

which carries them to the saturator, where they are converted into the state of milk of lime, until complete exhaustion. Between the helix and the saturator there is a series of fixed partitions radiating from the center to the circumference, and which have the effect of facilitating the decantation by arresting the eddies due to the revolution of the paddles.

The water, saturated with lime and perfectly decanted, makes its exit at the top of the saturator, and through K reaches the decanter. Opposite the motive wheel is situated the soda reservoir, G, the discharge of which is regulated by the float, I. The soda regulator is connected with the water regulator, so that the flow of the soda ceases as soon as the entrance of water is interrupted.

The liquid to be purified and the reagents enter the small mixing back, L, overflow into the reaction column, M, and descend toward the lower part of the apparatus. The water at the end of this first passage gives up the heaviest deposits, which fall to the bottom, O, of the decanter. Passing under the edge of the internal cylinder, the liquid afterward begins an ascensional motion and is distributed through the various spirals.

The spirals, N, have the effect of separating the liquid into movable strata of slight thickness, in such a way as to reduce the height of fall of the precipitate, and consequently to hasten the purification. They at the same time force the water to circulate in distinct veins, separated from one another by full strata, so that the deposits abandoned by the upper portions of the liquid cannot, on descending, pollute the portions in the lower spirals in the act of becoming clarified. As for the deposit of the precipitate, that is naturally favored by the very form of the surfaces of decantation. In fact, the liquid, by virtue of its ascensional motion, enters the helix and continually follows the upper region of the spirals, while the lower spaces are occupied by the deposits, which thus move freely over the helicoidal surfaces, independent of the force due to the velocity of ascension. The deposits descend to the mud reservoir, whence they are removed by opening the mud cock, P, and keeping it open until clear water makes its appearance. The liquid, freed from all the precipitated salts and all solid substances that polluted it, lastly traverses a filter, Q, and makes its exit clear and limpid from the decanting apparatus at R.

The numerous applications made of this purifier in various industries testify to the qualities of the system. Some idea of their importance may be had when it is known that the apparatus is now being employed for the treatment of 500, 800, 1,000, and even 2,000 cubic meters of water, a day.—*Revue Industrielle*.

COTTON BLEACHING WITH OXYGENATED WATER.

By M. PRUD'HOMME.

THE addition of calcined magnesia to oxygenated water has been recommended for bleaching cotton, but the superiority of the results obtained has not received any explanation. It depends, as I am about to show, on the formation of magnesium peroxide, which at 100° is more stable than hydrogen peroxide.

1. Oxygenated water at 6 volumes, diluted with 10 parts of water, was boiled for half an hour; its standard fell from 1,000 to 100.

2. A similar quantity, with the addition of calcined magnesia (5 per cent. on the weight of the hydrogen peroxide), falls in strength only to 900.

3. Calcined magnesia is placed in contact with oxygenated water at 3 volumes, at the ordinary temperature. The duration of the contact varies from some hours to many days. It is filtered, washed on the filter, and the product dried at from 100° to 105°.

The determination of the active oxygen by means of a normal solution of potassium permanganate corresponds to the formula $3\text{Mg}(\text{OH})_2 + \text{MgO}(\text{OH})_2$. This body, by an alkaline reaction, loses all its active oxygen at about 300°.

Magnesium peroxide is also formed on dissolving the metal in oxygenated water. Weltzein considers the product of the reaction a soluble magnesium hydrate. It is easy to show that when evaporated to dryness it gives with the ordinary tests the well-known reactions of oxygenated water.

The oxides of zinc and cadmium (metals belonging to the same series as magnesium in Mendeleeff's classification) also give rise to peroxides.

The mixture of zinc oxide and peroxide corresponds approximately to the formula $2\text{ZnO} + \text{ZnO}(\text{OH})_2$.

Cotton bleaching with oxygenated water would remain unintelligible if we confined ourselves to consider it as a simple decolorizing agent. It has a direct action upon the different bodies which bleaching has to modify or to eliminate, and even upon cellulose.

Action upon Fatty Bodies.

