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THE ISSUE OF THE *Publishers' Weekly* for March 30 contains the spring announcements of American publishing-houses. This list shows comparatively few books of importance, — a fact very likely due to the tendency, on the part of the trade, to put off their best things and postpone their best efforts until fall. This has come about through the custom, at present prevailing in this country, of buying books only through one or two months in the year, which has led to a considerable demoralization of the trade of book-making. There are now in America sixty millions of people, using one language, the most of them able to read, and, on the average, more able to buy books than the people of any other country. The trade in reading-matter is certainly enormous, but it is largely confined to newspapers and periodicals; the newspapers especially growing bigger and bigger, until their Sunday issues supply for three or four cents more than a day's reading. For the time being they monopolize a great part of the reading-time of the week, and lessen in this manner the time available for books. Yet, taking all this into consideration, and remembering that in the thirty years since 1859 our population has more than doubled, and the proportion of illiteracy has decreased, there ought to be a great demand still left for books. There are certainly a large number of cheap editions supplied through the dry-goods dealers and similar channels of distribution; but it remains that the book-market is not of as high a class as was that of a generation ago. Just before the war several of the existing houses and the predecessors of existing houses in New York, Boston, and Philadelphia, were almost at the culmination of their prosperity; and, besides these, there were a number of other publishing-houses of note or respectability whose names are honorable in the history of literature. It would be difficult to find now any publisher who would undertake at his own risk the issue of the many standard series of books which were so creditable to American book-production of thirty years back.

Publishers find in the present state of American literature little to encourage them; authors find in the present state of American literature little to encourage them. The largest houses are unwilling to take the risks which a generation ago their fathers in the business would have taken. The retailers of books have certainly not increased in number, and have apparently decreased. Take, for instance, the city of Salem, Mass., the home of Hawthorne, Prescott, Bowditch, and of many others who have made American literature famous, — a place whence some of the noted publishers in the American trade found their way to Boston and other places, a city of great intellectual activity. In old days it was well supplied with retail stores, some of which grew to be publishing-houses. The book-trade of Salem has not been displaced by a free public library. It is only within the last year or two that such an institution has been started. Yet only one book-store of any importance remains in Salem, and that is largely devoted to the sale of wall-papers, etc., and expects rather to take orders than to carry any considerable amount of standard books in stock. The live book-trade has gone almost entirely into the hands of an enterprising dry-goods house, who are members of the Syndicate Trading Company, and who handle at Christmas time and throughout the year a considerable quantity of books, but could scarcely be relied upon to perform the functions of the old-fashioned book-store, with its supply of standards on the shelves, tempting a customer to increase his library with books that are books. It can scarcely be said that the retail trade has gone to Boston, for the trade of Boston is not so wonderfully larger than it was in old times; and this state of things is more or less true throughout the country. Book-selling and book-buying have both suffered a decadence in quality as well as in quantity, except in the case of books of exceptional popularity. The size of editions is scarcely larger, if as large, as in the days when we had not a third of our present reading population.

ALUMINIUM AND ITS MANUFACTURE BY THE DEVILLE-CASTNER PROCESS.

ALUMINIUM was shown to be a distinct substance in 1754 by Marggraff. It may be ranked among the noble metals, because it does not tarnish, even when exposed to damp and very impure atmospheres; and until lately it was almost a precious metal, the price ranging as high as 60 shillings per pound. Indeed, even now, absolutely pure aluminium is scarcely to be obtained, the metal used in the arts being contaminated with from two to five per cent of iron, silicon, and other substances. The chemical symbol of aluminium is Al: its atomic weight is 27.4. Aluminium is very widely diffused over the earth. Its silicate forms the chief constituent of clays, and enters into the composition of a vast number of minerals, especially of felspars. Its fluoride, united with that of sodium, forms cryolite. A ferruginous hydrate is known as bauxite, and forms probably the most convenient ore from which to extract the metal.

The method now generally adopted in preparing aluminium was discovered early in this century by the eminent French chemist, Henri Saint-Claire Deville, and consists in reducing the double chloride of aluminium and sodium ($2\,NaCl\,Al_2Cl$) by means of metallic sodium at a high temperature. The manufacture, therefore, resolves itself naturally into two parallel processes; the one comprising the preparation of the double chloride, and the other the production of metallic sodium. As sodium to the extent of nearly three times the weight of aluminium is required in the reduction of the latter metal, it will be seen that the cheapness and abundance of the aluminium depends very much on the cost of the sodium, and the quantity in which it can be produced. Till quite recently, the price of sodium was as high as 5 shillings a pound; and the process of manufacture was so difficult, and even dangerous, that very large quantities could not be obtained. The improvements effected by Mr. Hamilton Y. Castner in the manufacture of sodium, by which it can be made in any quantity without the slightest risk at about 1 shilling per pound, has rendered it possible to produce aluminium of about 98 per cent purity which can be sold profitably at 20 shillings per pound.

The object of a paper by William Anderson, in a recent number of the *Journal of the Society of Arts*, London, is to describe the process of manufacture adopted by the Aluminium Company, at the works, which have just been started, at Oldbury, near Birmingham.

