CHAPTER XIII

METALS AND ALLOYS: MODERN ELECTRIC FURNACES

PURITY is an ideal that is rarely ever attained, and, owing to inherent difficulties in the methods of isolation, this is especially true with metals. Absolutely pure metals have few of those properties that we are accustomed to associate with them. Though the amounts of impurities that they may contain may be relatively small, they usually exercise a remarkable influence upon the actual properties of the resulting metals. Thus pure iron is extremely difficult to prepare and when obtained, we find that it is very soft as compared with cast iron and the various kinds of steels. Ordinary iron contains an appreciable amount of carbon, which is largely responsible for its durability. On the other hand, carbon is a potent cause of the ease with which impure iron rusts. During recent years considerable attention has been devoted to the effects produced by incorporating other impurities, chiefly metals, in steel, with the consequence that considerable advances have been made. Perhaps the chief cause is that certain types of electric furnace have been discovered in which metals, not only can be melted at high temperatures, but can be kept in a state of violent agitation—a condition which is necessary in ensuring thorough mixing of the added metal. These improved methods of electric heating have also contributed largely to the production of many new alloys.

We sometimes regard the present time as the "Iron Age," but if we look around we soon realise how large a part is played by aluminium. But the present age has learnt how to use other metals with advantage, and although iron and aluminium may actually be used in preponderating quantities, we find that even some of the rarer metals now play essential and indeed indispensable parts in the activities of human kind. Thus without platinum motor-production would be handicapped, for it often occupies vital points in the engine in sparking plugs and contact-breakers. Metals such as manganese, chromium, tungsten, molybdenum and vanadium have been found to give to steels qualities that enable them to stand up to the rush of modern times. The gas-filled electric lamp depends on the glowing on a fine tungsten filament, without which we should have to revert to the comparative gloom of the gas-lit era. Again, many of these metals, in finely divided form, are used as catalysts in certain vital chemical industries upon which civilisation will become more and more dependent, e.g., the nitrogenous fertiliser and margarine industries. As we have seen, catalysts constitute the key to the modern nitric acid industry, and in so doing they hold a prominent place in the production of dyestuffs, synthetic medicines, cinematograph films, etc. As another example of the part played by modern alloys in present-day life, we may refer to the nickel-chromium alloy, nichrome, which in wire form constitute the heating elements of electric fires, cookers, irons, etc. We shall now enquire into the production and composition of some of the more important metals and alloys.

IRON AND STEEL

Iron is isolated from oxides of iron, chiefly red hæmatite, Fe_2O_3, brown hæmatite, $2Fe_2O_3, 3H_2O$, and magnetic iron ore (lodestone), FeO, Fe_2O_3. In this country, use is made of red hæmatite which is mined in Lancashire, Cumberland and Cornwall. About three-quarters of the steel of Germany used to be made from a brown hæmatite mined in Lorraine.

To obtain iron of 99·99% purity, electrolytic methods must be employed, in which the iron is deposited from solutions of iron salts, e.g., ferrous chloride. Very little iron is produced electrolytically, though the method has been successfully employed in restoring worn machine parts. Pure iron also finds application in the manufacture of special steels, boiler tubes, etc.

Ordinary cast-iron or pig-iron is obtained from the blast-furnace in which the iron oxide is mixed with either coal or coke, and after ignition is subjected to blasts of air. In this way the furnace contents are kept at bright-red heat. The carbon is thereby oxidised to carbon monoxide, CO, and in consequence of there being insufficient free oxygen available to convert the carbon monoxide into carbon dioxide, the reaction takes place at the expense of the oxygen bound to the iron, thus

