3.50, brings the cost of pig iron up to \$12 per ton, assuming that the plant is valueless after ten years. The cost per kilowatt is obtained on the basis of 24 tons of pig iron per hour, producing 11,760 kilowatts. One ton of pig iron is thus equal to 490 kilowatts, and as each ton costs \$12, 1 kilowatt costs 2½ cents to produce.

Theoretically it may be said that pig iron is a by-product of the new improved gas producer, fired with coke and charged with iron ore as a flux for the ash and clinkers. The latter are melted down, however, thus avoiding the stoking, and characterizing the blast furnace as the best gas producer of larger size. The

* Iron Age.

connection of a steel plant is desirable, because in it the coke oven gas may be used either pure or mixed with the blast furnace gas for heating the various melting and heating furnaces. The boiler is then entirely avoided, as all rolling-mill engines run on gas, all auxiliary machines with electricity, and no other coal is supplied than may be required for the manufacturing of the coke for the blast furnace. This would constitute an electric plant using only plain coking coal and iron ore for power.

[Concluded from SUPPLEMENT No. 1545, page 24759.]

PRECIOUS METALS RECOVERED BY CYANIDE PROCESSES.*

By CHARLES E. MUNROE, Ph.D.

The methods used in the Witwatersrand have been described recently by John Hays Hammond,† as follows:

"The following description applies to the treatment of ores in the pyritic zones. Ores from the upper (oxidized) horizons of the reefs, which constitute but a small percentage of the ores treated, require a slight modification of the process.

"The ground near the mines is level, and does not permit transportation by gravity; consequently the ore must be first elevated into the ore bins at the mill, and the tailings leaving the mill must be elevated for treatment by the cyanide process. This is done either by tailing pumps, or, preferably, by tailing wheels. These are from 40 to 50 feet in diameter, and discharge the tailings into a launder, which, with a grade of about 3.5 per cent, carries them to the cyanide works. The auriferous pyrites are, to a large extent, taken out as concentrates by means of Spitzlütten (hydraulic classifier). About 10 per cent of the mill pulp recovered in this way consists of pyrites with coarse sand, a concentration of 10 to 1 being obtained. These concentrates are taken to tanks for separate treatment. From two to three weeks of treatment is required in order to obtain from this material a recovery of from 90 to 95 per cent of the gold it contains. A solution of about 0.25 to 0.3 per cent of cyanide of potassium is used. After passing over the Spitzlütten the tailings are run to Spitzkasten (pointed boxes), where the heavier sands are allowed to settle, while the lighter material (slimes) overflows, and is carried to the slime works for special treatment. The sands which settle in the Spitzkasten, representing about 70 per cent of the battery pulp, are continuously discharged by pipes leading from the bottom of the box, and are delivered by a hose or by an automatic revolving distributor to settling tanks, into which they are so fed as to be as thoroughly mixed as possible. This separation of the sands from the slimes has to be carefully made, so as to remove all clayey substances, the presence of which would otherwise prevent rapid percolation of the solution and the free access of atmospheric oxygen, which is essential to the solution of gold by cyanide.

"Most of the modern plants have a system of double treatment, the tailings being settled in the settling tanks, when they are treated, after being allowed to drain, with a weak solution of cyanide of potassium. This addition of the cyanide of potassium is made rather for the purpose of saturating the sands with the solution than for thorough leaching, which would be difficult on account of the packing of the sands as they are settled, rendering percolation difficult. After the solution has been drained off, the sands from the settling tanks are discharged into the leaching tanks, placed immediately below the settling tanks, from which they are filled from discharge doors on the bottom of the latter. For a 200-stamp plant sixteen steel settling and sixteen steel leaching tanks are usually employed. From three to four settling and leaching tanks are used for the treatment of the Spitzlütten concentrates above described. The settling tanks are usually 40 feet in diameter and 9 feet high. The leaching tanks have the same diameter, but usually a foot less height. The capacity of these tanks is about 400 tons of pulp each.

"In the leaching tanks the pulp is subjected to three treatments with cyanide of potassium. Where the MacArthur-Forrest process is used, the strong solution contains 0.25 per cent, the medium solution 0.2 per cent, and the weak solution 0.10 per cent of KCy. In the Siemens-Halske process the solutions are weaker, namely, the strong solution, 0.10; medium, 0.02; and weak, 0.01 per cent of KCy.

"The treatment requires from four to seven days. From 130 to 150 tons of solution are usually employed for 100 tons of sand. After being allowed to drain, the sands are discharged through bottom discharge doors into trucks, in which they are removed to residues or tailings heaps. Here, again, elevation is necessary, on account of the flatness of the country, and is usually effected by the endless rope system. These tailings heaps are conspicuous throughout the mining district. By reason of the heavy winds prevailing at certain seasons of the year, they are becoming a great nuisance, and the question of their future disposition is one of the problems for the mining engineer.