We will first take the manufacture of the double chloride of aluminium and sodium. The raw material is hydrate of alumina (Al_2O_3 + water), which is the only oxide of aluminium. It can be prepared in a variety of ways, and from various materials, such as common alum, which is the double sulphate of aluminium and potassium, $Al\,K\,(SO_4)\ 12\,H_2O$; bauxite, which, as already stated, is a ferruginous hydrate; and other substances; the price being about £13 per ton when it is sufficiently pure for the purpose.

The hydrate of alumina, in a finely divided state, is mixed, on a suitable floor, with lamp-black, charcoal, and common salt; moistened with water; the mass is thrown into a pug-mill, and, after being thoroughly mixed and incorporated, is forced through dies constructed exactly as in a drain-pipe machine, the issuing cylinders of the compound being cut off by wires into pieces about three inches long, which are carried to the tops of the chloride furnaces, and spread out there to dry thoroughly.

The next process is to expose the mixture of hydrate of alumina, carbon, and salt, to a high temperature in presence of chlorine gas, in order to obtain the vapor of the double chloride, which is distilled over, and condensed in the form of a deliquescent, light-yellow substance of very pungent odor. This operation is performed in regenerative furnaces, constructed very like banks of ordinary earthenware gas-retorts. The gas from the producers plays round groups of five retorts, set in ovens, in which their temperature is raised to a bright-red heat, the exact intensity of which is a matter of much importance, and requires an experienced eye to regulate.

The retorts are connected at their mouths — that is, their opening ends — by means of earthenware pipes to gas-holders containing chlorine gas, special means being taken to regulate the pressure of the gas and the rate at which it is allowed to flow. The opposite ends of the retorts are fitted with pipes, which convey the fumes of double chloride to cast-iron condensers, and thence to brick chests or boxes, the outsides or ends of which are closed by means of wooden doors. Convenient openings are arranged for clearing out the passages, because the double chloride condenses very quickly. The greater portion of it liquefies, and trickles down into the brick chambers; while a portion sublimes, and comes over in the form of a yellow powder. The brick chambers are emptied from time to time, and the contents packed away in air-tight wooden chests, — a precaution rendered necessary on account of the deliquescent properties of the substance. The re-action which takes place is as follows: —

$$2\,Al_2O_3 + 3\,C_2 + 4\,Na\,Cl + 6\,Cl_2 = 2\,(Al_2Cl_6\ 2\,Na\,Cl) + 6\,CO.$$

That is, two molecules of alumina, three molecules of carbon, four molecules of salt, and six molecules of chlorine, give two molecules of double chloride and six molecules of carbonic oxide.

The chlorine gas used in the retorts is manufactured on an enormous scale, being prepared in the usual way, by the action of hydrochloric acid on manganese dioxide, at a moderately high temperature. One molecule of the manganese dioxide combining with four molecules of hydrochloric acid, produces one molecule of manganous chloride, two molecules of water, and one molecule of gaseous chlorine: —

$$Mn\,O_2 + 4\,H\,Cl = Mn\,Cl_2 + 2\,H_2O + Cl_2.$$

The manganous chloride is soluble, and forms the "spent still liquor," which is reconverted into manganese dioxide by Weldon's method; that is, by first neutralizing all free hydrochloric acid by means of powdered limestone, and then adding milk of lime to the neutral solution, when manganous oxide and calcic chloride are formed: —

$$Mn\,Cl_2 + Ca\,O = Mn\,O + Ca\,Cl_2.$$

By exposing the manganous oxide to a strong current of air, it takes up another atom of oxygen, and becomes again $Mn\,O_2$, or manganese dioxide.

The chlorine plant forms a very imposing part of the factory. The hydrochloric acid is conveyed by a 2-inch gutta-percha pipe a distance of some 700 feet across the canal, from Messrs. Chance Brothers' Alkali Works. It is received into six large stone storage-tanks, each capable of containing 10 tons; and from these it is run, as it is wanted, into two large stone stills made up of huge slabs of sandstone cramped together in an ingenious manner by iron bolts and cast-iron angle saddles, the joints being made by means of solid India-rubber cord. In these stills the manganese dioxide and the acid are mixed; and, being warmed by injected steam to the proper temperature, the chlorine gas is at first given off rapidly and with effervescence. The rate gradually decreases, and at length the disengagement of gas ceases altogether. The chlorine is carried off by means of lead and earthenware pipes to four large lead-lined gas-holders, capable of containing several thousand cubic feet of gas; and from them it is led away to the double chloride retorts, various ingenious devices having been introduced for indicating the pressure of the gas, and measuring the quantity passed into each retort. Chlorine, besides being valuable, is a very disagreeable gas when it gets out of its proper place: hence great care and method are required in manipulating it.

The "spent still liquor," the solution of manganous chloride, is run into a large neutralizing well, 20 feet diameter, and 20 feet deep, built of stone, and fitted with agitators. It is there neutralized by intimate mixture with powdered limestone, and is allowed to settle, after having been pumped up to a system of tanks elevated above the oxidizing-tower, during which process iron and some other impurities are carried down. The clear solution, which has a pinkish color, is then run into the oxidizing-tower, which is a wrought-iron cylinder standing on end, about 12 feet diameter and 30 feet high, where it is warmed by injected steam. Milk of lime is added, and the whole violently agitated by a powerful current of air, pumped in at the bottom of the tower by an 80-horse-power horizontal engine driving a large double-acting air-pump. In two or three hours the manganous oxide has absorbed as much oxygen from the air-current as it had at first given up to the hydrogen of the hydrochloric acid, and thus reverts to its original state.

