

# The Laboratory and Commercial Production of Oxygen

## A Review of the Principal Methods Proposed

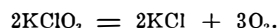
By A. S. Neumark

THE date of the discovery of oxygen gas has been given as August 1st, 1774, when J. Priestley prepared this gas for the first time by heating mercuric oxide, but at almost the same time Scheele in Sweden was also producing oxygen in his laboratory. The French chemist Lavoisier gave it its present name (from the Greek oxys, acid, and genao, to produce) for the reason that he supposed it to be the essential constituent of all acids. It was he who perceived its real nature, putting forward the true theory of combustion.

Oxygen is the most abundant of all elements, it makes up by weight fully one-half of the globe, including earth, air and water. However, it exists nowhere in the pure and uncombined state; therefore certain processes are required to isolate it. It can be abstracted by a great many methods which depend on different physical as well as chemical principles. These methods may be classed as follows:

1. By the decomposition by heat of compounds containing oxygen.
2. By the decomposition by chemical means of compounds containing oxygen.
3. By the decomposition by electrical means of water.
4. By the extraction of oxygen from the atmosphere.

Of compounds from which oxygen may be abstracted by dissociation through heat may be mentioned the alkali chlorates, perchlorates, hypochlorites, chromates, manganates, nitrates; also certain oxides (manganese, lead, mercury, etc.). The method mostly used in this country by the small manufacturer and welders, is to heat potassium or sodium chlorate. If potassium chlorate is heated to a temperature of 350 deg. C., it gives off all its oxygen, leaving potassium chloride as a residue, according to the following equation:



The gas is evolved slowly at first, but soon generation increases rapidly, ending with explosive violence. This can be prevented by adding a catalytic agent, such a manganese dioxide, iron oxide, copper oxide, lead peroxide; also sand and graphite has been recommended. Manganese dioxide ( $\text{MnO}_2$ ) is usually employed for this purpose; however it must be pure and must not contain any coal dust with which the commercial black oxide of manganese sometimes is adulterated. The proper proportion is 1:8 or 1:12. Too much manganese causes the formation of chlorine; if not enough is added, the chlorate will melt before giving off oxygen and generation will then be sudden. A better substitute would be freshly precipitated and ignited iron oxide ( $\text{Fe}_2\text{O}_3$ ). Both substances cause the chlorate to give off the oxygen more slowly and continuously than the chlorate alone, and at a considerably lower temperature (at 200 to 210 deg. C. when manganese is used, and at 110 to 120 deg. C. where iron oxide is employed). If sodium chlorate is used instead of the potassium salt, additional precautions are necessary to prevent too rapid generation, as the decomposition of the sodium salt is more exothermic than that of potassium chlorate. The molecular weight of the last being less than that of the potash salt, a greater amount of oxygen per unit of weight can be obtained (16 to 18 per cent). Retorts of a special design should be used; those manufactured by the Oxy-Carbi-Co., New Haven, are probably best adapted for this purpose. Potassium chlorate yields  $4\frac{1}{4}$ - $4\frac{1}{3}$  cubic feet per pound, at a cost of  $2\frac{1}{2}$  cents; sodium-chlorate produces nearly 5 cubic feet, which brings the cost down to 2 cents (and less) per cubic foot. The oxygen after leaving the retort is washed thoroughly in water and caustic soda (or similar chemicals) to remove the chlorine which is always present. The scrubbers usually consist of three barrels partly filled with the washing fluid, the inlet pipes being provided with some device for breaking up the bubbles. The last barrel is connected with a gasholder (gasometer), from which the gas is forced into storage tanks by means of compressors. The latter usually have two stages of compression with intercooling to prevent heating of the cylinders. As an additional precaution the latter can be submerged in water. Oil or other carbonaceous lubricant should never be used, as it is liable to cause ignition and explosion; for the same reason wool or similar material should not be employed as packing; asbestos may be used instead. The oxygen is compressed into either low pressure tanks (225-300 pounds), made of steel and tested to twice the charging pressure or into high pressure tanks (1,200-