The saponification of the oils or fats is effected in part by the magnesia, but it is also due to the direct action of the oxygenated water. During ebullition there takes place an abundant liberation of carbonic acid; it may be derived from the oxidation of the glycerine, as it is verified directly. But the oxygenated water, very faintly acid, attacks also the neutral fatty bodies at ebullition, with the liberation of carbonic acid and a formation of fatty acids. These again are transformed by the mixture of oxygenated water and of calcined magnesia, and always with the production of carbonic acid. This happens with the stearic and the oleic acids of commerce. There must occur a partial transformation of this latter body into palmitic acid (as if by the action of potassa lye), for the product of the reaction, if suitably treated with an acid, is richer in soluble fatty acids than the oleic acid of which it forms a part.

The fatty bodies which remain upon the fiber in the state of magnesium oleates, palmitates, etc., are eliminated by a passage in weak acid, followed by an alkaline lye.

Action upon Cellulose.

In bleaching with oxygenated water the cellulose tends to become converted into oxycellulose. This is easily recognized by dyeing in basic coloring matters which fix themselves without a mordant upon oxycellulose.

The modification of the cellulose is more strongly marked if it has been mercerized, i. e., saturated with

concentrated caustic soda before treatment with oxygenated water. The disaggregation becomes complete, and the tissue becomes a pulp if we add caustic soda to the bath of oxygenated water until it marks 6° to 8° Tw.

The action of oxygenated water upon cellulose is much increased by the presence of certain bodies, such as metallic oxides, which serve merely as a vehicle or intermediate agent for active oxygen. A swatch of cloth mordanted with iron, chrome, or alumina, and boiled with oxygenated water or magnesia for one to two hours, is profoundly attacked at the parts covered by the mordants. It is well, therefore, to let a treatment with weak acid precede the bleaching with oxygenated water, to eliminate the salts or the metallic tissues from the tissue.

The action of oxygenated water and that of cuprammonium upon cellulose present great analogies.

It is easy to show that the ammoniacal solution of copper oxide is an oxidizing agent, by allowing it to act upon a swatch dyed blue with indigo. The solution, if sufficiently diluted to produce no sensible alteration of the tissue, decolorized the blue in 24 hours in the cold and in a few minutes at 60°. If the cuprammonium solution is sufficiently concentrated to weaken the fiber, this, if well washed and treated with a dilute acid to dissolve out the copper oxide, takes up a full shade on methylene blue; there is therefore a formation of oxycellulose.

A swatch of cotton cloth mercerized in caustic soda at 36°, and thoroughly washed, is left in contact for some hours with a cuprammonium solution of medium concentration. The fiber is more attacked than that of a check swatch which has not been mercerized.

We conclude from these experiments that, contrary to the received opinion, cellulose is attacked and transformed by contact with the reagent of Schweitzer.—*Comptes Rendus* (cxii., p. 1374), *Chem. News*.

THE MANUFACTURE AND INDUSTRIAL VALUE OF ALUMINUM.*

By J. H. J. DAGGER, F.I.C., F.C.S.

IT is little over five years ago since I had the pleasure of being present for the first time as a member of this society, and then listening to a paper read by our esteemed treasurer on what he very truly termed a new departure in metallurgical science—the application of electricity to the reduction of metals from their ores. As in all things new, greater expectations were formed than have been realized; still, the electrical furnace then described marked the first step in the production of aluminum at a cost that would place it in the market beside the common metals, and also the raising of electrolytic and electrothermic methods from laboratory and lecture table experiments to the rank of manufacturing processes. Before passing to a description of some of these, it will be interesting if for a moment I give you in outline the history of this, one of the most beautiful and destined to be most useful of the metals.

History.—Its name is from *alumen*, the word given by the Romans to all bodies having an astringent taste, hence alum, which is alluded to by Pliny and Vitruvius as being used as a mordant in producing brilliant dyes. Most probably this was "kalinite," a potash alum which occurs in large quantities in the Solfatara, near Naples, probably formed by the action of volcanic gases on feldspathic trachyte. It was not until 1746, however, that Pott first stated the base of alum to be an argillaceous earth, and eight years later Margraff distinguished alumina from lime, with which up to that time it had been confounded. In 1807 Davy made an unsuccessful attempt to decompose alumina with the electric current. In 1824 Oersted obtained a gray powder which oxidized rapidly in the air by heating aluminum chloride with potassium amalgam. Three years later, 1827, Wohler, by decomposing the anhydrous chloride with potassium, obtained a metallic powder which became bright under the burnisher, but it was not until 1845 that he produced the metal in the form of globules as large as pin heads. From these he, with infinite patience, determined for the first time the physical characteristics of aluminum.

