much as possible. In order to guide the instinct of the falcon in the desired direction, it was fed on the flesh of the species of bird which it was being trained to hunt, for every falcon was educated with reference to some particular kind of game. After the falcon's confidence had been won it was exercised in attacking its quarry in the following manner: A heron (or other bird) with its neck bandaged to prevent the falcon from inflicting a mortal blow, with its beak tipped with bits of elder cane to prevent it from wounding the falcon, and with a strong cord attached to its leg, was set down in a field about forty paces in front of the hooded falcon. When the hood was removed the falcon darted toward the heron, which either crouched and attempted to hide in the grass, or betook itself to flight, and was usually soon overtaken by the swifter falcon. In either case a combat ensued, on the ground, which was terminated by pulling the quarry away by means of the cord, while the falcon's attention was diverted by an offer of food. This maneuver was repeated many times, and the falcon was gradually taught to leave the quarry and return to his master at the call of the latter. If the falcon did not promptly obey the call it could usually be brought to obedience by coaxing and the promise (which experience appeared to make intelligible) of reward in the form of a fat pullet or pigeon. Failure of these means of persuasion indicated that the falcon was surfeited or too fat. In this case the falcon was removed by force from the quarry. If the falcon, on the other hand, showed no inclination to pursue the heron, a hunting spirit was inculcated by means of a course of fasting. The work of tuition was sometimes facilitated by associating the young falcon with an old and experienced bird, which first attacked the quarry, and substituting the young falcon for the old one after the heron had become more or less exhausted by the struggle. In this case the young falcon was allowed to kill and devour the quarry, but if it refused to attack the heron, the hunger cure was applied.

The aristocratic character of falconry was largely due to the fact that the sport was never pursued on foot. The noble lord rode to the chase, with his hooded falcon on his hand, accompanied by dogs trained to start the game. When the quarry came in sight the falcon's hood was removed and the hand which carried the bird was shaken. The falcon instantly spied the quarry, darted in pursuit and quickly overtook it. The heron often made a spirited defense, and a fierce battle in the air ensued, which usually was won by the falcon, which was stronger, though smaller, than its adversary. Occasionally, however, the highly prized falcon was transfixed by the long and sharp beak of the heron. More frequently, some of the falcons escaped during the hunt, raided neighboring poultry yards and were killed by irate peasants. A heavy penalty, however, was soon attached to the killing of a falcon, and a correspondingly high reward was paid for restoring an escaped falcon unharmed to its owner. The falcon was captured by offering it food and seizing the fetters which were attached to the legs of every hunting bird. Touching the wings or tail was prohibited.

Some falcons had a bad habit of turning aside from the quarry and settling on the limbs of trees. A bird which showed this peculiarity was taken out repeatedly on frosty and rainy days until the chilling of its feet by contact with the frost-covered branches and the soaking of its plumage with rain induced it to abandon the habit.

Falconry, like many other institutions of the "good old times," has become invested with a halo of romance, but it was in reality a cruel and bloody sport, which has very properly been abolished by the advance of civilization.—Die Gartenlaube.

ARTIFICIAL PRECIOUS STONES.*

LABORATORY MIMICS OF NATURE.

BY PROF. DR. M. BAUER OF MARBURG.

IF I have undertaken to report on the artificial production of precious stones which is now practised on such a large scale, I do not, of course, intend to refer to inferior substitutes which are so frequently palmed off for genuine stones, but only to such materials as are perfectly identical with the respective minerals in their entire constitution, chemical composition, form of crystals, and physical properties.

We are dealing here with mineral syntheses differing from ordinary attempts of this kind only by the experimenter's endeavor to give the artificial product not only its general essential characteristics but the handsome appearance required of a gem and due to transparency, luster, color, etc., and also the necessary size. It will be evident that only gems of a relatively high price can be considered in practice, since they alone will give the manufacturer an opportunity of covering the rather high cost of production by realizing a good price for the artificial stone. The list of gems which we may attempt to reproduce artificially is therefore rather restricted at the outset, and this applies with even greater force to stones in the case of which favorable results have been obtained already. At present attempts at artificial production must be limited to the turquoise and stones in the mineral group of corundum.