The contents of the tower, now a thick black turbid liquid, are run into a second system of settling-tanks, five in number, erected below the level of the tower. The tanks are each 18 feet square by 7 feet deep, and are used alternately for settling the charges as they are withdrawn from the tower. The recovered manganese dioxide settles out, leaving a clear solution of chloride of calcium, which is drawn off by overflow pipes; and the recovery process is then complete, the manganese mud being thus used over and over again, and re-recovered, suffering but an inconsiderable amount of loss in the process.

We next come to the manufacture of sodium. Previous to the year 1886, sodium was produced by reducing it from the hydrate or carbonate of soda by heating it to a very high temperature, with an excess of carbon, great care being taken to avoid fusion of the mass, to which end lime was added. Fusion was prejudicial to the process, because, when fused, the carbon separated from the alkali, and only a small return was obtained: hence the temperature had to be carried sufficiently high for the alkalies to be volatilized, because only in that form could the soda compounds come into sufficiently intimate contact with the carbon for its combination with the oxygen of the alkali to take place, and set the metallic sodium free. The high temperature required caused great wear and tear of the iron retorts in which the process had to be carried on, and dangerous explosions were not uncommon; the practical effect being that the production of sodium was very limited in quantity, and the price, as already stated, ranged as high as 5 shillings per pound.

Mr. Castner, a chemical engineer of New York, became possessed of the idea, that, if suitable means were discovered, it would be possible to reduce the sodium and potassium compounds at a much lower temperature by bringing the carbon into intimate contact with the alkalies in a molten condition. If six molecules of the hydrated oxide of sodium, commonly called caustic soda, be added to one molecule of carbon, it will yield, when heated to a high temperature, two molecules of carbonate of soda, three molecules of hydrogen, and one molecule of sodium, —

$$6\,Na\,HO + C_2 = 2\,Na_2CO_3 + 3\,H_2 + Na_2\,, —$$

and the reduction will take place in an atmosphere of hydrogen, provided that a sufficiently intimate contact can be secured between the carbon and the alkali. Mr. Castner's process to attain this end, arrived at after a couple of years of patient experiment, is partly mechanical and partly chemical. He prepares an artificial carbide of iron by coking an intimate mixture of finely divided iron and pitch, or other hydrocarbon; the result being a heavy metalliferous coke, which, when ground fine and mixed with caustic soda in the fused condition, blends intimately with it, and causes the reduction of the soda at a temperature very much below that hitherto found possible, namely, below that of melting silver, which has been estimated to be about 1000° C. The chemical re-action during reduction cannot be confidently defined, but it probably is somewhat according to the following formula: —

$$4\,Na\,HO + Fe\,C_2 = Na_2CO_3 + Fe + 2H_2 + CO + Na_2\,;$$

that is to say, four molecules of caustic soda and one molecule of the carbide of iron, as above defined, produce, in the liquid form, one molecule of carbonate of soda and one atom of iron; while two molecules of hydrogen, one molecule of carbonic oxide, and one molecule of sodium, escape in the gaseous state. The hydrogen and the carbonic oxide ignite, and burn with a brilliant flame colored by the characteristic sodium hue, while the sodium distils, and condenses into suitable vessels. The reduction thus takes place in an abundant atmosphere of hydrogen and carbonic oxide, which effectually preserves the sodium from oxidation till it can be safely deposited in mineral oil.

The apparatus for preparing the sodium is sufficiently simple. The caustic soda is received in drums from the neighboring alkali works of Messrs. Chance Brothers. The finely divided iron is mixed with melted pitch in iron pots set in a suitable stove, and the mixture of pitch and iron is then calcined into coke in large iron retorts set in an ordinary furnace.