1,800 pounds per square inch) made of drawn steel with a perfectly smooth inner surface. Small particles of loose iron can cause oxydation and ignition. They should be kept in a cool place, as the rays of the sun can increase the pressure considerably. It is of course much cheaper to generate oxygen in the retorts under sufficient pressure to force it into storage tanks. This would do away with gasometer and compressor and thus occupy very little space. However, the results from this type of generator can not very well be satisfactory. The purity of the gas plays an important part when used for welding; chlorine, for instance, affects the strength of the weld to a great extent. It stands to reason that if three washbarrels are required in the compressor type of oxygen generator, it would require much more washing fluid to remove the impurities in the pressure generator. A single scrubber filled with caustic soda or dry chemicals will never remove the chlorine completely. Then there has to be considered the waste of gas while recharging, which brings down the yield of gas to four cubic feet per pound of chemical. Besides, there is always danger of an accident caused by leaving the valve between the retort and storage tank (or scrubber) closed. After all, the compressor type can be installed for but little more than is asked for pressure generators by some manufacturers, and they produce a gas of the greatest purity and at the lowest possible cost from the chemicals. Both methods mentioned yield the oxygen by external heating of the retorts. Another type is the internally heated type. Here the chlorate (or perchlorate), which must be in large excess and in the powdered state, is mixed with some combustible matter (charcoal, hydrocarbons, cellulose, powdered metals, etc.), and an inert matter (sand, clay, infusorial earth). The "Oxygenit," sold in this country, belongs to this class; it contains chlorate and manganese dioxide in the preparation of 100:13, to which has been added some lamp-black to support combustion. The admixture of manganese dioxide reduces the temperature and prevents the chlorate from melting. This chlorate mixture is placed in asbestos-lined retorts and fired by a match or some kind of ignition powder. Other combinations sometimes used are 100 parts of chlorate and 40 to 60 parts of manganese oxide (with, or without, the addition of infusorial earth); or 100 parts of chlorate, 20 to 40 parts of infusorial earth, and 3 to 5 parts of powdered charcoal. Quite a number of such combinations have been patented by the French chemist Jaubert, who for the past ten years has made a specialty of preparing mixtures giving off oxygen either by ignition or when being brought in contact with water. He is still working along these lines. The retorts used for the compressor type of oxygen generator are usually cylindrical in shape, and made of light steel or wrought iron. Sometimes a series of such retorts is used; or one can be in operation, while another is allowed to cool, and a third is being recharged. Or a large retort, rotating about an axis over a gas flame, is so connected with the gas holder, that the movement of the latter (due to consumption of gas) may cause such movement of the retort as to bring another portion of it over the flame. This action continues automatically until the charge in the retort is exhausted. According to a French patent, a number of retorts communicating with and grouped around a common delivery pipe (which also acts as a support ing axis) are brought in turn over the burner. As soon as one retort is exhausted, the gas shuts off automatically, and brings a fresh retort over the burner, which is relighted. The movement of the retorts and value on the gaspipe is actuated by the movement of a diaphragm, a ratchet wheel and a series of levers. The chlorate is sold in kegs, holding 112 to 120 pounds, at 9 to 10 cents per pound, and is manufactured by an electrolytic process. It usually comes in crystals; the powdered chemical is more expensive, although it gives much better results. Large crystals must never be used, as they will delay the generation of oxygen until the chlorate is melted and then will evolve the gas so suddenly that the latter cannot escape fast enough. The attempt of one of the chlorate manufacturers to mix the chlorate with a small percentage of barium sulphate caused a "blow-out" a couple of years ago at an oxygen plant in New York, doing considerable damage. The manufacturers apparently did not know, that, although an inert powder, barium sulphate increases the decomposition of the chlorate, owing, according to Sodeau, to the formation of bari-

um chlorate by double decomposition. Barium sulphate is one of the heaviest chemicals known, the reason for adding it is, therefore, obvious. However, the entire lot of chlorate (ten kegs) were exchanged for unadulterated sodium chlorate without offering any explanation.

There are a number of proprietary chemicals on the market which evolve oxygen when brought in contact with water, such as epurite, oxone, lavoisite, etc. The two first named preparations are simply fused. sodium peroxide; the cost of oxygen is high (13 to 20 cents per cubic foot) where such chemicals are used, although the gas is of great purity. Sometimes the alkali peroxide is mixed with a small percentage of copper sulphate, potassium permanganate, hypochlorite, etc., and agglomerated by compression. A mixture of 200 parts of bleaching powder and 70 parts of sodium peroxide is often used.

Manganese dioxide alone, when heated to a bright red heat in retorts placed in a furnace, gives off one-third of its oxygen. It requires two and one-third pounds of chemical to obtain one cubic foot of gas. This method is inconvenient on account of the high temperature required.