The first successful experiments were probably made with the turquoise, an aluminium phosphate which is opaque, crystalline, dense, water-bearing, and owes its fine blue color to a small percentage of copper. As long ago as the last quarter of the nineteenth century there appeared on the market turquoises which resembled genuine stones to such a degree as to deceive experts, yet jewelers suspected that they were imitations. No difference from indubitably genuine natural stones could be detected in their appearance, and the constitution, the specific gravity, and the microscopic structure are substantially the same. Later it was ascertained as a matter of fact that artificial turquoises were being made in Paris and Vienna in large quantities according to some method details of which have not been disclosed. It is said to be a process involving precipitation from an aqueous solution, a loose precipitate of copper-bearing aluminium hydrophosphate being obtained which is then compacted by strong pressure. It is impossible to tell this product from a genuine turquoise with certainty by the mere appearance and the usual tests, and the only material difference in behavior is said to appear when a high temperature is employed.

In more recent times much greater prominence has been reached by the artificial production of gems belonging to the group of corundum, which is aluminium oxid forming hexagonal-rhombohedric crystals. In this group is included the blue sapphire, the yellow Oriental topaz, and other stones commonly termed Oriental, and chief of all, the ruby, which in its finest specimens surpasses in value all other gems, even the diamond. In the class of transparent gems the first great success has been achieved with the artificial production of this most precious of all gems in specimens available for commercial purposes. This entire industry is now dominated by the manufacture of artificial rubies. All other syntheses of this kind which are allied to it are of so much less importance that I shall refer to them but briefly.

Gaudin, a Frenchman, was probably the first to produce artificial corundum. His procedure (begun 1837 and repeated several times) involved melting at high temperatures. The same result has been obtained since in a similar way by many other chemists and mineralogists, as H. Sainte Claire Deville, Ebelmen, Ch. Friedel, Morozewicz, etc. But in all these cases the product was of poor appearance, dull, of bad color, and often consisted only of minute crystals, many of them of microscopic size. The Goldschmidt thermit process does indeed yield large amounts of corundum, but this is entirely unavailable as a gem and is only of value for technical purposes on account of its enormous hardness.

While the production of common corundum therefore is easy, the production of the beautiful, transparent, finely-colored, precious corundum remained exceedingly difficult for a long time. Let us first consider the ruby which owes its beautiful red color to a small percentage of chromium.

The first artificial product worthy of being cut dates from the early eighties of the last century. I refer to the so-called reconstructed rubies, or Geneva rubies (rubies de Genève), it being supposed that they were made in Geneva. It is now believed to be established that they were obtained by melting together ruby fragments with the addition of partly lead-bearing fluxes. The beautiful red color of the ruby is preserved, but its hardness is somewhat diminished, and sometimes the entire mass will become amorphous and glassy, so that the double refraction and the dichroism characteristic of the ruby will disappear. Other specimens, while not entirely amorphous, show that they are not uniform crystallographically and optically. Examination with a polarizing microscope reveals the fact that some ruby fragments (although not discernible to the naked eye) have remained substantially unaltered and imbedded in a glassy body. A greater or smaller number of microscopic air bubbles are always present, but they are not detrimental. The stones have a good appearance and may be made of a pretty good size (several carats). After being an article of some importance for a while, they now seem to have vanished from the market almost entirely. They are not true artificial products in the sense spoken of above, since the raw material is genuine natural ruby. The manufacturer's aim, in this case, was simply to produce from many worthless small particles, larger pieces of apparently great value, but this could not be done without at least partial destruction of the ruby substance. The process has remained a perfect secret, but in any event it does not accomplish the actual reproduction of rubies, that is the production of a crystallized red aluminium oxid, capable of being cut, from suitable raw materials of a different character. This true synthetic reproduction of rubies shall now be discussed more fully.