The metalliferous coke is ground into a fine powder by means of ordinary edge-runners, and is ready for charging into the sodium-retorts, which are of specially ingenious construction, and deserve a detailed description. Each furnace is heated by gas, applied on the regenerative principle, and contains five cast-steel crucibles, or pots of an egg-shaped form, arranged with their long axes vertical. The upper part of the egg is formed into the head or cover, much like the artificial Easter eggs which contain sweets; but it is fitted with a vertical pipe, which passes up through the top of the furnace, and forms the passage by which a portion of the charge is introduced, and it also has a lateral branch connected to the condenser, which consists of a small cast-iron vessel of peculiar form, arranged so as to allow the fluid sodium to trickle out, to let the hydrogen and carbonic-oxide gases escape, and to afford facilities for cleaning the passage, so as to prevent it from becoming choked. The form of this condenser is of some importance, if the best results are to be obtained. The whole of the head above described is secured immovably in the upper part of the furnace, and is protected by the oven-setting from extreme heat; it can, however, be readily removed if desired. The lower part of each retort rests on the top of a vertical hydraulic lift, which is worked by a moderate water-pressure, provided by a special duplex pump; and it is this pressure, which, with the interposition of some luting, forms the joint between the head of the retort and its lower portion. The upper part of the lift or platform is so arranged, that, when the retort resting on it is in its place, the aperture in the bottom of the furnace is completely closed. When the lift is lowered, the bottom half of the crucible sinks to the floor level; and a two-wheeled iron hand-truck of special construction is wheeled up, and catching hold of the crucible by two projections on its sides, provided for the purpose, lifts it off the hydraulic ram, and by the aid of two men transports it to the "dumping" pits, on the edge of which it is turned on its side; the liquid carbonate of soda and finely divided iron, which form the residue, are turned out; and the inside is scraped clean from the opposite side of the pit, under the protection of iron shields. When clean inside and out, the crucible is again lifted by the truck, and carried back to the furnace, receiving a portion of the fresh charge on its way. It is then again placed on its ram and lifted to its place, having still retained a good red heat. It takes two minutes only to remove and clear a crucible; from six to eight minutes performs the same office for the set of five; and the whole cycle of operations, including the distilling of the sodium, requires one hour and fifteen minutes. The five crucibles yield 500 pounds of sodium per twenty-four hours; so that the battery of four furnaces is competent to yield 2,000 pounds, or nearly one ton, of sodium per day.

The only portions of this plant liable to exceptional wear are the bottom halves of the crucibles, the durability of which is found to depend very much on the soundness of the cast steel of which they are made, because any pores or hollows are rapidly searched out by the furnace flames. The average duration of each crucible at present is about 750 pounds of sodium, or 125 charges. The carbonate of soda removed from the retorts is returned to the alkali-makers, and is again converted into caustic soda, fit for further use.

The six pounds of sodium, the produce of each charge, is allowed to trickle from the condensers into small iron pots, in which, when cool enough, it is covered with mineral oil, and then transported to the sodium-store, where it is melted in large pots, which are heated by an oil bath, and cast into ingots of convenient form for the subsequent operations. The strong affinity of sodium for oxygen is well known: hence it is best kept covered by an oil, such as mineral oil, which does not contain oxygen in its composition; and the greatest care has to be taken to protect it from water, because water is decomposed with so much energy by sodium, that the heat caused by the clashing-together of the atoms of sodium and the oxygen of the water is sufficient to ignite the liberated hydrogen. Hence the apparent paradox, that, to make the sodium-store fireproof, it is necessary to make it waterproof also, and at the same time to avoid naked lights, which may chance to set the vapor from the oil on fire.

We have now got the two ingredients required for the production of aluminium; namely, the double chloride of aluminium and sodium, and metallic sodium. The double chloride is broken into small pieces, and mixed with cryolite (the native fluoride of aluminium and sodium, $6\,Na\,F\,Al^2F^6$), and with metallic sodium cut into thin slices by an ordinary tobacco-cutting machine. The mixture is tightly enclosed in a revolving wooden box, in which it gets thoroughly mixed. This part of the process is somewhat trying, on account of the hydrochloric-acid gas given off by the double chloride, which slowly decomposes when exposed to the air. When the ingredients are sufficiently mixed, they are turned out on to the hearth of a regenerative reverberatory furnace, over which the mixing cylinder is placed. The hearth is made to slope towards a lateral opening, which is closed during the process of reduction by clay, supported by iron plates and keys. There are two furnaces, — a small one, capable of producing 60 pounds of aluminium per charge; and a large one, which yields 140 pounds. The charge introduced into the furnace melts quickly; and a re-action, represented by the following formula, takes place: —

$$2\,(Na\,Cl)\,Al_2Cl_6 + 3\,Na_2 = 8\,Na\,Cl + Al_2\,.$$

That is to say, one molecule of the double chloride and three molecules of sodium yield eight molecules of common salt and one molecule of aluminium. The process of reduction lasts about three hours. The melted slag, which consists chiefly of common salt and the cryolite (which merely served as a flux), is drawn off by breaking the clay stopping of the hearth-opening from above downwards; and finally the lower tapping-hole is broken through, and a silvery stream of metallic aluminium runs out, and is received into cast-iron moulds. The reducing operation requires considerable skill, and great attention to the temperature of the furnace, which has to be varied during the continuance of the re-action.

The large furnace is competent to produce 840 pounds of aluminium per day of twenty-four hours; and the small one, 360 pounds.

The first portion of metal which runs out, and which forms rather more than three-fourths of the charge, is of the greatest purity; the remainder, which has to be scraped off the hearth, or which gets entangled in the slag, and has to be subsequently separated out, contains a larger proportion of foreign substances. The cause of the difficulty in obtaining the separation of the metal from its slag consists in the very low specific gravity of aluminium.

The metal is now taken to the casting-house, arranged like an ordinary brass foundery, is remelted in plumbago crucibles, and cast into ingots, plates, or bars for subsequent sale or manufacture.

It is evidently impossible to here enter into all the details of manufacture, although these details are of the highest importance in obtaining commercially valuable results. Day by day, as the manufacture progresses, improvements are made which either enhance the economy of production or increase the purity of the sodium or aluminium produced. Such improvements in details cannot very well be made public till their value is thoroughly ascertained, and the protection of the patent law obtained when considered necessary.