More practical methods are those where bleaching powder (or any other hypochlorite) is used. If a concentrated and filtered solution of bleaching powder (calcium hypochlorite, chlorinated lime), to which a small quantity of cobalt oxide has been added, is gently heated to 70 or 80 deg. C. a steady stream of oxygen is evolved. If the filtering of the bleaching powder solution should be found inconvenient, a thick paste of the chemical with water may be used (always with the addition of cobalt, nickel or copper oxide). To prevent frothing of this mixture, some paraffin or a few drops of paraffin oil must be added. The oxygen gas is liberated with great ease and regularity, so that this method is well adapted for the small manufacturer. Ten pounds of chlorinated lime (33 per cent) yield about eight cubic feet of gas. Flettman modifies this process by passing a stream of chlorine through milk of lime, to which has been added some cobalt salt. The following method has first been recommended by Jaubert and is often used. A tank is filled with a solution of bleaching powder (1:6) and a solution of 12 parts of iron sulphate and 3 parts of copper sulphate in 50 parts of water is slowly added. Oxygen is liberated. It is perhaps better to add the iron sulphate to the chlorinated lime, and introduce the copper salt when required. Several patents have been taken out on generators based on this process. They all are provided with agitators to occasionally stir up the residue. If bleaching powder is mixed with slaked lime and heated to redness, oxygen is also given off.

If sulphuric acid is allowed to drop on red hot surfaces, it is decomposed; oxygen and sulphurous acid are disengaged and can easily be separated. Eleven pounds of acid yield 20 cubic feet of oxygen. Zinc sulphate also evolves oxygen when heated. The following method has been tried for the manufacture of commercial oxygen, but has been found impractical on account of the very high heat required. A mixture of plaster of Paris and river sand is heated in retorts, placed in a furnace, to a dull red heat; then superheated steam is injected; oxygen and sulphurous acid are liberated. One pound of plaster of Paris is said to yield  $1\frac{1}{4}$  cubic feet of oxygen.

Oxygen can further be obtained by the action of chlorine on steam at a bright red heat. A generator based on this process has been patented in this country. The chlorine is obtained by subjecting muriatic acid gas and compressed air to heat in the presence of a porous material saturated with a solution of copper chloride. Superheated steam is then brought together with the chlorine, forming muriatic acid gas and oxygen. The former can be used over again. This method can hardly find much practical use, as it is too cumbersome and costly. Alkali nitrates (niter) do not yield pure oxygen, otherwise they could be used for commercial purpose. There are a number of other compounds that evolve oxygen by decomposition by heat or chemical means, but none of them are of any practical value and they are only used for laboratory purpose.

A Viennese engineer proposes to decompose steam into its elements, oxygen and hydrogen. This he accomplishes in a furnace made of chromic iron (being impermeable at all temperatures) at a temperature of 2,912 deg. F. The steam is dissociated by an elec-

tric spark, or a layer of fire brick material, or by means of thin platinum sheets. The decomposition of water into oxygen and hydrogen, by electrolysis, can successfully be used only where power can be had cheap enough or where there is a market for the double volume of hydrogen simultaneously set free with the oxygen. The electrolyte is usually a 20 per cent solution of alkali-hydrate, the gases being separated by a diaphragm, placed between the cathode and anode. The electrolytic process is used in Europe to a considerable extent; in this country there are but three such plants to the writer's knowledge. The high cost of electric power, the need for skilled labor and the large floor space required, have made this process too expensive.

Oxygen can also be extracted from the atmosphere. The methods which utilize the atmospheric oxygen may be classed into two groups: the extraction by chemical means and by purely mechanical (physical) means. Of the first named group the following methods may be mentioned:

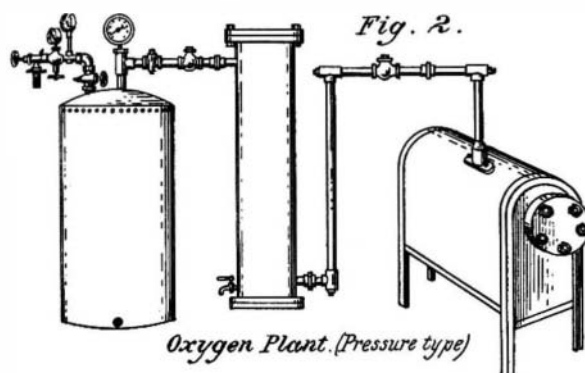
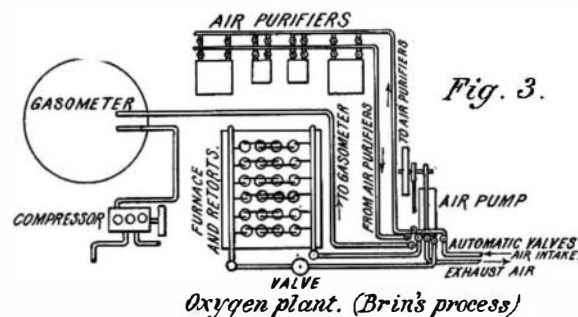
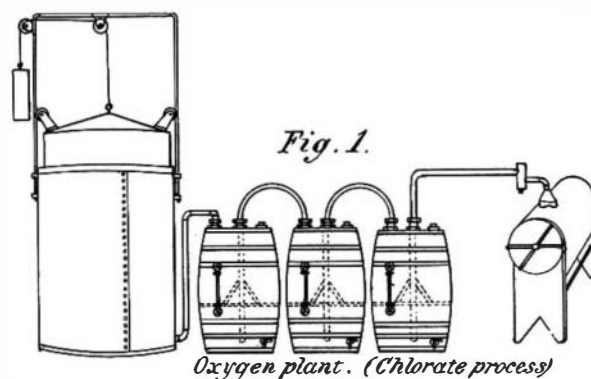
1. By alternate formation and decomposition of barium dioxide. If barium oxide ( $\text{BaO}$ ) is subjected to a temperature of 500 to 600 deg. C. in a current of air, it takes up oxygen from the latter, forming barium dioxide ( $\text{BaO}_2$ ). By raising the temperature to 800 deg. C. this dioxide is again decomposed, giving off oxygen and passing back into the oxide, the decomposition being expressed as follows:  $2\text{BaO}_2 = 2\text{BaO} + \text{O}_2$ . This process has first been used by Boussingault, who proposed to use this method for the manufacture of commercial oxygen. However, it was soon found that the barium oxide after several operations lost its power to take up oxygen from the air. It was many years later that the brothers, L. Q. and A. Brin, succeeded in overcoming these difficulties by using reduced pressure during deoxidation, avoiding too high temperature, and, above all, by careful purification of the air. The latter must be completely freed from carbonic acid gas, moisture and organic matter, or else barium hydroxide and carbonate are formed which will make useless the whole expensive charge. Fig. 3 shows the diagram of a plant of this kind (Elkan's oxygen plant in Berlin), consisting of a series of air purifiers, an air pump and a number of retorts placed in a furnace. The pump draws the air through the purifiers into the retorts. As soon as the barium oxide is transformed into the dioxide, the air supply is shut off which causes a rise in temperature; oxygen is liberated and is drawn off and forced into the gas-holder. By an arrangement of valves—of the "three-way" kind, the same air pump is used, acting alternately as pressure and vacuum pump. Until a few years ago, this has been the most successful process for the production of oxygen gas on a large scale. In this country only two plants have been in operation; a patent is an improved generating plant of this type having been taken out only recently. At the works of the Brin Oxygen Co., London, 140 operations have been made in one day, one pound of baryta yielding one cubic foot of gas (15 per cent pure) at a cost of \$1.80 per 1,000 cubic feet. Such a plant requires a very carefully constructed apparatus, and constant and careful attention.

2. By alternate formation and decomposition of alkaline manganates. Manganese oxide (or peroxide) is heated in a current of air to 450 deg. C., together with some caustic soda, whereupon it takes up oxygen until all the oxide is converted into sodium manganate. Steam is admitted, which decomposes the manganate, disengaging oxygen, and leaving manganese oxide and caustic soda, which is used again for a fresh supply of gas. The originators of this process are Tessie du Motoy and Maréchal. Plants utilizing this system were erected in Paris, Lille, Brussels, Vienna, Frankfurt and New York. At the works of the Oxy-Hydrogen Gas Co. in New York (1870) the daily output was from 25,000 to 30,000 cubic feet; a large amount of the oxygen being used for lighting purpose in connection with hydrogen gas, which was obtained by heating calcium-hydrate with anthracite; 2,000 cubic feet of oxygen were used alone for illuminating the work during the building of the Brooklyn Bridge. Oxygen was sold for five cents per cubic foot; the retorts used were nearly six feet long and two feet in diameter. Two chaldrons of cake were used daily, the whole plant requiring the services of three men. This company failed in 1871, the same fate being shared by other firms using this process. It was found that after a time the manganate deteriorates and the yield of oxygen almost ceases. The difficulties were later partly overcome by Fanta, Bowman, Chapman and others, but this process has never met with any practical success. A modification of this process is the one proposed by Stuart, and is still in use. The manganate is in a fused condition, the temperature being constantly kept at 375 to 400 deg. C. At one of the plants using Stuart's process, retorts eight feet deep and two feet wide were used, each retort holding 1,500 pounds. Steam is blown through the bottom and just before the flow

of oxygen stops, air is admitted. The cycle of operations lasts 10 to 15 minutes, and a set of four retorts (as described above) is said to furnish 140 to 150,000 cubic feet of gas in 24 hours.