In 1854 Deville and Bunsen, working independently, obtained aluminum by electrolysis of the fused chloride, and the same year Deville, substituting sodium for potassium, obtained the metal in quantity for the first time by the well known process which, until the recent development of electrolytic methods, has formed the basis of the operations for the production of aluminum at Salindres, and the more recent developments of the industry at Newcastle and Birmingham in our own country. It will, perhaps, not be forgotten that the first aluminum in this country was produced in 1855 in the laboratory of the Royal School of Mines, by Messrs. Dick and Smith, under direction of Dr. Percy, by the action of sodium on cryolite.

Gerhard established a factory at Battersea in 1859, and Messrs. Bell Brothers at Newcastle, 1865, produced aluminum by the Deville method, but neither of these undertakings proved successes commercially, and after a time were abandoned.

The next stage in the development of the aluminum industry was the improvement and simplifying of the sodium methods by Castner and Netto, both of which processes have been described in the *Journals* of this society, as also the well known Cowles process for production of alloys, which I described at length in a communication to the society in September, 1889.

The advance of electrical science has given us an increased knowledge of the laws of electrolysis, and the improvement in dynamos and electrical machinery has within the last two years reduced the cost of aluminum from 15s. to 5s. per pound. The price of aluminum having fallen from 360s. 1855, 103s. 1857, 62s. 1860, 20s. 1862 to 1887, 15s. 1888, 5s. 1890-91. Any further reduction in price will be rather from improved methods in the production and purification of alumina, for the exceeding difficulty of obtaining the metal free from silicon and iron has been and still remains an obstacle in the way of its cheap production, greater than we have to deal with in the case of other metals. Although aluminum is one of the most widely distributed of the elements, the necessity of using alumina free from impurities reduces the number of minerals available in

*A paper recently read before the Society of Chemical Industry.—*From the Journals.*

our present state of knowledge to very few. These are:

Bauxite, preferably that from Beaux, in the Department of Var, of which the following are typical analyses:

	Red.	White.
Al ₂ O ₃	60.73	64.83
Fe ₂ O ₃	20.08	65
SiO ₂	3.62	12.60
TiO ₂	1.91	3.44
P ₂ O ₅	0.39	..
H ₂ O	13.27	15.47
	100.00	99.99

Corundum.—Very hard crystalline mineral, sp. gr. 3.909, occurs massive in northern Georgia, and in India, often as water-worn pebbles in *debris* from river torrents. Here is an analysis of such pebbles from Ceylon and of rock from India, locality unknown:

	Pebbles.	Rock.
Al ₂ O ₃	89.23	84.26
FeO	0.77	..
Fe ₂ O ₃ .....	..	0.73
SiO ₂	5.55	11.77
TiO ₂	4.86	3.31
CaO	Traces	..
MnO ₂		
	100.43	100.00

Cryolite.—This mineral, a double fluoride of aluminum and sodium, is found in large deposits in one district in Greenland, from which nearly all that is used is obtained. It is found in smaller quantities at Minsk, in the Ural Mountains, and near Pike's Peak, California. An average analysis of the Greenland mineral is as follows:

Al	13.23
Na	32.71
F	54.19
Mn ₂ O ₃	0.83

This mineral is not used as a direct source of aluminum, but as a flux in the manner I am about to describe.

Grabau's Process.—Before passing to a description of the electrolytic process for the production of aluminum, I will say a few words about the sodium process as modified by Grabau, of Hanover, in which the difficulties arising from the action of molten alkaline fluorides are overcome in a very ingenious manner, and an aluminum of a high degree of purity is produced. In this process the sodium and aluminum fluoride are heated in two separate iron vessels; the one containing the sodium is provided with a suitable cock for discharging the molten metal, and that containing the fluoride has a drop bottom, or is fitted with a slide that can be readily drawn. A reducing vessel which is kept cool with a water jacket, and which swings on trunnions, is arranged underneath the two vessels. The aluminum fluoride is heated to a temperature of about 600 deg., at which it remains pulverent; the sodium is then melted and run into the reducing vessel. When the metal has all run in, the slide is withdrawn and the pulverent fluoride is allowed to fall on to the sodium; the reaction which ensues produces much heat, and the contents rapidly become fluid; the cryolite produced, however, solidifies on the cool sides of the vessel, and the crust thus formed is not attacked by either the fluid cryolite or the aluminum. The aluminum is collected by rapidly shaking the vessel to and fro, and after a minute or two the vessel is tilted and the contents flow into a lower vessel lined with cryolite or aluminum, leaving a crust of solidified cryolite in the reducing vessel. Notwithstanding the great improvement in the mechanical arrangements and the cheapening of sodium by the recent improvements of Castner and others, it is, I think, only a question of time when the old chemical methods will be superseded altogether by the newer electrolytic processes for the production of aluminum. Even at the present time it is not possible to produce aluminum of equal purity by the use of sodium at anything like equal cost.