The French chemist Frémy was the first who attained results of some utility, and in 1891 he published a process originally worked out by him in conjunction with A. Verneuil. This process is based on the fact that at a high temperature the action of hydrofluoric acid and water upon amorphous alumina will promote its crystallization. Pure precipitated alumina was melted at a heat of about 1,500 deg. (Centigrade) in a muffle furnace in the presence of some potassium carbonate, a small amount of BaF_2 or CaF_2 with the addition of about 2.5 per cent of $K_2Gr_2O_7$. A platinum crucible should not be used, but a clay crucible, it having been found indispensable to have the moist air and the steam-bearing combustion gases penetrate the molten mass. The amorphous Al_2O_3 was thus gradually converted entirely into a mass of Al_2O_3 crystals. It was found that in order to obtain a fine product, the employment of raw materials of absolute chemical purity was essential, particularly as regards the alumina. The size of the crucible greatly influenced the size of the crystals produced. Small crucibles yielded only small crystals, and the larger the vessel, or in other words the larger the molten mass, the larger were the rubies produced. These always had the rhombohedric crystal form of the genuine natural ruby. They were thin plates, bounded at top and bottom by the wide base surface, and at the edges by the very narrow surfaces of the main rhombohedron, and measurement showed the characteristic angles of the ruby reproduced exactly. Like the form of the crystals, the physical properties, as the specific gravity (4), the hardness (9), and the optical conditions, were absolutely identical with those of natural rubies. The product was an artificial ruby of perfect transparency and clearness and (owing to the chromium contents) of a very beautiful red color, although a few specimens exhibited the blue color of sapphire. The product therefore from its properties was eminently suitable for use as a gem, but it had one very important defect, which lay in the small size of the crystals, even the largest of them, making them unfit for practical use. The width of the thin plates seldom exceeded a few millimeters, and their thickness was always even much less, so that one could hardly think of cutting them. It was therefore attempted to set the entire pretty tiny crystals in their natural form in various articles of jewelry, and some handsome objects of adornment were obtained in this way. Notwithstanding, the artificial production according to this method never attained commercial importance, its use remained limited and soon stopped altogether. Frémy indeed expressed the hope of being able to produce crystals of practically available size by melting large masses up to 50 kilogrammes; but evidently the experiments were unsuccessful, as nothing further was heard of them. These were the so-called scientific rubies (*rubis scientifiques*).

Another article, however, has acquired considerable importance in the gem trade and now dominates this department of the market, and this is the synthetic ruby (*rubis synthetique*). In the raw state these synthetic rubies are of an appearance entirely different from that of the small crystals of scientific rubies, and judging by their appearance, raw synthetic rubies would not be suspected of being large ruby crystals of uniform structure. The process of manufacture also is materially different. This process was described in

* Translated for SCIENTIFIC AMERICAN SUPPLEMENT from a paper read before the Verein Deutscher Chemiker.

1902 by the Parisian chemist A. Verneuil, and is now employed, with greater or smaller modifications of details, for the production of very large quantities of beautiful artificial rubies and occasionally other gems of the corundum group.

The most important of the raw materials in this case also is alumina, and the coloring principle, chromium oxid. Both should be chemically pure and particularly the presence of even the slightest amount of iron should be avoided, since otherwise the product will take the little valued orange-red tinge which makes the Siam rubies so much inferior in value to Burma rubies. In order to secure uniform coloring, the mixture of chromium oxid and alumina should be perfectly homogeneous. With these requirements in view, Verneuil proceeds as follows: He makes an aqueous solution of ammonium alum and chrome alum (obtained free from iron, by repeated crystallization) in proportions corresponding to the desired shade of color, and from this solution, while hot, he precipitates chromium-oxid-bearing alumina by the action of ammonia. The precipitate is dried in the air first at ordinary temperature and then at a cherry red heat and is finally melted while in a powdered condition, in a peculiar apparatus designed for this purpose.

The apparatus consists, in its leading features, of an oxy-hydrogen blowpipe directed vertically downward, its flame being produced by illuminating gas (preferably containing a large proportion of heavy hydrocarbons) in conjunction with oxygen of the greatest possible purity. The tube through which the oxygen is supplied has at the top an enlargement in which the alumina powder to be treated is placed upon a fine-mesh platinum sieve. A little hammer, actuated electrically, strikes this sieve at short intervals, and each blow causes a cloud of the fine powder to issue downward from the sieve, the powder being then carried along by the oxygen current under pressure and thus conveyed to the flame. There the small particles are melted and are caught on the vertex of a small cone, also made of pure alumina, the so-called foot, which is disposed beneath the flame and is heated by it to incipient fusion. A few screw threads permit the cone to be raised or lowered as required and to be shifted laterally, during the operation, the progress of which may be watched through sights, the attendant using dark spectacles.