The following table gives the quantities of the several ingredients employed to make one ton of aluminium: —

Metallic sodium	6,300 lbs.
Double chloride	22,400 "
Cryolite	8,000 "
Coal	8 tons.

To produce 6,300 pounds of sodium are required —

Caustic soda	44,000 lbs.
Carbide made from pitch (12,000 lbs.) and iron turnings (1,000 lbs.)	7,000 "
Crucible castings	2½ tons.
Coal	75 "

For the production of 22,400 pounds double chloride are required —

Common salt	8,000 lbs.
Alumina hydrate	11,000 "
Chlorine gas	15,000 "
Coal	180 tons.

For the production of 15,000 pounds of chlorine gas are required —

Hydrochloric acid	180,000 lbs.
Limestone dust	15,000 "
Lime	30,000 "
Loss of manganese	1,000 "

The works are constructed so as to produce 1½ tons of aluminium per week: the quantities of the ingredients consumed are consequently half as much again as the figures given in the table. It is easy to see, therefore, that the factory must be on a very large scale; and the brief account of the process here given indicates also how complicated the manufacture is, and how much care and skill are necessary to conduct it successfully, if pure aluminium is to be made. The great enemies of the metal are iron and silicon, especially the former. When once it gets in, it is impossible to get it out again by any commercially practicable means: hence every precaution has to be taken to insure the purity of the materials; to which end a well-appointed laboratory, presided over by Mr. Baker, a very able chemist, is kept in active operation.

Aluminium is endowed with several remarkable properties. It is the lightest of the metals which possess considerable tenacity and hardness. A given volume of aluminium is only a little more than 2½ times (2.65) the weight of an equal bulk of water; whereas iron is 7¾ times, copper nearly 9 times, gold 19½ times, and platinum 21½ times, as heavy as water. The metal has a bright silvery lustre. It is capable of taking a very high polish, and of retaining its brilliancy and color under conditions which would rapidly tarnish silver, because it does not oxidize from exposure to either dry or damp air, and is unaffected by that great enemy of silver, sulphuretted hydrogen, or other sulphur compounds present in London fogs, either at ordinary temperatures or even at a red heat. At ordinary temperatures it is not affected by either strong or diluted nitric acid. Weak sulphuric acid has no action on it, neither have sulphuretted hydrogen or sulphide of ammonium, which explains the reason why it does not tarnish, even in very impure atmospheres. Water has no effect on pure aluminium under ordinary conditions; but, if it be made the oxygen pole of a galvanic battery, it is readily converted into alumina, forming a copious white precipitate. The vegetable acids, such as acetic and tartaric, have no effect: hence aluminium is admirably fitted for making into cooking utensils, coffee-pots, teapots, etc., its extreme lightness being also an advantage for this purpose. It is not acted upon by the hydrates of potassium and sodium in a state of fusion; but solutions of these alkalies in water dissolve it readily, forming aluminates of potassium and sodium, with evolution of hydrogen. Of this property the silversmith takes advantage in producing very beautiful frosted effects, by plunging the polished metal for an instant into a weak solution of caustic soda, washing in a large quantity of water, and then digesting in strong nitric acid. Its powers of conducting heat are high in the scale, being about two-thirds that of copper; its specific heat is .22, only lithium, sodium, and magnesium being above it. Its electrical conductivity is eight times higher than that of iron, and about equal to that of silver. Its elasticity and tenacity are equal to that of silver, and have been determined by Mr. W. H. Barlow at about 12 tons per square inch; but weight for weight, its tenacity would be the same as high-class steel, or 36 tons per square inch, that is to say, bars of equal weight would carry the same loads. Experiments on very fine wire have given the same results. It is very malleable and ductile, when proper attention is paid to annealing during the process of working, — a precaution common to the manipulation of most metals. Aluminium of about 97 per cent to 98 per cent purity may be rolled into thin sheets, and may be beaten into foil as thin as any that can be produced from silver and gold. It can be drawn into very fine wire, of only one-tenth of a millimetre diameter, and ought to supersede silver in the manufacture of metallic braid and tissues, because it will never tarnish as silver does. It can be stamped or spun into hollow ware, but there is as yet some difficulty in soldering it; at any rate, the process of performing the operation is known to very few people.

Aluminium forms alloys with most metals. Iron is always more or less associated with it; but it seems doubtful whether it be a true alloy, or wholly or in part a mixture, like the carbon contained in cast iron and in steel. Silicon is also invariably found associated more or less with the metal. Aluminium added to molten iron and steel lowers their melting-points, and consequently increases the fluidity of the metal, and causes it to run easily into moulds and set there, without intrapping air and other gases, and forming blow-holes and similar imperfections. It is in consequence used to the extent of about ½ per cent and less by some steel founders, and seems to render the production of sound steel castings more certain and easy. Admiral Kolokolzoff, the director of the great gun-factory near St. Petersburg, uses ferro-aluminium, — an alloy with iron, containing 10 per cent of aluminium, — and adds it to the crucibles of melted steel about ten minutes before pouring, in the proportion of one pound of the alloy to 80 pounds of steel, which gives one part in 800 of pure aluminium; and the result is that he gets the largest steel castings, completely free from air-bubbles, and with very excellent mechanical properties.