3. By alternate oxidation and deoxidation of cuprous chloride. Dry copper chloride when heated is decomposed into cuprous chloride and chlorine. The former is treated with steam and air at a temperature of 100 to 200 deg. C., whereupon it takes up oxygen, forming copper oxychloride. When this is heated to 400 deg. C. oxygen is liberated, leaving cuprous chloride which is again treated as described above.

4. By decomposition of calcium plumbate (Kassner's method). This substance is obtained by heating an intimate mixture of calcium carbonate (or limestone) with oxide of lead in a current of air. It is decomposed by carbonic acid gas, passing back into calcium carbonate and lead oxide, and liberating oxygen. The plumbate can also be decomposed by a solution of alkali carbonate. Another modification is the following: Hot air and steam are forced alternately through six chambers from opposite directions. The first three chambers are filled with limestone and lead oxide, the following two chambers contain copper oxide,



while the last chamber is filled with oxide of iron. A constant stream of oxygen is evolved by oxidation and deoxidation (Claus and Elsner Patent). A similar method is used by the Oxygen Producing Syndicate, London. All these processes have found little favor on account of the complexity and the large amount of labor required.

Methods of extracting oxygen from the atmosphere by mechanical means:

1. Oxygen and nitrogen may be mechanically separated by atmolysis, i. e., by taking advantage of the different rates of diffusion of the two gases (*dialysis*). If air is forced through plates of plaster of Paris, it will be found that the air emerging from the other side of the plates consists of nearly pure nitrogen, most of the oxygen being retained. The property of caoutchouc in thin layers of allowing oxygen to pass through it more readily than nitrogen, has been used and several patents have been taken out for processes of this kind. Margis used bags made of silk and coated with specially treated caoutchouc. A vacuum pump causes the air to pass through the bag, and this air is drawn off by a steam injector. Steam and air pass through a water cooler, where the steam is condensed and the air is drawn off and forced through a second bag and the operation is repeated. One operation yields a 40 per cent oxygen mixture, the following operations bring the concentration up to 60 per cent, 80 per cent and 95 per cent. Neam forces air through only one separator, made of porous clay, having partitions of carbon diaphragms and filled with masses of porous caoutchouc. A rather odd contrivance is the one patented by De Villepigne. However,

none of these devices have been of practical value, as the process of dialysis is an extremely slow one.

2. A somewhat more promising method is the one which makes use of the different degrees of solubility of oxygen and nitrogen in water and other liquids. The first patent based on such a process was taken out by Mallet in 1869. In 1871 such a plant was put in practical use in Cologne by Philipps, who used the oxygen for lighting part of the city with specially constructed oil lamps. Four absorptions of air in water, with recovery of the absorbed air mixture, were used. This yielded a mixture of 75 per cent oxygen and 25 per cent nitrogen; the cost being 39 cents per 276 cubic feet; this being the amount obtained in one hour. A great many patents have since been taken out, some of them only recently; and although most of the claims are for "air rich on oxygen," a gas of 93 to 97 per cent purity can be obtained by a sufficient number of absorptions and expelling of the absorbed gas mixture.

3. By using the absorbing power of porous material for gases. Charcoal is best suitable for this purpose; 25 gallons of quenched charcoal yielding 70 cubic feet of oxygen gas (95 to 96 per cent pure) after one absorption and releasing the absorbed gas when the charcoal is sprinkled with water. The bark of trees and shrubbery also absorb oxygen to a considerable extent; 15 pounds of the bark are said to yield 20 cubic feet of oxygen in 1 hour, the gas being of 98 per cent purity. However, the absorbing power of the bark is not of long duration.