I now come to describe the electrolytic processes in operation on a commercial scale for the production of aluminum. They are, first, the Hérault process, in operation at the works of the Aluminum Industry Company, limited, at Lauffen-Venhausen, on the Rhine fall, and those of the Societe Electro-Metallurgique, at Froges, near Grenoble. In this process the electrolysis is conducted in iron pots or tanks lined with carbon, the pot is raised on insulating supports, and connected with the cable from the dynamo, so that the lining forms the negative electrode, or else this is made of a piece of metal, iron or copper, fixed in the bottom of the pot. The positive electrode is of carbon and so arranged that it can be lowered or raised in the molten charge. The first charge is a small quantity of cryolite, which is rapidly melted by the heat generated by the resistance to the current. As soon as it is fluid the current passes and alumina is fed into the molten flux. The process is continuous, and the aluminum which accumulates in the bottom of the pot is tapped every twenty-four hours. The purity of the metal produced varies from 97 to 99 per cent. During the operation the oxygen combines with the carbon of the positive pole and produces carbonic oxide, which burns at the vent in the cover to carbonic acid gas.

At Froges the electric current is supplied by four dynamos, each 6,000 ampere, with a voltage of fifteen, worked by two large turbines of 300 horse power each. At Venhausen are two dynamos constructed to de-

velop 14,000 amperes at thirty volts and a smaller one of 3,000 amperes at sixty-five volts. The total horse power of this plant is about 1,500.

In the Hall process, alumina is dissolved in a fused bath of the double fluoride of aluminum and potassium, or of aluminum or sodium. The salts are mixed in a proportion corresponding to the formula $K_2Al_2F_6$ (Al_2F_6 , 169, KF, 116). An excess of the potassium salt will increase the solvent power of the bath, but decrease its fusibility. A larger quantity of alumina fluoride renders the bath more fusible, but diminishes the alumina dissolved. The operation is conducted in iron tanks arranged in series. They are lined with carbon, and form the negative electrodes or cathodes. The positive electrodes or anodes are carbon rods, 3 in. diameter, attached by $\frac{3}{8}$ in. copper rods to the conductors or leads by means of suitable clamps. The current of 5,000 amperes and 50 volts in one series and of 2,000 amperes and 20 volts in the other series is turned on. The mixture of fluorides in the tanks or pots is melted by the heat generated by the resistance they offer to the current. In about two hours' time the mixture becomes fluid, and alumina is added. The resistance of the electrolyte falls from 15 to about 8 volts, and electrolysis commences, the liberated aluminum sinks to the bottom of the tank, the oxygen going to the positive electrode, combining with the carbon, and escaping as CO_2 . During the operation the bath is kept covered with fine carbon dust, and on this is placed the powdered alumina. When the voltameter indicates a rising resistance, the attendant stirs in more alumina from the surface of the pot, the carbon dust rises again to the surface, when fresh alumina is placed upon it. The metal produced is dipped out with cast iron ladles, any entangled electrolyte being skimmed back into the pot. The operation is a continuous one. The metal produced by this process is very pure. The first "run" of metal carries with it all the iron and silicon of the electrolyte, the only remaining sources of impurity being the alumina added, and the ash of the carbons which are consumed in proportion of a little less than weight of carbon to weight of metal produced.

The electrical energy expended is calculated at 22 E. H. P. per hour per pound of aluminum.

Aluminum." Aluminum is given the most exaggerated properties, and much harm is done to the real value of the metal.