One of the most remarkable applications of the property which aluminium possesses of lowering the melting-point of metals has been made by Mr. Nordenfelt, in the production of castings of pure iron; that is to say, iron free from any sensible quantity of carbon or manganese. Pure iron melts at about the same temperature as platinum, that is, about 1700° C.; yet even then the molten mass is not liquid enough to be run into moulds, but the addition of from $\frac{1}{2000}$ to $\frac{1}{700}$ part by weight, of aluminium, lowers the melting-point to such an extent that it becomes fluid enough to run into the most minute and intricate forms. Mr. Nordenfelt has given the name of "mitis" (flexible ductile) to his metal. Mr. Anderson then called attention to a wire brush of solid casting, the back and iron bristles forming one mass, and yet the bristles may be bent about just like the softest iron wire.

The process of manufacture is as follows: Wrought iron is placed in crucibles, which are put into a liquid-fuel air-furnace of peculiar and ingenious construction. In a furnace for six crucibles, for example, they are arranged on an elongated hearth in pairs, cross partition walls being so built as to cause the flame to embrace each crucible thoroughly. In the roof of the furnace are openings, covered by movable, brick-lined plates, or doors, through which the crucibles can be got at. The flame playing over the hearth is conveyed by a short flue, fitted with a damper, to the chimney. Under the hearth is another flue communicating with the furnace, and also leading to the chimney, and fitted with a damper. By manipulating the two dampers, the flame may be directed either under or over the hearth at pleasure. The furnace proper is at the end of the hearth farthest from the chimney, and consists of a peculiarly constructed apparatus, whereby the cheap residues resulting from the distillation of kerosene, or the heavy oils obtained from gas-works, can be burned with the ordinary chimney-draught, and a most intense heat produced. The pair of crucibles next the furnace are the most highly heated. The metal in them melts first, and, as soon as the crucibles are removed for pouring, the remaining four are moved up near the flame, and two freshly charged ones put in at the end nearest the chimney, by which means most of the heat produced by the combustion of the fuel is utilized. As soon as the iron is fairly melted, but not overheated, aluminium is added, when the charge instantly becomes quite fluid, and fit for pouring, the lowering of the melting-point having had the same effect as superheating the metal.

The mitis castings possess all the properties of the best forged iron, the tensile strength ranging as high as 27 tons per square inch, with an elongation of 20 per cent. The metal can be worked and welded just like wrought iron, and in fact cannot be distinguished from it, except that it is perfectly homogeneous and free from stratification.

When aluminium is used in such small quantities, it is best to make a preliminary rich alloy with iron (say, one containing from 10 per cent to 25 per cent of aluminium), and then to add so much of the alloy to the charge in the crucibles as will give the desired proportion of the more costly metal. This is the more necessary on account of the extreme lightness of aluminium, which makes it reluctant to mix with a metal three times its specific weight.

Aluminium alloys readily with copper in all proportions, and constitutes the metal known as aluminium bronze. The usual proportion ranges from 2½ to 10 per cent of aluminium; and it is probable that the bronzes resulting form true alloys or solutions, because the addition of the lighter metal causes a marked increase of temperature of the molten mass, indicating the existence of chemical re-action; and the bronzes may be melted frequently without changing the relative proportion of the constituent metals. The tenacity and rigidity of the copper are much enhanced; 10-per-cent alloys having sustained as much as 45 tons per square inch, with an ultimate extension of 25 per cent. It must be remembered, however, that, to obtain the best results, absolute purity, or, at any rate, fixity of composition, both in the copper and aluminium, must be insured. Failing that, very discordant and disappointing results will be arrived at. The aluminium alloys of copper, up to 10 per cent, can be forged, and rolled hot, and worked as readily as copper, proper precautions with respect to annealing being observed. The color of the aluminium bronzes approaches very nearly that of gold. The metal takes a high polish, and is less liable to tarnish than ordinary bronzes or than copper itself.

Aluminium forms alloys with most other metals; but they possess no practical value at present, and therefore need not be described.

A discussion followed, in which Mr. E. Riley said he had gone into this question many years ago, when Sir Lowthian Bell brought out his process, and he had some experience of the so-called alloys of aluminium, having had numerous samples submitted to him. He wished to ask whether the Aluminium Company had any process by which the aluminium could be got from clay. With regard to the result of the alloys, he thought that practically the alloy of copper had proved very satisfactory, but, when they came to analyze it, no aluminium was found, except, perhaps, a mere trace. Some mitis castings were submitted to him a few years ago by Mr. Nordenfeldt, but he found no aluminium in them; and so it was in the so-called alloys. He had also had several samples from America. There was nothing more easy to find than aluminium, but it might be there were several things which could be confounded with it. As regarded the action of aluminium on metals, his view was that it took away the oxygen, and made the casting more solid. It was important to the Aluminium Company to know whether any of the processes put forward really reduced alumina or not. It was not an easy matter to find small quantities of aluminium. He had had samples submitted to him which were said to contain 2½ per cent, but he could only find a small trace. He believed that aluminium would be a very valuable adjunct in making steel castings, and it was now being used. He had seen samples of cast iron in which it had been used, and found the castings exceedingly good, besides showing a considerable amount of strength.