"The cyanide solution, after being drawn off from the leaching tanks, is taken to the precipitation boxes. The gold from the strong solution is precipitated in one set and that from the weak solution in another set of boxes. Precipitation is effected by either the MacArthur-Forrest or the Siemens-Halske process.

"The MacArthur-Forrest Process.—In this process the gold is precipitated by zinc, the solution passing

upward through a succession of compartments, in which are placed zinc shavings or filings, resting on a movable tray of coarse screening. About twenty precipitation boxes, 20 feet by 3 feet by 3 feet 9 inches in size, are used. The gold-bearing solution is brought into close contact with the zinc, causing the deposition of the gold, partly as a metallic coating on the zinc and partly as gold slimes, which sink to the bottom of the box. As the zinc is gradually dissolved by cyanide more is added.

"Once or twice a month the boxes are emptied, and the gold slimes are treated with dilute sulphuric acid, then dried and melted in crucibles. The dried slimes contain about 15 to 20 per cent of gold, and after fluxing with borax and soda an ingot of 0.750 to 0.800 fineness in gold and 0.100 in silver is obtained. The slag, carrying from 5 to 50 ounces of gold per ton, is usually sold to smelters.

"This precipitation process yields satisfactory results only with solutions containing more than 0.1 per cent of cyanide, the weaker solutions not being acted upon by zinc. An improvement of the method is the addition of lead to the zinc, whereby the combination of the two metals forms a galvanic couple, which also reacts with weaker solutions, such as are employed, for example, in the treatment of slimes.

"The Siemens-Halske Process.—In this process the solution flows through compartments very similar to the zinc boxes above described, but the zinc shavings are here replaced with lead strips (0.1 pound per square foot) or shavings hung between iron plates placed vertically and longitudinally in the box, about 4 inches apart. The lead strips are connected with the negative, and the iron plates with the positive pole of a dynamo, and the solution is thus electrolytically decomposed, the gold being plated on the lead cathode. The iron plates are wrapped in canvas to prevent short-circuiting. The current employed is from 2 to 3 volts, giving a current density of about 0.06 ampere per square foot of cathode. Once a month the lead sheets are removed and replaced, and the gold-coated lead is melted and cupelled, yielding a bullion of 0.880 fine in gold and 0.100 in silver. The litharge is sold to smelters. The solutions passing through the treatment boxes are collected in tanks, and are made up to a proper strength by adding the necessary KCy.

"The cost of the Siemens-Halske process is slightly greater than that of zinc precipitation, and the percentage of extraction is about the same. But the Siemens-Halske process may be applied to any solution, weak or strong."

Scope.—From the description of its mode of operation it is evident that the "straight cyanide process" is readily applicable to free milling ores which are free from mineral substances that would foul the solution or consume the cyanogen salt, and the gold in which is finely divided and so exposed that the cyanide solution may come in intimate contact with it. In old tailings which have been exposed for years to the action of the weather, whereby the sulphurets have been oxidized and the acids and salts formed, dissolved and washed away, there has been found much material ready at hand for immediate treatment in the simplest manner. The problem is comparatively simple, also, in the case of siliceous gold-bearing deposits free from sulphurets, but the ore must be crushed, and in many instances it is more economical to concentrate it than to expose the entire mass to the action of the cyanide solution. Moreover, even in the case of neutral and otherwise suitable ores, the fine particles of metallic gold may be so enveloped in an impermeable covering—such as iron or aluminium hydroxide—as to necessitate a preliminary treatment, such as roasting, to rupture the envelope. An example of this kind is found in the ores of the Republic gold mine, Washington, described by T. M. Chatard and Cabell Whitehead.* When coarse gold is mingled with the fine, it is usually more economical to separate the coarse gold by amalgamation than to await the slow-acting process of solution. With tailings in which the sulphurets are but partly decomposed and which still contain ferrous and ferric salts and sulphuric acid, cyaniding may be preceded by washing and neutralization.

The treatment of refractory ores is determined, in each case, by the chemical and physical characteristics of the ore under consideration. Hence, we find that cyaniding may be combined not only with crushing, roasting, concentration, and amalgamation, but also with smelting and chlorination. In some instances it is most advantageous to separate the ore into fractions, each of which is subjected to a different treatment. In fact, it is essential to success that the ore should be thoroughly examined by a competent metallurgical chemist before any investment in a plant for treatment by chemical processes is made, and also that the cyaniding process should be under chemical supervision, in order that, by assays of the ore and tailings and by analyses of the ore and the cyanide solutions as they enter and issue from the zinc boxes, and of the solvent during preparation and regeneration, a complete check may be made upon the operation in each of its stages.