4. By partial evaporation and fractional distillation of liquid air. Of the world's supply of oxygen gas nearly 85 per cent is now produced by this process. It is not the intention of the writer to go into the details of the liquefaction of air and the recovery of the oxygen, inasmuch as this method can hardly be of interest to the small manufacturer. I only wish to outline briefly what has been accomplished in a practical way along these lines in the United States. Whether Prof. Linde of Munich, or Hampson of London, or Charles E. Tripler, of New York, was the first one to build an air liquefier, has not been decided. Tripler began his experiments in 1890, and finished his first liquefier in 1894. The Tripler Liquid Air Company had its plant at 330 7th Avenue, New York city. In the fall of 1900, this firm failed, Tripler having lost in the law suits instituted against him by the Linde interests. In the spring of 1900, Raoul Pictet, of Geneva, came to New York. He began a series of very expensive experiments, endeavoring to use liquid air as a means of producing large quantities of oxygen gas. This was at a time when Tripler had failed to convince the world of science that he could produce liquid air without cost, doing away with fuel of any kind. His perpetual motion scheme was laughed at and he had to hear much bitter criticisms. Therefore, Pictet's claims were not taken seriously and it was pointed out to him that there was no market for oxygen even if his experiments should prove a success. However, he failed to make good. He worked first in Tripler's laboratory and later continued his experiments at the plant of the General Liquid Air and Refrigerating Company, where he was assisted in the work by M. Burger. In spite of their widely circulated claim that with a 500-horse-power plant they were able to produce within 24 hours 3,550,000 cubic feet of oxygen, and 3,550,000 cubic feet of nitrogen, with 3,000 pounds of carbonic acid thrown in for good measure, and this at a cost of only \$75, nothing was done toward the actual manufacture of oxygen on a commercial basis. Pictet left, having accomplished nothing on this side of the Atlantic. It was more than a year later that the first liquid air oxygen was being sold by the Columbia Liquid Air Company, Washington, D. C. According to Mr. E. C. Foster, manager of the works, liquid air was being produced at the rate of 12 to 18 gallons per hour with an expenditure of 150 horsepower. The liquid air contained at an average 35 per cent oxygen. By evaporating two-fifths from the daily output 50 gallons of 70 per cent liquid oxygen could be made, or 5,000 cubic feet of the gas, at a cost of three-tenths cent per cubic foot. The Washington plant was later abandoned, and a new one erected in New York. By the "Eagle Oxygen Company" liquid air oxygen was sold for medical purposes, some also for limelights. The medical oxygen was in most cases of 75 per cent purity, although in some cases a 90 per cent product was put up. The gas tanks were charged without the aid of compressors, by filling a high pressure steel cylinder, surrounded by a vacuum jacket, with the liquid oxygen. The latter was allowed to gradually assume the gaseous state, forcing its way through the filling device, and from here was drawn off into the tanks at the required pressure (225 to 1,250 pounds). Whatever profit was made by the company was used up by constant experimenting of Mr. Foster and his mechanic, John J. Worland. After a short career of 1½ years the Eagle Oxygen Company closed its doors. Remnants of the first liquid

air oxygen apparatus are still buried in the cellar of a shop in Bleeker Street, New York. The British Oxygen Company, London, has secured the Linde patents for Great Britain; they also own the Claude's patents and with their five plants in operation practically control the oxygen market in England. The Linde Air Products Company in this country, controlled by German, English and American capitalists, has four plants in operation, and also owns the Claude's patents if the writer is correctly informed. A company for developing Hildebrand's patents is also being formed and a plant about to be erected. In far-off Los Angeles, the United States Liquid Air and Oxygen Company, using Babrick's patents, has been producing oxygen for the past ten years; while the General Liquid Air Company, of Dover, Del., is making frantic efforts to complete their plant. The oxygen industry in this country is, however, still in its infancy, although the progress that has been made within the past two years is remarkable. In Europe commercial oxygen has been on the market since 1880; Germany being especially active, with France a good second. In 1899 the yearly output of oxygen in Germany was doubled, and the following year trebled. The output in 1902 was 35,000 cubic meters, in 1903 it jumped to 50,000 cubic meters, in 1905 to 90,000 cubic meters, in 1908 to 400,000 cubic meters; the production of France for the same year was 300,000 cubic meters, and for England 100,000 cubic meters. In 1910 more than two million cubic meters of oxygen were sold by manufacturers in Germany, to which must be added the oxygen produced by individual plants, amounting to almost another million cubic meters of oxygen. Of this amount 8,000 cubic meters had been produced by the Brin's process; 342,000 by the electrolytical process, and 2,200,000 cubic meters by fractional distillation of liquid air. The output of oxygen in the United States is far behind those figures. During the latter part of 1910 the monthly output was 30,000 cubic meters (1,060,000 cubic feet) per month; but at present more than two million cubic feet per month are being produced.

#### Rules Governing the Competition for the \$15,000 Flying Machine Prize Offered By Mr. Edwin Gould

1. A prize of \$15,000 has been offered by Mr. Edwin Gould for the most perfect and practicable heavier-than-air flying machine, designed and demonstrated in this country, and equipped with two or more complete power plants (separate motors and propellers), so connected that any power plant may be operated independently, or that they may be used together.