During this treatment a thin rod will at first grow upward from the foot, that is, from the tip of the incandescent alumina cone, this rod becoming thicker fairly quickly and finally developing into a round ball of greater or less regularity. The finished formation resembles a pear or rather an inverted water-bottle having a thick and wide body, the neck of such bottle adhering firmly to the foot, which must be renewed at each operation. The place of junction is thus very small, and this is of extreme importance, preliminary experiments having shown that if the solidified molten drop has a wide surface of adhesion, it will always exhibit many cracks and thereby become unsuitable for cutting. The reduction of the diameter of the molten drop at its point of contact with the foot overcame this objectionable result in the main, but still for a long time the finished drops, after solidification, would often split lengthwise into two halves with a tolerably smooth cleavage surface, each half having then to be cut separately. Later improvements enabled this defect to be avoided, and the entire drop now yields a single stone, of double size, of course, cut according to the usual methods.

In this process of manufacture the apparatus must be disposed and adjusted very carefully and particularly the gas tubes should be absolutely vertical. Furthermore, the pressure of the gas and of the oxygen must be regulated properly according to empirical data, as the treatment progresses. Apart from this, the procedure is very simple and one workman can attend at the same time to several apparatus placed in the same room. According to the more or less favorable course of the operation, which to some extent is governed by uncontrollable accidental influences, the drops vary in size somewhat. The largest drops are about 1.5 centimeters thick and 2.5 centimeters long, or several millimeters longer if we include the thin neck. The weight may be up to 50 carats (about 10 grammes) and the cut stones have a corresponding size. I have seen some as large as 12 carats.

The entire mode of production makes it clear that these molten drops, considered chemically, are nothing but pure alumina, mixed in varying proportions with some chromium oxid. If the amount of chromium oxid is slight, the color will be light pink. Stones of this character have been termed erroneously synthetic topazes on account of their striking resemblance to the so-called pink topazes which are obtained by heating yellow Brazilian topazes. Genuine synthetic topazes, however, have not yet been produced. If the amount of chromium oxid is increased, say up to 2 per cent or a little more, beautiful dark red stones of various tints will result, among them fairly often the rare and highly valued pigeon blood red of the natural Burmese rubies, the pure carmine red. It seems that these different shades of red still depend, in the main, upon accidental causes, so that at present they cannot yet be produced at will. If the chromium oxid is omitted altogether, quite colorless drops are obtained which correspond to the white sapphire. Whatever the color, the mass is perfectly clear and transparent, except at the bottle's neck and its bottom; that is, the part formed last during the process, where the drop always terminates with a thin cloudy white or grayish layer. With the polarization microscope we can observe that each drop represents a complete unitary crystal whose crystallographic principal axis and optical axis frequently, but not always, extend lengthwise in the direction of the bottle's neck. It is true these crystals are generally rounded off externally, so that their true nature cannot be perceived at once with the naked eye. In rare cases, however, the bottle-shaped body exhibits six fairly regular plane surfaces parallel with the direction of the axis, which intersect in six similarly regular edges under angles of 120 deg., corresponding to a hexagonal prism and to the natural characteristics of a ruby. Minute ruby crystals are frequently found in large numbers on the bottle neck and on the small alumina cone or foot. As with the scientific rubies, all other properties are like those of natural rubies, such as specific gravity, hardness, coefficients of refraction, dichroism, etc. In brief, here again we have an artificial ruby which is absolutely identical with the natural ruby in every respect, chemically, crystallographically, and physically. As it also possesses the size, clear transparency, and magnificent color required of a precious stone suitable for jewelry, it may be said that with these synthetic rubies the problem of artificially producing this valuable gem has been thoroughly solved, in the main. The methods of production may perhaps be further improved, but the product itself is hardly susceptible of greater perfection.

This is therefore the process of manufacture which has acquired such importance since 1902. A. Verneuil, who is using it upon a large scale in Boulogne, near Paris, states in one of his publications that during the last six or seven years he and others have made there annually more than five million carats (1,000 kilogrammes) of these artificial rubies. In Germany the "Deutsche Edelsteingesellschaft Zu Idar," according to its circular, is carrying on the same manufacture, employing a special process worked out by Prof. A. Miethe of Charlottenburg, details of which are not available.