What are the facts, to begin with? Aluminum can never possibly take the place of iron and steel for structural purposes, such as in bridges and heavy machinery; it is not a rigid metal; a bar supported on bearings 24 in. apart was deflected $\frac{5}{8}$ in. with 100 lb. load, $\frac{1}{4}$ in. with 200 lb., and $2\frac{1}{2}$ in. with 300 lb. The permanent set with this load was $2\frac{3}{4}$ in., showing the low elasticity; and again, although aluminum is only one-third the weight of iron, it has less than one-half the tensile strength of the best wrought iron, and only one-third that of a mild steel. These facts would prevent it ever replacing these metals in shipbuilding and for structural purposes. But aluminum is beyond all doubt one of the most valuable of metals, and is, I believe, destined to displace almost entirely some of our older metals, for instance, copper, which its superior power in resisting corrosion, its great lightness, will enable it to replace in light machinery and fittings, gas and water fittings, steam pipes, electrical machinery. It would also be invaluable for all art work and decorative purposes. Aluminum plating would supersede both tin and nickel plating; it would largely take the place of tinned ware and German silver and electroplate for table ware. It would also be invaluable to the chemist for many of his laboratory fittings, replacing brass and iron, which corrode so rapidly in such atmospheres. Now, bringing this paper to a close, I regret its imperfect character arising from its being put together amid pressure of other duties. I hope at some future time to bring before you a further account of the development and uses of this valuable and beautiful metal.

Mr. Dagger, replying to Dr. Kohn's question regarding the liberation of fluorine by decomposition of the cryolite, and the part it played in the process, said that in the operation as described no fluorine was liberated. The alumina was decomposed by the electric current, and the action of the fluoride seemed to be merely that of a flux when comparatively small quantities of fluoride were used. If, however, those proportions were departed from, and the pot was allowed to get out of "ore," or alumina ceased to be

on iron in preventing the formation of blow-holes, and in giving sounder castings. Its action was most probably deoxidizing, and thus enabled it to destroy the oxides and various impurities which were entangled in the molten iron, and which rose to the surface, leaving a much purer and better metal underneath. He had seen it stated that aluminum lowered the melting point of cast iron, and he had himself taken it for granted and stated so in previous papers on aluminum; but from recent observations he rather doubted the statement, although given on high authority. For air baths, the trouble of aluminum softening at 600° was felt, and it was not considered a suitable metal. The action of sulphuric acid on aluminum would be slight at 55° C. In answer to Mr. Norman Tate, the action of coal gas on aluminum fittings caused no danger, and he could not say that they would be affected to any extent by the impurities contained in ordinary coal gas, certainly not to the degree to which iron fittings were corroded.

EXPERIMENTS WITH LEYDEN JARS.

EXPERIMENTS RECENTLY MADE BY DR. O. LODGE BEFORE THE PHYSICAL SOCIETY, LONDON.

The first one was with resonant jars, in which the discharge of one jar precipitated the overflow of another when the lengths of the jar circuits were properly adjusted or tuned. The latter jar was entirely disconnected from the former, and was influenced merely by electro-magnetic waves emanating from the discharging circuit. Lengthening or shortening either circuit prevented the overflow. Correct tuning was, he said, of great importance in these experiments, for a dozen or more oscillations occurred before the discharge ceased. The effect could be shown over considerable distances. In connection with this subject, Mr. Blakesley had called his attention to an observation made by Priestley many years ago, who noticed that when several jars were being charged from the same prime conductor, if one of them discharged, the others would sometimes also discharge, although they were not fully charged. This he (Dr. Lodge) thought might be due to the same kind of influence which he had just shown to exist. The word *resonance*, he said, was often misunderstood by supposing it always had reference to sound, and, as substitutes, he thought that *sympsoning* or *sympsonic* might be allowable.

The next experiment was to show that wires might be tuned to respond to the oscillation of a jar discharge, just as a string could be tuned to respond to a tuning fork. A thin stretched wire was connected to the knob of a jar, and another parallel one to its outer coating, and by varying the length of an independent discharging circuit, a glow was caused to appear along the remote halves of the stretched wires at each discharge; each of the wires thus acted like a stopped organ pipe, the remote ends being the nodes at which the variations of pressure are greatest. By using long wires he had observed a glow on portions of them with the intermediate parts dark; this corresponded with the first harmonic, and by measuring the distance between two nodes he had determined the wave length of the oscillations. The length so found did not agree very closely with the calculated length, and the discrepancy he thought due to the specific inductive capacity of the glass not being the same for such rapidly alternating pressures as for steady ones. He also showed that the electric pulses passing along a wire could be caused, by tuning, to react on the jar to which it was connected and cause it to overflow, even when the distance from the outside to the inside coating was about eight inches. During this experiment he pointed out that the noise of the spark was greatly reduced by increasing the length of the discharging circuit. The same fact was also illustrated by causing two jars to discharge into each other, spark gaps being put both between their inner and outer coatings, so as to obtain "A" sparks and "B" sparks. By putting on a long "alternative path" as a shunt to the "B" spark gap, and increasing that gap, the noise of the "A" spark was greatly reduced. He had reason to believe that the "B" spark was a quarter phase behind the "A" spark, but the experimental proof had not been completed.