$$3CO + Fe_2O_3 \longrightarrow 3CO_2 + 2Fe.$$

Iron is liberated in the molten stage and can be tapped off at the bottom and run into moulds, where after cooling it is removed as " pig iron " or " cast iron." Unfortunately ores are never just one substance, e.g., iron oxide. They invariably contain small amounts of other substances. Thus iron ores usually contain varying amounts of silica, sulphates and often of phosphates. In the blast-furnace these impurities also become de-oxidised and in so doing contaminate the iron. Another impurity which finds its way into the molten iron is carbon from the coke. It is largely attracted into the iron by the formation of a carbide of iron. Pig-iron usually has therefore the very high carbon content of from 2% to 5%. It should be mentioned that much of the silica present in the ore is removed during blasting by inserting lime in the furnace. This combines with the silica to form a molten mass of calcium silicate that flows to the bottom where it is drawn off. Use is sometimes made of this slag in road-making and cement manufacture. The presence of much carbon in cast iron causes it to be extremely brittle and hard. Whilst it can be cast into varying shapes, e.g., iron gates, it cannot be hammered. To obtain iron that can be manipulated by the blacksmith the carbon content must be substantially reduced to about 0·2%. This type of iron, known as " wrought iron," is maleable such that it can be hammered and welded while hot into any desired shape. It may also be drawn into wire or used to make nails. Incidentally wrought iron has a much higher melting point. In order to convert cast iron into wrought iron it has to be melted on the hearth, lined with hæmatite, of a reverberatory furnace. The carbon in the iron combines with the oxygen of the hæmatite and escapes as carbon monoxide.

FIG. 46.—Charging Steel Furnace by means of Electric Crane suspended from overhead rail.

(*Courtesy, Messrs. British Basic Slag, Ltd., London.*)

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Steel is a generic name which is applied to a series of alloys of iron and carbon, together with one or more of the following elements, viz., manganese, chromium, silicon, nickel, tungsten, molybdenum, vanadium. The properties of steel are largely connected with its composition, though they can be made to undergo considerable variations by the heat-treatments, quenching and tempering, to which they are subsequently subjected. The latter is especially true in the case of "stainless steels." Unlike cast and wrought iron, steel must be rendered almost entirely free from phosphorus and sulphur, and the amounts of carbon, silicon, manganese, etc., must be rigidly controlled. The carbon content of ordinary steels is from 0·3% to about 1·5%, depending on the hardness of steel required—the greater the carbon content, the greater the hardness. Thus a carbon steel containing 0·60% is suitable for boiler-makers' tools, hammers, miners' tools; 0·75% for blacksmiths' tools, chisels; 0·90% for miners' drills; 1·05% for turning tools, punches; 1·20% for lathe-tools and 1·35% for extra-hard planing and turning tools.

Two methods of converting cast iron into steel are used, viz., the Siemens-Martin or basic open-hearth process and the Bessemer process. The latter, though formerly was widely adopted, is being rapidly replaced by the basic open-hearth process in England and Germany. In the Bessemer process the carbon, phosphorus and sulphur are extracted to a great extent from the molten pig iron by blowing air through the "converter" which causes these elements to escape as volatile oxides. The requisite quantity of carbon is introduced at the end of the operation in

FIG. 47.—Héroult Arc Furnace. Pouring molten "Cronite" (a heat-resisting Chromium-Nickel Steel) to the Ladle at the Works of Messrs. Cronite Foundry Co., Ltd., Tottenham.

(*Courtesy, Messrs. The Mond Nickel Co., Ltd., London.*)

[*To face page* 203.

the form of "Spiegeleisen," an alloy of iron and manganese having a relatively high carbon content. The basic open-hearth process consists of melting the pig iron, together with some scrap iron, on the hearth of a furnace, where it is subjected to the action of a flame of producer gas (chiefly carbon monoxide) for some hours. During the process some hæmatite is added to the molten iron. Again carbon is added as Spiegeleisen. In the earlier operation of the process the hearth was lined with silica, but basic linings are preferred. These are made of lime and magnesia. Basic slag is a valuable by-product (see page 189).

Though the above process is amenable to a certain amount of control and produces steels suitable for ordinary purposes, including ferro-concrete structures, it is not altogether suitable for the manufacture of many of the special steels with which we have become familiar during recent years. These demand the use and control of higher temperatures, which a few years ago could not be obtained, but now have been rendered possible through the introduction of electric furnaces by Héroult, Wyatt and Northrup. In addition, gas-fired crucibles are used in preparing special steels, though there are definite indications that they are being superseded by the electric furnace.

THE HÉROULT ARC FURNACE.