The question will be asked if it is possible to distinguish these artificial rubies with certainty from natural ones. At first this was comparatively easy. The synthetic stones produced first, when viewed under the microscope, showed numerous round air-bubbles which it is true did not impair their fine appearance. But these bubbles are entirely lacking in natural rubies, which on the other hand sometimes contain small angular cavities, so-called negative crystals, and also minute real crystals. Among these there are especially noteworthy microscopic brown needles which are often found ingrown in the crystals parallel with the base in three directions intersecting under angles of 60 deg. Improvements made in the manufacturing process have led to the almost entire disappearance of the small round bubbles, but the tiny needles, etc., characteristic of natural rubies cannot be embodied in the artificial ones, so that the presence of such needles, etc., indicates a natural ruby with certainty. If they and the round bubbles are both absent, then no microscopic test of genuineness will be available.

In regard to telling the difference by the mere appearance, without the help of instruments, it should be noted that experienced gem connoisseurs assert they can always recognize an artificial ruby as such and distinguish it from a similar natural ruby. They say that even with the finest color and the most perfect qualities producible artificially the synthetic stone still always lacks the beautiful velvety gloss of the natural product. Be that as it may, it certainly requires a very large experience, and I must confess that I have not reached this point as yet. I have seen a great many artificial and natural rubies, both separately and side by side, but I have not always been able to distinguish them with certainty.

It will therefore be readily understood that this manufacture has caused considerable anxiety in the ruby trade, all the more in view of the fact that the price of even the best synthetic stones, which at present amounts to about 75 cents per carat (0.205 gramme) is far below that of corresponding natural rubies. A one-carat natural ruby of the finest quality may cost more than $250, a two-carat stone up to $2,500, and still larger ones, on account of their scarcity, are sold at often incredible fancy prices. On the other hand, synthetic stones of 10 carats and over, which size natural stones have attained in only a few instances, can be produced artificially with great ease.

It is not surprising, therefore, that the owners of natural rubies should have devised steps to guard against the seriously threatened depreciation of their dearly-acquired possessions. Thus, among others, the syndicate of Parisian dealers in precious stones resolved that the name "ruby" should be applied only to stones cut from natural raw material and that every jeweler should be obliged to expressly declare artificial stones sold by him and to unconditionally take back any artificial stone brought into the market by him unwittingly. It is of course very doubtful if the sale of artificial rubies can be effectively checked by such measures for any length of time, since the recognition and distinguishing certainly are very difficult, to say the least, and of course entirely impossible in the case of the general public. No doubt very many synthetic rubies have been brought upon the market without declaration, with and without the seller's knowledge, and have been accepted as natural by the public. The surprising fact has also been ascertained that the manufacture of artificial rubies has not caused a fall in the price of natural rubies; on the contrary, it has gone up somewhat since that time. The fears of the owners of natural rubies are therefore unfounded, at least for the present.

Besides rubies, artificial stones of other colors, all belonging to the variegated group of precious corundum, have been made according to Verneuil's process and placed on the market, but the coloring agent is not generally known in most cases. Compared with rubies, this is of some scientific but of no economic importance. The natural stones of this kind have only an inferior place in the precious stone trade, and their price is not so very high, so that their reproduction is not remunerative in the same degree as with rubies.

We have spoken already of the colorless corundum, the white sapphire. It can be produced in very beautiful specimens, just as clear as water, which have exactly the same properties as natural stones, but are said not to equal them in luster and fire.

A very beautiful stone is the artificial yellow corundum, which corresponds to the natural Oriental topaz or topaz-sapphire; the violet Oriental amethyst, the violet ruby, has also been reproduced artificially.

We shall deal a little more fully with the artificial production of the blue sapphire, which after the ruby is the most important gem of the corundum family. In this case particular difficulties have been experienced in the application of Verneuil's method, and real success has not been achieved so far. What is now sometimes called "synthetic sapphire" is not, as in the case of the ruby, an artificial stone having all the properties of the natural one, but a product which differs from the natural article materially in important points.