He next described some experiments on the screening of electro-magnetic radiation, in which a Hertz resonator was surrounded by different materials. He had found no trace of opacity in insulators, but the thinnest film of metal procurable completely screened the resonator. Cardboard rubbed with plumbago also acted like a nearly perfect screen. In connection with resonators he exhibited what he called a *graduated electric eye* or an *electric harp*, made by his assistant, Mr. Robinson, in which strips of tinfoil of different lengths are attached to a glass plate, and have spark gaps at each end, which separate them from other pieces of foil. One or other of the strips would respond according to the frequency of the electro-magnetic radiation falling upon it.

Mr. Blakesley asked whether the tuning of the resonant jars needed readjustment when the distance between their circuits was varied, for, according to theory, the mutual induction should diminish the self-induction of the primary, and cause its oscillations to be more rapid. If this was true, the method might be used for getting rapid oscillations. He also inquired whether the glow would appear in the same position on the two stretched wires if their ends were joined.

Dr. Sumpner wished to know how the resistances, inductances, and capacities of the circuits and jars were determined, and whether any evidence of irregular distribution of the charges on the tinfoil had been noted. With reference to the overflowing of a jar caused by using a certain length of discharging circuit, he asked whether the overflow did not prove the existence of a higher potential than that which originally existed between the coatings of the jar, and, if so, where did the excess energy come from?

Dr. Thompson asked if it would be possible to make a wire circuit analogous to an open organ pipe by putting sheets of metal on the ends of the wires.

Dr. Lodge, in reply, said Mr. Blakesley's suggestion was an important one, but he had not observed that any change in the adjustment was necessitated by varying the distance between the resonating circuits. Neither had he noticed any glow on wires joined to

COMPARISON OF ALUMINIUM WITH IRON AND COPPER.

	Aluminium.		Iron.		Steel.	Copper.	
	Cast.	Rolled.	Cast.	Wrot.		Cast.	Rolled.
Colour.....	Bluish white.		White.	Grey.	..	..	..
Density.....	2.5	2.7	7.5	7.1-7.8	7.7-7.2	8.96	
Weight per cubic foot in pounds..	162		450	485	490	555	
Melting point.....	1,300° F.	..	2,780° F.	above 4,000° F.	4,000° F.	1,990° F.	
Tensile strength in pounds per square inch.	20,000 to 25,000.	30-35,000	15,680 lb. (7 tons)	45-60,000 (19-27 tons)	60-90,000 (40-45 tons)	20,000 (does not cast as well as Al.)	30-40,000 lb.
Elongation per cent.	14	3.0	..	7-22	5-15	..	20-40
Specific heat*	0.218	..	.1138	..	..	.0952	..
Electrical conductivity	34.0	..	16	..	..	99	
†Thermal conductivity.....	33.7	..	11.9	..	..	75	

* Higher than any metal except lithium and glucinum.
Al.—Atomic weight, 27.4, sp. heat equal weights, 0.2143, sp. heat atomic weights, 5.87.
Li.—Atomic weight, 7, sp. heat equal weights, 0.9408, sp. heat atomic weights, 0.49.
† Ag. = 100.

Properties of Aluminum.—The pure metal, free from silicon and iron, is said to be perfectly white, but as produced it has a bluish-white tinge. When burnished it is exceedingly beautiful; under all ordinary conditions it is unacted upon by air and moisture, sulphureted hydrogen, ammonium sulphide, and cold dilute sulphuric acid have practically no action on it, when free from silicon. The non-corrodibility, however, depends entirely upon the freedom of the metal from silicon and iron. It is not affected by cold nitric acid, and only slowly when heated. The organic acids and salts, as acetates, tartrates, and citrates, have practically no corrosive action on it; though in presence of salt action is set up, though very much less than in the case of copper or tin. The salts of aluminum formed are also non-poisonous, and this would make it valuable for cooking utensils, tins, and cases for preserved foods and meats, etc. Another point in its favor is that following on its high specific heat, it takes much longer for the internal heat to penetrate an aluminum vessel, and so food heated in an aluminum pan would keep warmer for a longer time. If a plate of aluminum be heated and then withdrawn from the fire, it will retain its heat for a sufficient time to cook an egg. Its lightness, too, would make it the ideal metal for travelers' and soldiers' equipments, water bottles, canteens, etc. It would also be most valuable for surgical instruments and tubes.