##### CONDITIONS OF ENTRY.

2. Competitors for the prize must file with the Contest Committee complete drawings and specifications of their machines, in which the arrangement of the engines and propellers is clearly shown, with the mechanism for throwing into or out of gear one or all of the engines and propellers. Such entry should be addressed to the Contest Committee of the GOULD-SCIENTIFIC AMERICAN Prize, 361 Broadway, New York city. Each contestant, in formally entering his machine, must specify its type (monoplane, biplane, helicopter, etc.), give its principal dimensions, the number and sizes of its motors and propellers, its horse-power, fuel-carrying capacity, and the nature of its steering and controlling devices.

3. Entries must be received at the office of the SCIENTIFIC AMERICAN on or before June 1st, 1912. Contests will take place July 4th, 1912, and following days. At least two machines must be entered in the contest or the prize will not be awarded.

##### CONTEST COMMITTEE.

4. The committee will consist of a representative of the SCIENTIFIC AMERICAN, a representative of the Aero Club of America, and the representative of some technical institute. This committee shall pass upon the practicability and efficiency of all the machines entered in competition, and they shall also act as judges in determining which machine has made the best flights and complied with the tests upon which the winning of the prize is conditional. The decision of this committee shall be final.

##### CONDITIONS OF THE TEST.

5. Before making a flight each contestant or his agent must prove to the satisfaction of the Contest Committee that he is able to drive each engine and propeller independently of the other or others, and that he is able to couple up all engines and propellers and drive them in unison. No machine will be allowed to compete unless it can fulfill these requirements to the satisfaction of the Contest Committee. The prize shall not be awarded unless the competitor can demonstrate that he is able to drive his machine in a continuous flight, over a designated course; and for a period of at least one hour he must run with one of his power plants disconnected; also he must drive his engines during said flight alternately and together.

Recording tachometers attached to the motors can probably be used to prove such performance.

In the judging of the performances of the various machines, the questions of stability, ease of control and safety will also be taken into consideration by the judges. The machine best fulfilling these conditions shall be awarded the prize.

6. All heavier-than-air machines of any type whatever—airplanes, helicopters, ornithopters, etc.—shall be entitled to compete for the prize, but all machines carrying a balloon or gas-containing envelope for purposes of support are excluded from the competition.

7. The flights will be made under reasonable conditions of weather. The judges will, at their discretion, order the flights to begin at any time they may see fit, provided they consider the weather conditions sufficiently favorable.

8. No entry fee will be charged, but the contestant must pay for the transportation of his machine to and from the field of trial.

9. The place of holding the trial shall be determined by the Contest Committee, and the location of such place of trial shall be announced on or about June 1st, 1912.

10. Mr. Edwin Gould, Munn & Co., Inc., publishers of the SCIENTIFIC AMERICAN, and the judges who will be selected to pass upon machines, are not to be held responsible for any accident which may occur in storing or demonstrating the machines on the testing ground.

#### Engineering Notes

**Lead-Coating Iron Fittings.**—Valves and small fittings made of iron well galvanized on the exterior may be homogeneously covered with lead in the workshop by any mechanic. The method consists in immersing the piece to be coated in water to which a few drops of sulphuric acid have been added. Then, while in the acid water, the piece is readily amalgamated in the usual way by squeezing mercury through close-woven cloth all over its surface and thoroughly rubbing it in. The excess mercury is rubbed off and the piece carefully dried without heat, and then immersed in a bath of lead, which should be well above its melting point, so that it would not tend to solidify by introduction of the cold piece. The casting may be withdrawn after about 20 seconds, and will be found to be homogeneously covered with lead. This method requires the piece to be galvanized before applying the lead.—*The Engineer*.

**Corrosion of Rails in Tunnels.**—The corrosion of steel rails in different localities on a railway is an interesting and important subject, bearing directly as it does on road expenses. Some particulars given in the *Engineering Record* of the wasting of steel rails in the tunnel at Land Patch, Pa., on the Baltimore and Ohio Railroad, U. S. A., which is 4,775 yards long, and which is operated with double-track traffic on a single-track line, show that the dampness and tunnel gases greatly reduce the life of the rails. Plain Bessemer rails have a life of about eighteen months, and the deterioration proceeds in the flaking of the scale from the rail until the edges of the base become quite sharp, and the rail has to be removed. At the last renewal chrome-alloy rails were substituted for Bessemer rails, and have now been in service for nearly three years. Not only have these chrome-alloy rails been found to resist corrosion much better than the Bessemer rails, but they also show fewer breakages, the number being less than one-fourth of those in the plain rails.—*Engineer*.