Mr. Jeans bore testimony to the admirable way in which the company's works were conducted, and considered they reflected great credit on the inventor. There was only one other system which had all at once been brought so near perfection by its inventor; viz., the Bessemer process. Having come into contact with people who were likely to use the metal, he thought the general impression was that it would prove a valuable adjunct to the various forms in which iron and steel were manufactured. It was said that it would be an important element in the production of steel castings; but he was afraid, from the limited quantity of steel castings produced in England, that it would not be largely used for that purpose for some time to come, though in the production of mitis castings and the like it might be employed on a larger scale. Taking the production of pig-iron in the United Kingdom as about 7,500,000 tons a year, he should be disposed to say that rather more than 2,000,000 tons were employed in the production of Bessemer steel, 1,000,000 tons in the Siemens process, and 2,000,000 tons in the production of manufactured iron, leaving rather over 2,000,000 tons for castings and other purposes. The technical literature of this country, the Continent, and the United States for some time past, had teemed with references to the subject; and experiments had been made on a large scale, which indicated, that, for castings of every description, this metal was especially valuable. For some time it had been a disputed point how far aluminium was an important element in the production of steel. Professor Faraday undertook researches into the subject in connection with Wootz steel; but his conclusions were disputed by eminent chemists, who went over the same ground; and, if his memory served him accurately, Faraday considered the good properties of Wootz steel due to the fact that there was a small percentage of aluminium in it. There could be no question, from what they had seen that night, that there was a great future for the new metal in connection with the metallurgy of iron and steel; and the effect of the paper would be to throw a new light on the subject, and to inform the outside public of a matter which was of high scientific and commercial importance. He thought the time would come when those who used aluminium for alloying purposes would prefer to have a metal in the purest condition in which it could be produced, in order that they might infuse into the casting such a proportion of aluminium as they might deem to be essential for certain specific purposes. In that way the field in the future would belong to the process which could produce the purest aluminium.

Mr. Alexander Siemens was afraid he occupied the rather invidious position of finding fault with this very excellent process, which gave plenty of opportunities of allowing impurities to get into the aluminium. This fact was admitted in the paper. He had been asked by the inventor of a rival process to describe it, which might be done in a very few words. Mr. Grabau produced a fluoride of aluminium by certain means, and it was heated until it began to evaporate. When this temperature was attained, a suitable quantity of sodium was melted and poured into the vessel, which was lined with cryolite and cooled by water; and the heated fluoride of aluminium, in the form of powder, was thrown upon the melted sodium. Very violent re-action took place, and the heat generated by the re-action was great enough to melt the aluminium as well as the by-product. As soon as the re-action was complete, the whole molten mass could be poured out in suitable forms; the aluminium settled at the bottom, and the cryolite at the top. To obtain the fluoride of aluminium, Mr. Grabau used the cryolite, which he procured by the final re-action by putting the powdered cryolite into a solution of sulphate of aluminium. The re-action which took place between the sulphate of aluminium and the cryolite gave the aluminium fluoride. The solution was afterwards evaporated, and the residue was washed with water, which took out the sulphate of sodium, and left the aluminium fluoride ready to be reduced. The advantages of this process were that all the materials were treated at a comparatively low temperature. The vessel in which the aluminium fluoride was heated, as well as the vessel in which the re-action took place, was lined with cryolite, so that there was no danger of impurities being imported into the aluminium which was the result of the process. The low temperature was very much easier managed than the high temperatures of which Mr. Anderson had spoken.

On the chairman asking what temperature was necessary, Mr. Siemens replied about 900° (Celsius), just above a dull red. The process, of course, required the action of sodium, and the inventor was engaged in experimenting upon a new process to prepare this; but, as the necessary patents had not yet been taken, he was not at liberty to describe it in detail. At a short distance from Hanover the factory was at work producing aluminium on a commercial scale, though it was not on the magnificent scale of Mr. Castner's; but the process was extremely simple, and the extremely clever way in which the by-products were used promised exceedingly well for the process.

Mr. W. Boby said it appeared from the tables that 263 pounds of coal were used to produce 1 pound of aluminium; and this, to his mind, seemed a very formidable figure. He was himself connected with a rival process for manufacturing aluminium, which was in practical work, by the use of the electric furnace. This process did not produce pure aluminium; but one of the great and important uses of aluminium was as an alloy. If you got a pure aluminium, it was an extremely light metal, and it was very difficult to alloy it with iron. In the Cowles process the aluminium was produced in the furnace, and it was alloyed with iron, and came out in the proportion of 12 or 16 per cent of aluminium to the entire mass of the product. The aluminium in the alloy may be considered pure, as we know the other constituents. It was reduced from a hard white clay known as bauxite. The interior of the furnace was 5 feet long and 2 feet deep. They had a dynamo, which gave a current at 60 volts of 5,000 ampères, and it was conveyed through the furnace by means of carbon electrodes. The charge of bauxite and broken iron was put into the furnace, which was luted with charcoal to resist the heat, the current was turned on, and in an hour and a half they tapped the furnace and got out the charge of alloy. In the mean time the bauxite had become reduced from the intense heat in the furnace. There was a certain admixture of carbon in the charge, which formed a resistance to the current, and enabled it to diffuse heat through the charge. About 200 pounds of aluminium were produced per day. In answer to the chairman's question as to the percentage of the silicon which the alloy of iron contains, he could not tell the exact percentage, but he knew it was not a large one. In the copper alloy, in making 10 per cent bronze, the percentage was about .5.