Working Costs.—It is obvious that the cost of the cyanide process will vary at the different plants, according to the variations in the chemical composition and physical structure of the ore treated, in the condition of the ore at the time of treatment—that is, whether it be in the form of sand or slimes—in the character of the process and the apparatus used; in the location of the mill with regard to the supply of ore or tailings used; and the source of power, water, materials, and

labor. According to H. M. Chance,* in the Black Hills, S. Dak., the cost of smelting siliceous ores was between \$4.75 and \$5.75 per ton; the cost of chlorination, from \$3.50 to \$4.50 per ton; and the cost of the cyanide treatment, possibly from \$3 to \$3.75 per ton. From the Report of the Director of the Mint, for the calendar year 1901,† it appears that in that year there were 11 cyanide plants in active operation in South Dakota, having a united capacity of over 1,500 tons daily, and that some of these mills claim to be able to treat ore at a cost not exceeding 80 cents per ton, though the average cost is probably nearer \$1.50 per ton. Julian and Smart‡ give 21 different detailed accounts of costs at mines in Australia, Africa, and the United States, the results ranging from 2s. 1.23d. per ton by the Siemens process, in South Africa, to 17s. 1.02d. per ton by the Diehl process, in Western Australia.

Effect on the World's Supply of the Precious Metals.—The data collected at this census deal only with the output of the United States for 1902. There are no collected data to afford a comparison of the condition of this industry in that year with the condition during any previous period since its introduction into this country, in 1891. But the consensus of evidence, as presented in current literature, indicates that the industry has been constantly growing, that new plants are going up each year, and that established ones are increasing their capacity. This is true not only of the United States, but also of Africa, Australia, New Zealand, Mexico, and the other gold-producing countries; from each are coming increased supplies of the precious metals extracted from low-grade ores and tailings.

CALENDAR OF EVENTS AND DISCOVERIES RELATIVE TO THE PRECIOUS METALS.

- 1530-1540. Pillage of Peru.
- 1547-1548. Discovery of Guanajuato silver mines in Mexico.
- 1577. Discovery of gold in Brazil.
- 1670. Discovery of placers of Garazua.
- 1680. Discovery of placers of Minas-Geraes.
- 1704-1728. Silver mines opened in Russia.
- 1743. Discovery of gold in the Ural.
- 1848. Discovery of placers in California.
- 1848. Introduction of Plattner's chlorination process at Reichenstein in Silesia.
- 1851. Discovery of placers in Australia.
- 1853. Introduction of hydraulic mining in California.
- 1853. Maximum annual production of gold in California, amounting to \$65,000,000 for the year.
- 1858. Introduction of chlorination process at Grass Valley, California.
- 1866. Invention of dynamite.
- 1886. Opening of the "banket" reef of the Rand, South Africa.
- 1889. Development of Manké's method of bessemerizing copper mattes, and the successful refining of this impure copper by electricity.
- 1890. Introduction of the cyanide process in the Rand, South Africa.
- 1897. Discovery of placers in the Yukon.

Apart from the phenomenal annual increase in the production of gold during the period from 1841 to 1855, which includes the discoveries of the rich placers of California and Australia, the increase in the world's production during the last decade of the nineteenth century was unprecedented. It was most marked during the period from 1891 to 1895, following the opening of the "banket" reef of the Rand and the introduction of the cyanide processes, but it was continuous throughout the decade, except during the period of the Boer war, and the output of gold in 1902 exceeded that of any other year of our record except 1899. It is true that the use of the cyanide process is only one of several causes contributing to this result, but that it is an important one is indicated by the fact that the returns for this census show that the amount of gold recovered by the use of the cyanide process in the United States in 1902 exceeded that won throughout the whole world by all existing means during any year of our record up to 1661, and probably up to 1701.

COUNTERFEIT RELICS.

An article in a recent number of the Birmingham (England) Mail states that a factory in that city is turning out weekly about 1,200 flint-lock muskets, and that a large number of this antiquated firearm are also made at Liege, Belgium. These guns are sent to Central and East Africa for use by the natives, to whom the possession of modern firearms is denied by statute. Directing attention to this industry, Consul Halstead says:

It is known in the trade that many of these newly made weapons fall into the hands of travelers who regard them in the light of a "find," and a story is told of a Birmingham manufacturer having received a letter from a dealer asking him to procure some old flint locks, for which the dealer had several customers, when the manufacturer wrote that he could not supply old muskets, but was prepared to make him any number of new ones required. These were, of course, given the appearance of age. The demand for old weapons is so great, especially in the American season, that the genuine articles would go but a little way to satisfy it.

* Census Bulletin.

† Transactions of the American Institute of Mining Engineers, Vol. XXXI, pages 817 to 854, 1902.

* Transactions of the American Institute of Mining Engineers, Vol. XXX., pages 419 to 423.

* Transactions of the American Institute of Mining Engineers, Vol. XXX., pages 278 to 282.

† Production of the Precious Metals during 1901, page 201, 1902.

‡ Cyaniding Gold and Silver Ores, 1904, pages 372 to 381.