It is extremely malleable, following after gold in this respect, and may be drawn into fine wire. It can be rolled into sheets about 0.0007 in. thickness, and drawn, spun, and stamped. It, however, becomes hard by working, and requires frequent and careful annealing at low temperatures; the best temperature for working is 100 deg. to 150 deg. C. Its hardness equals that of silver. Bars of the metal give a clear musical sound if struck, but the presence of even a small proportion of impurity destroys the resonance.

Castings can be made in ordinary dry sand moulds. Gates should be somewhat larger than for brass, but great care should be taken not to heat the aluminum much above the melting point, for otherwise it will absorb gases and become spongy and unsound. The shrinkage is about $2\frac{1}{4}$ per cent. of the length of the mould, and ample provision must be made for this in the cores. 100 lb. casting in Al would be equal to 290 Fe, 360 Cu, 280 Sn or Zn, 420 Ag, 48 Pb, 770 Au, 860 Pt.

Aluminum is readily corroded by alkaline solutions forming aluminates, and also by hydrochloric acid and chlorine, and is acted upon more or less by solutions of the chlorides. Very much has been written and said about the properties of aluminum, sensational leaders appear daily in the press, describing wonderful bridges and machinery, ships and houses of the aluminum age, or as one note put at the head of an article, besides which Jules Verne is dull reading, "A Dream of

added in excess, the fluoride would begin to decompose and that meant the formation of an infusible mass filling up the pot and ending the operation.

In the process conducted by the Pittsburgh Co., practically nothing of this kind took place, and the run was continuous. The softening temperature of aluminum would take place between 600° and 700° F.; at that temperature it would begin to get crumbly and work a little. In contact with most other metals aluminum in presence of moisture oxidized. If a plate were taken and bound round with platinum wire alumina would gradually be formed at the contact. In the case of copper and iron vessels, corrosion would take place at the juncture of the two metals. For steam pipes, since the softening of aluminum occurred at a low temperature, its action would be uncertain for steam under high pressure, and would therefore not be a reliable metal to use. Out of a yield of 2 lb. of alumina containing 53 per cent. aluminum there would be a loss of about 3 per cent. of the aluminum, so that 97 per cent. of the theoretical amount would be about the yield obtained. Dr. Rawson had asked which would be the best mineral to use in the electric furnace, and he (Mr. Dagger) believed that corundum, if it could be obtained cheap, was certainly the best, having 87 per cent.—93 per cent. Al_2O_3 ; but for making the alloys he preferred bauxite, as it was easier to obtain and softer. Cryolite was simply used as a flux. It had been found that using cryolite as in the sodium process the quality of metal fell far short and did not repay for the trouble taken. In reply to Dr. Rawson whether bauxite reduced the amount of iron, he would point out that it was the rule now to prepare alumina from bauxite, and in that case bauxite was a far better mineral to use than corundum, but he would deal with that question at another time. About the carbons, there was rather a difficulty in obtaining them. The great trouble, as a rule, was that they were far too soft. He had found that the best were those which they had obtained from the United States from the mineral oil carbon, and was exceedingly pure, the ash going down to about 0.01 or 0.02 per cent. The carbons used were solid, and varied from $1\frac{1}{2}$ in. to 3 in. or 8 in., made in sections and in plates banded together. Mr. Knight had raised the question as to soldering aluminum. It had not been properly overcome, but he (Mr. Dagger) would give him the formula, which might be of interest to others, and which he had found to give fairly good results. The difficulty in soldering arose of course from the formation of a film of unreducible oxide, which prevented the contact of the solder with the aluminum surfaces. For ordinary work the solder containing Al 6 parts, copper 4, zinc 90, would be used, but the zinc had to be free from iron. For heavy soldering a mixture of Al 12, copper 8, and zinc 80. In reply to Mr. Jones' question, aluminum had a beneficial action