Mr. Oliver J. Williams asked whether Mr. Anderson knew any thing of Brin's aluminium process, which he understood produced aluminium alloy from clay at a very small cost.

Mr. Anderson, in reply to Mr. Riley, said that wrought iron had been cast into large ingots, and the Germans had a cast-wrought iron; but it was new to him to hear that small and delicate castings, such as those exhibited, had been made without the use of aluminium. He did not think it could be done. Bauxite was a species of clay, and they had to pick out a material which had the greatest purity. If you could get it at a reasonable price, it was better to use a pure material than one which was impure, and have to get out the impurities afterwards. In steel a fractional percentage of carbon made a wide difference in the quality. He was not surprised, therefore, to find that aluminium would produce wonderful effects in the quality of the casting, and yet be scarcely distinguishable in the product. He was sorry to hear from Mr. Jeans that aluminium was not likely to be used very extensively in steel castings, and thought he was mistaken in this respect.

Mr. Jeans said what he meant to say was that the quantity of steel castings made in England up to the present time was so small, that the quantity of aluminium to be used would be comparatively small, at any rate until the production of castings had extended.

Mr. Anderson said that the production of steel castings was increasing immensely every day. Aluminium would be used for the following reason: that when one made a bad steel casting it was a desperate job to get rid of it. It was very important to be sure that the castings made were sound; and, when aluminium could be obtained pure, it would come very much into use. It was no use making impure aluminium. It was quite possible, with a little extra expense, to get aluminium containing only one per cent of impurity. French aluminium had had the pre-eminence in this respect up to the present, but the purity of the French material had not exceeded 98 per cent. If aluminium could be got at 99 per cent of purity, or even a little above this, it would be an invaluable material for the manufacture of fine wire for making into braid, as it did not tarnish. The process referred to by Mr. Siemens was a very interesting one, and the only objection to it was the use of cryolite. The Aluminium Company were doing their best to get rid of the use of cryolite.

Mr. Siemens said the cryolite was a by-product of the raw product; it was made from the sulphate of aluminium.

Mr. Anderson thought that any process which would produce the metal on a large scale, and cheaply, would be a great advantage. He was not aware that any aluminium was made of a greater purity than 98 per cent, or at a lower price than 40 shillings per pound. His paper had nothing to do with the electrical process for making aluminium alloy.

BOOK-REVIEWS.

Suggestive Therapeutics: a Treatise on the Nature and Uses of Hypnotism. By H. BERNHEIM, M.D. Tr. by Christian A. Herter, M.D. New York and London, Putnam. 8°. $3.50.

HYPNOTISM is no longer a novelty. Its long apprenticeship among the charlatans has been served; the ill name it gained during the days when pretension took the place of proof has been outlived; its apparent contradiction to the recognized laws of physiology has been minimized, if not removed. It holds a recognized place as a psychological method, as an extension of the domain of medicine, as a most promising field of scientific psychological advance. However interesting would be the history of the steps by which this favorable change of aspect has been accomplished, it must for the present be dismissed with the remark that it was in France that the movement grew and prospered, and it is to French scientists that most of our knowledge is due. The object of Dr. Bernheim's work is to give an exposition of the present appearance of the topic, especially with reference to its application to practical medicine.

At the risk of repeating what is well known, it must be prefaced that students of hypnotism are divided into two camps, — the school of Paris, of which Dr. Charcot is the leader; and the school of Nancy, represented by Dr. Bernheim. The former recognize three stages of hypnotism marked by constant physiological characteristics, transition from the one to the other of which is obtained by physical means; they believe, too, in the action of the magnet upon hypnotic patients, regard the appearances in hysteria as typical of hypnotism, and in part lay claim to such abnormal effects as the action of drugs at a distance. The school of Nancy may be characterized as "suggestionists," for this is the keynote of their view. They regard the phenomena as psychical in origin, recognizing no physical effects except as they act upon the mind; and they see differences of degree in the various stages of hypnosis, but no sharp distinctions of kind; furthermore, they assimilate the appearances to natural sleep, repudiating all claims to supernatural effects.

In this work of Professor Bernheim's we have the best exposition of the Nancy school, — a view, it should be added, that is daily gaining ground, and has received the sanction of almost all the German, Swiss, and Italian investigators, who have critically examined both views. No work is better suited for translation into English; and, with the translation of Binet and Féré's "Animal Magnetism," the English reader is favorably situated for gaining a clear insight into this enticing study. The arrangement of the book is capable of improvement. After explaining the modes of producing the state, the various degrees of its intensity, the *rôle* of