The blue coloring agent of the natural sapphire is not proof against the action of heat (like that of the ruby) but is destroyed thereby and for this reason is thought by many to be of organic nature. Accordingly, in making artificial sapphires, cobalt in the form of Co_2O_3 has been resorted to as a means of giving a blue color to the molten alumina mass. But, quite unexpectedly, the molten drop at first absolutely refused to take any color. Even when an addition of 5 per cent of Co_2O_3 was employed, none of it became incorporated, and the drop remained colorless. The coloring matter did not enter into the melt until a further addition of a few per cent of CaO or MgO was made to the mass, and then even 0.1 per cent of Co_2O_3 was sufficient to produce a very bright blue color. In this case, however, these slight admixtures of foreign substances produce the remarkable result that the molten drops consisting chiefly of Al_2O_3 do not form a unitary crystal after solidification (as they did in the case of the ruby, etc.), but they yield a glassy amorphous body having indeed the same external shape as in the case of the ruby, but no double refraction and no dichroism, and a smaller hardness than crystallized alumina and also a smaller specific gravity (from 3.6 to 3.8 instead of 4). Physically considered, it is therefore a substance totally different from corundum and comparable to quartz glass (fused quartz in its relation to rock crystals). In any event, we cannot term this a synthetic sapphire in the sense defined at the beginning of this paper. The small contents of CaO, MgO, and of the cobalt compound have evidently been sufficient to entirely destroy the crystal-forming capacity of the molten alumina, whereas in the case of the ruby the color-giving chromium compound is presumably admixed as Cr_2O_3 isomorphous with alumina and therefore does not hinder crystallization.

Even in external appearance this artificial product is far inferior to the beautifully blue natural sapphire. It is too strongly blue, of a hue no genuine sapphire will exhibit; it is the vulgar blue color of cobalt glass, smalt, and we miss the attractive velvety gloss of the natural crystallized stones. Furthermore, by lamplight the color turns to purple, which defect may indeed be avoided by a slight addition of iron. The conclusion is that a real synthetic sapphire does not exist as yet and for the reason stated above, is not likely to be produced in the near future, at least not according to Verneuil's method.

There is, again, the so-called synthetic alexandrite. The genuine alexandrite is the dark emerald-green

variety of the mineral chrysoberyl, another variety of which, known as cat's eye, also has some importance among gems, being distinguished by a peculiar wavy reflection of light. The alexandrite is noted for its remarkable change of color. In daylight only it will show an emerald-green, by lamplight it has a decided purple color. Among the molten drops produced in accordance with Verneuil's method and the stones cut therefrom, there are some that exhibit a similar change of colors. In daylight they appear light green, under artificial light beautifully purple. For this reason they have been considered artificial alexandrite, or at least designated as such. Careful analysis has shown, however, that these artificial stones contain no beryllium, or at least very little of it, that they have not the specific gravity of alexandrite (3.7), but that of corundum (4), and likewise that all other properties, practically the optical ones, are those of corundum and not of alexandrite. We are therefore dealing not with alexandrite but with an artificial corundum, and as a matter of fact there are in this group, but only as specimens of extreme rarity, some natural stones in which we observe a change of color similar to that seen in these artificial gems. How the latter are made, that is, what coloring principle is used, is entirely unknown.

If we sum up the substance of the facts recited above, we perceive that, if we except the so-called synthetic sapphire, Verneuil's method is applicable at present only for producing gems of the corundum group as crystallized bottle-shaped molten drops. The topaz and alexandrite cannot as yet be reproduced in this manner, notwithstanding the suggestive names given to some of these artificial products.

In connection with the above remarks, I may refer to the so-called synthetic emerald. The emerald is the fine green variety of the mineral beryl, and in flawless specimens is about equal in value to the ruby in the list of precious stones. What is called synthetic emerald and brought into the market as such, is nothing but fraud. Sometimes it is glass colored green with chromium, sometimes so-called doublets. The top of the cut stones and the bottom are colorless glass or rock crystal or aquamarine, a variety of beryl of a light bluish-green color and of no great value on account of its frequent occurrence. Between the top and bottom there is inserted a thin emerald-green plate of glass or of gelatine, which when the stone is viewed from above, gives it the same color in a perfectly deceiving fashion. But if the stone is looked at from the side or otherwise examined closely, the imitation will be discovered readily; such examination, however, cannot be made when the stones are set. Other similar combinations of worthless green and colorless parts have also been observed. The manufacture of these imitations is also said to have its chief home in Paris. The synthetic production of real emeralds has not been accomplished as yet, neither has that of aquamarines or other varieties of the mineral beryl.

In conclusion, I shall mention the diamond, but only to say that it has been produced in various ways in the form of very tiny crystals. Such manufacture, however, has not so far acquired any importance for the trade in precious stones; I therefore believe that I should not enter into the matter any further at this place.