This type of electric furnace was introduced by Paul Héroult, who is sometimes regarded as the founder of European electrometallurgy. It has gained considerable favour in the principal steel-making countries, and one electric engineering firm alone, the Electric Furnace Co., Ltd., has installed such furnaces that are capable of giving an annual

Fig. 49.—Electric Induction Furnace for the Manufacture of Stainless and Special Steels.

(*Courtesy, Messrs. Edgar Allen & Co., Sheffield.*)

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output of 400,000 tons of steel. At least one thousand are now in operation, the first of these furnaces having been installed about 17 years ago. The heat is generated by the production of an electric arc within the molten metal itself. The arc is established between vertical graphite electrodes dipping into the molten metal (see Fig. 47).

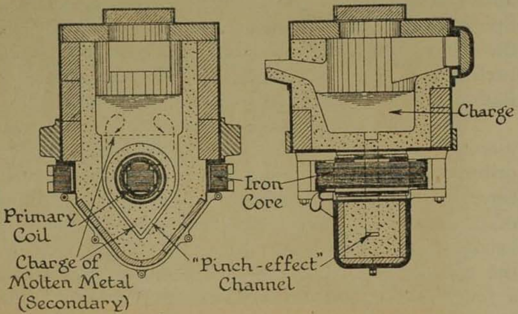

FIG. 48.—Sections of the Ajax-Wyatt Induction Electric Furnace.

THE AJAX-WYATT MELTING FURNACE.

The Ajax-Wyatt furnace is used extensively in the manufacture of non-ferrous alloys and to a lesser extent in steel production. The heat energy received by the metal to bring about melting is induced from a coil carrying an alternating current of high-frequency. The furnace is, in effect, a transformer, the secondary circuit of which is the molten metal contained in a narrow channel (Fig. 48). As a result of the induced energy the molten metal in this channel is kept in a state of constant circulation and thereby causes the main charge not only to become molten but to be kept constantly agitated. This is a great advantage in the manipulation of alloys.

THE AJAX-NORTHRUP HIGH FREQUENCY FURNACE.

These furnaces, due to the pioneer work of Dr. E. F. Northrup, of the U.S.A., are being of notable importance in the steel and alloy industry. They are being constructed with capacities ranging from a few hundredweights to two tons. By their aid temperatures as high as 2,000° C. can be reached and maintained, and incidentally perfect mixing can be ensured. For this reason, they are especially serviceable in the production of metals having high melting points. It is represented diagrammatically in Fig. 50. Heating is supplied as the result of eddy-currents set up within the molten metal by induction from an alternating current of high periodicity in the

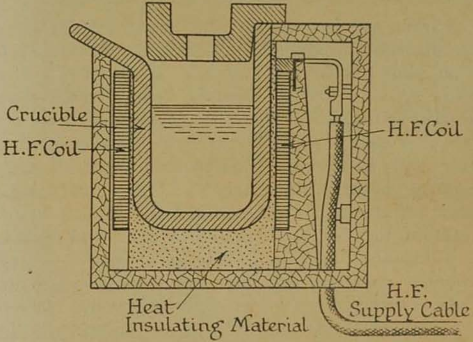

FIG. 50.—The Ajax-Northrup High Frequency Electric Furnace.

inductor coil. Besides imparting heat, it sets up a very rapid rotating movement of the metal in the vertical plane, so much so that in a bath of molten steel, 15 inches in diameter, the centre of the bath rises more than 1 inch above the metal at the circumference.

FERRO-ALLOYS, RUSTLESS STEELS, ETC.

Within the last decade the ferro-alloy industry has assumed considerable importance. Ferro-silicon is an alloy containing amounts of silicon varying from 25% to 75%. Besides being used as a deoxidising agent in the manufacture of ordinary steel, it is used to make high silicon steels containing about 15% of silicon. Examples of these are marketed as tantiron and duriron. They are silvery white and are very hard and brittle. Besides being rustproof, they are not attacked by acids and alkalis.