**Cooling Mines Artificially.**—In order to obviate the many economic and sanitary disadvantages connected with the increasing height of the temperature in depths below 1,000 or 1,200 meters, Messrs. Rosenbeck and Rath advocate, in a recent issue of *Gluckauf*, the installation of freezing apparatus similar to those which have been so successfully introduced, especially in tropic climes, in hospitals, slaughter-houses, theaters, market halls, etc. As specially suitable for erection underground, they recommend evaporation plants with compression pumps, the most suitable freezing agent being sulphurous acid. The plant would have to be erected in a specially constructed cooling chamber on the level it is to serve. From this chamber the cold air would be conducted to the working faces by pipes, which would, by passing through drives and crosscuts, cool the air in them as well. Although the cost of an installation sufficiently powerful to cool a mine section worked by shifts of 60 men each would amount to about \$3,870, and the working costs, inclusive of interest and sinking fund, to \$5,600 per annum, the authors arrive at the conclusion—which they substantiate by a series of careful calculations—that, quite apart from its sanitary advantages, the economic results achieved by such an installation in increasing the working capacity of the men, etc., would not only fully cover all expenses, but leave a profit.—*Engineering and Mining Journal*.

#### Trade Notes and Formulæ

**Cement for Ivory.**—Dissolve alum in hot water until a thick fluid mass is obtained; of this a coating is applied to each end of the broken ivory, the parts pressed together and kept in this position until the mass is dry. The cement holds very well.—*Drog. Rundschau*.

**The Production of Elastic Sealing Wax.**—To produce seals that will neither break nor crack off, a sealing wax is to be made according to the following process: Gutta percha or caoutchouc is mixed with shellac in such proportions, that we have to 100 parts of gutta percha, 10 to 25 parts of shellac. Experiments have demonstrated that 12.5 parts of shellac imparts the best consistency to the mass. The adhesive property of the sealing wax is increased by the addition of 25 part of the commercial solution of caoutchouc in benzine. The mixture is kneaded thoroughly in a water bath, at a temperature of about 212 deg. F., coloring substance is added and the wax is shaped and finished.—*Farben-Zeitung*.

**Hardening Mixture for Mill Picks.**—Melt 1,000 parts of tallow, 250 parts of beeswax, 250 parts of pine rosin, and add to the melted mass 150 parts of yellow prussiate of potash. The picks, heated to redness are thrust into the cooled mass and removed when the metal can be grasped in the hand. The picks are then again heated to redness and plunged into clean, soft water, of a temperature of about 60 deg. F. for hardening. The addition of saltpeter, alkalies, salts and acids to the water, materially increases the hardness; addition of soda, fat, oil and petroleum reduces the hardness.—*Tech. Rundschau*.

**Cleaning Paste for Removing Rust.**—To remove rust from stove-plates, etc., we either make use of rust dissolving media, which, as they are mostly acids, are not well suited for household use, or we remove the rust by mechanical means, such as pumice stone and emery. These two substances, in combination with a fat, which will lighten the mechanical labor, furnish an excellent rust removing medium. The following is a recipe for a preparation of this character: Ground pumice stone, 40 parts; fine emery, 20 parts; petroleum, 5 parts; oleine, 35 parts; ceresine, 6 to 8 parts, by weight. Melt the ceresine, together with the oleine and after removal from the fire, stir in the petroleum, the pumice stone and emery. Continue stirring until a thick fluid consistency is attained, then pour out into cans to disguise the petroleum odor, we can perfume with a little oil of mirbane or better, with amyl acetate.—*Der Chemisch-Technische Fabrikant*.

**Marble or Rubber from Ashes.**—The utilization of the treasures locked up in coal has thus far usually stopped at the ashes. All the other products, such as gas, coke, tar, sulphate of ammonia, benzol, etc., have for a long time formed most important materials in our industries. In view of the enormous quantities of coal consumed annually a recently announced discovery, according to which there can be produced from ashes at will, substances resembling marble or rubber, claims lively interest. From ashes, the type of the dead, the passed away, new life is to be created. The highly excellent substance obtained, as stated, possesses at once the properties of marble and rubber. Neither moisture, heat or acids can attack it, at the same time it is non-conducting, so that its use for electric conduits also comes under consideration. The cost of producing the new substance, which is also adapted for wall and floor coverings, for table-slabs, etc., amounts to about 2 to 3 marks (45.6 to 71.4 cents) per square meter. The process of manufacture consists in that the ashes, preferably briquet ashes or dust ashes, are first sifted, then treated with cold soda water and copal varnish and finally subjected to a kneading and drying process. According to whether an imitation of marble or rubber is desired, the proper coloring substance is added. The material will be marketed under the name of "Cinerite."—*Schatze der Kohle und ihre Verwertung*.

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