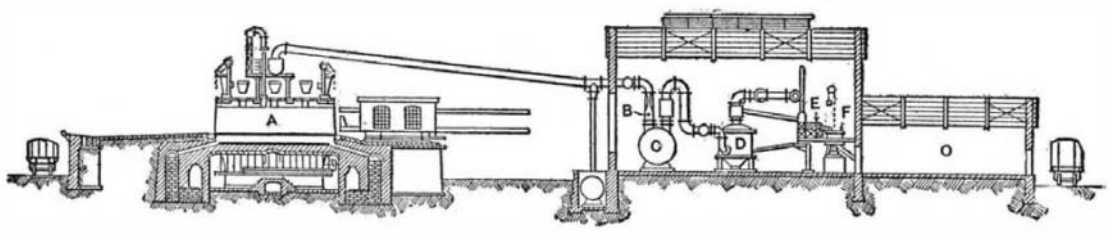
AMMONIA FROM COKE OVEN GAS.

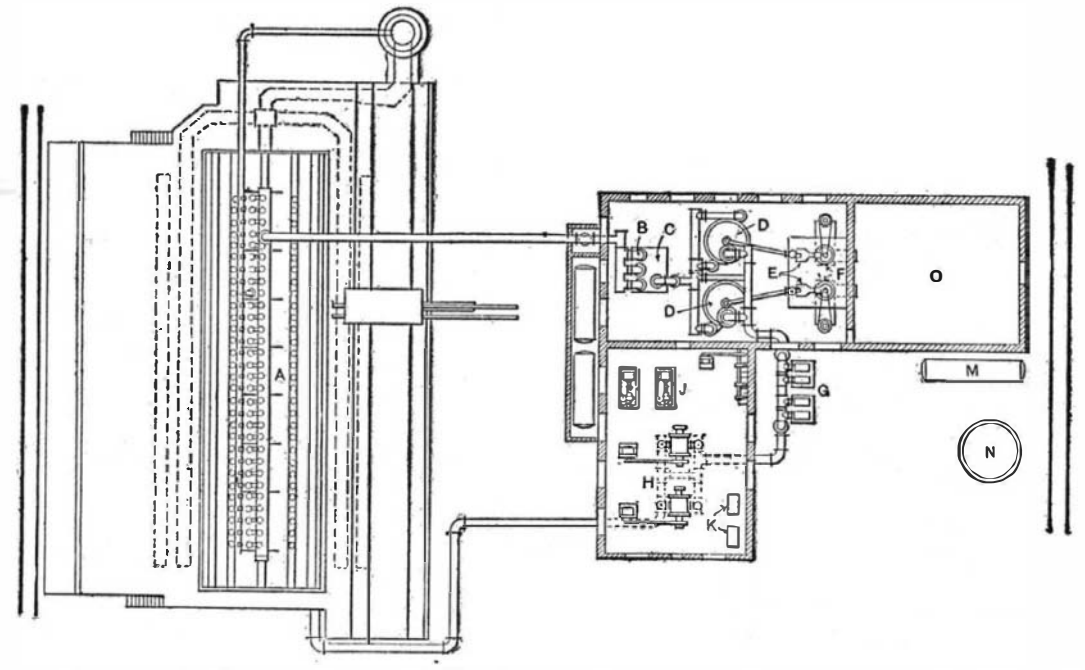
ITS DIRECT PRODUCTION.

G. Hilgenstock, Dalhausen, Ruhr, Germany, has an article in Stahl und Eisen, on "The Direct Production of Ammonia from Coke Oven Gas." The following is an abstract made by the Iron Age, with two of the illustrations used:

The winning of nitrogen in the form of ammonia from coke oven gases was concomitant with the preparation of phosphorus in useful form for agricultural purposes. The method laid down by Dr. Otto in 1884, while improved and simplified, still depends upon five distinct stages: First, the cooling of the gases by the air and water circulation; next, washing the gases with cold water to remove the last traces of tar and ammonia; then separation of tar and ammonia water in large tanks, through their specific gravities; then the driving off of the ammonia by steam and added lime; finally, the condensation of the ammonia into a strong solution or else combination with an acid, making a salt.

This roundabout method has been and is used because we have not developed a shorter one. It would seem possible to take the ammonia vapor as it comes from the ovens, diluted only by gas, into an apparatus, and there complete the operation. This supposition was based upon the working of the steam jet, and the knowledge that tar itself is the best solvent for tarry vapor. Experiments along these lines gave surprising results when the precaution was taken not to let the tar exceed 175 deg. F., and that no condensation took place. The tar for washing was introduced by a steam jet, and at the works where these trials were made it was perfected to a point where less than 45 grains remained in every 1,000 cubic feet of gas. Credit should be given the firm of Franz Brunck, which as early as five years ago passed the coke oven gases directly into concentrated sulphuric acid, this at temperatures precluding condensation. However, many difficulties were encountered, and the high temperatures and lack of solvents for the tar remained a detriment to the process for a long time. Other methods involving several stages could have been applied, but the one described herewith has given perfect satisfaction. Experiments have shown that the very small quantities of condensation products which separate out with the tar contain practically only ammonia salts, and these are returned to the gases in the saturation chamber with the steam. Where there are occasional abnormal quantities of condensation products, as for instance with very wet coal for coking, provision is made to separate these gases from the drier ones.





Figs. 1 and 2.—PLAN AND ELEVATION OF AN INSTALLATION FOR THE DIRECT PRODUCTION OF AMMONIA FROM COKE OVEN GAS.

The first installation using the "direct method" for ammonia is in operation at the Julia Colliery of the Harpener Association. Here the usual troubles of a newly introduced process were met with and overcome. Even here from the very first a perfectly white sulphate of ammonia was obtained. It had over 25 per cent. ammonia and only a few tenths free acid. The next installation was at the Vondern Colliery, where everything has worked smoothly from the start, the salt after centrifuging being perfectly white and containing 25.26 per cent. ammonia, and 0.20 per cent. free acid. After a short storage it becomes perfectly odorless.

The accompanying illustrations give a plan and elevation of a "direct" method installation. *A* shows the coke ovens. In the tar jets *B* a very intimate mixture of the tar and gases takes place, so that when the tar catch basins *C* are reached the gas is free from the tar. The tar pumps *J* supply the jets continuously and the product caught in *C* is carried into storage tanks. The hot gases, after the tar separation, and containing all the water vapors and ammonia, are led into the absorption tanks *D*, which are closed, and in which there is the necessary sulphuric acid. The reaction between ammonia and acid is sufficient to keep the temperature up to a point giving proper results, the sulphate of ammonia drops to the bottom after sufficient saturation, and is carried upon the drainage platform *E* by means of an ejector in the usual way. The centrifugal machines *F* dry it, and it is then carried to the storage *O*. The mother liquor from the draining platform is returned directly to the absorption tanks.

The gas is now dried, passing through the condensers *G*, fed by pumps *K* in the usual way. The gases pass to the benzol extraction apparatus and thence to the coke ovens for firing, or else into gas tanks for city lighting. At *M* is the acid tank and at *N* the tar shipping tank.

The advantages of the "direct" process are obvious. The washing and distilling apparatus is done away with, steam is saved, settling ponds and removal of slimes are no longer necessary and the operation is simple and cheap.

Warm-blooded animals possess fundamental means of protection against foreign substances which have invaded the organism. To the entrance or formation within the body of bacterial or other poisons, the organism responds by the production of specific antidotes or antitoxins, while it reacts to the invasion of living bacteria by producing special solvents or lysins. These natural safeguards, which are collectively called alexins, are at the disposal of warm-blooded animals in a normal state of health, and upon their presence depends the germicidal power which the cells of the body normally exhibit. The leucocytes or white corpuscles of the blood are concerned in the production of these antidotes. The well-known fact that fresh-water crabs possess very little power of resistance to the attacks of bacteria, so that an infectious disease almost annihilated the crabs of Europe in a short time, suggests the question whether cold-blooded animals possess these natural means of protection. Investigations made by Angerer at the Biological Experiment Station of Munich have shown that the blood of fishes (carp) exhibits a powerful germicidal action upon typhoid bacilli and other bacteria, which are devoured and digested in great quantities by the white blood corpuscles, by the process which Metchnikoff calls phagocytosis. Many experiments on crabs have confirmed the prevailing assumption that the blood of these crustaceans possesses only a very small power of producing bactericidal substances. The blood of snails and mussels is also very nearly destitute of bactericidal power, while on the other hand the slimy mucus exuded by hibernating snails possesses a strong germicidal power. The May beetle, also, appears to be very well protected by nature. This contrast between fishes and snails, crabs and May beetles proves that the thickness of the external armor stands in no relation to the power of the organism to protect itself against bacteria, and also that the armor does not prevent the entrance of bacteria.