Manganese steel is a substance that is being rendered necessary in these days when immense traffic is being placed on our railway systems. When steel contains from 11% to 13% of manganese and 1·2% of carbon it becomes so hard that it cannot be machined and consequently articles made from it must be cast or ground into shape. It is used in the manufacture of railway lines, especially those used at junctions, armour-plate and burglar-proof safes. The effect of varying the content of manganese in steel is somewhat surprising. Thus a content of 1·5% produces brittleness, when the content is 5·5% the steel is even more brittle, but greater amounts lead to greater hardness and ductility. The presence of 12% to 16% of manganese in steel renders it non-magnetic. Incidentally, if 3% or 4% of silicon is

FIG. 51.—The Quebec Bridge. The Cantilever Piers are 1,800 feet apart. Its construction was made possible by the use of Stainless Steel (i.e., containing Nickel and Chromium).

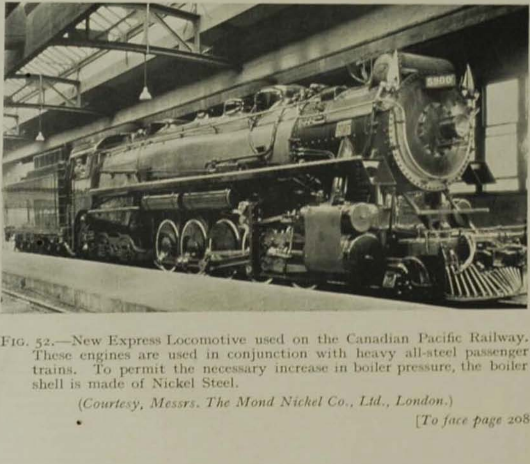

FIG. 52.—New Express Locomotive used on the Canadian Pacific Railway. These engines are used in conjunction with heavy all-steel passenger trains. To permit the necessary increase in boiler pressure, the boiler shell is made of Nickel Steel.

(Courtesy, Messrs. The Mond Nickel Co., Ltd., London.)

[*To face page* 208.

steels the carbon is removed from the grip of the iron by the chromium and in so doing tends to produce a homogeneous metallic structure. Careful heat treatment such as "quenching," i.e., raising to a particular temperature and suddenly cooling by immersion in oil or water, and "tempering," i.e., raising to a temperature and slowly cooling, is essential in order not to impair the structure of the steel on which its resistance to corrosion depends. Owing to this, difficulties may occur in welding.

To improve the working properties of stainless steels smaller amounts of other alloying elements are sometimes added, viz., nickel, silicon, copper, molybdenum, aluminium. Small proportions of nickel facilitate hardening ; silicon lessens the risk of air hardening of articles such as aeroplane valves during service ; aluminium imparts greater resistance to oxidation at high temperatures ; 0·5% of copper improves resistance to the attack of acids.

During the time that Brearley, in England in 1913, was carrying out his pioneer work on chromium steels in which he happened to note their resistance to corrosion, there were taken out by the German firm of Krupps, two series of patents that covered certain stainless steels. Unlike the steels of Brearley, the latter contained, in addition to chromium, quantities of nickel ranging from 0·5% to 20%. By incorporating nickel in chrome steels the strength can be increased so as to render the steels serviceable in structures, such as those of motor-cars, that have to withstand sudden stresses. Steels of this type contain about 0·12% of carbon, 0·24% of manganese, about 0·3% of silicon, from 15% to 18% of chromium and about 8% to 11% of nickel. To this class belongs

FIG. 53.—Sausage Stuffing Tables made with Monel Metal. (Messrs. John Morrell & Co., Ottumwa, Iowa.)

(*Courtesy, Messrs. The Mond Nickel Co., Ltd., London.*)

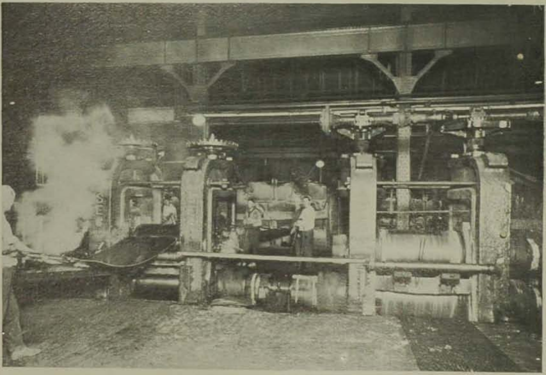

FIG. 54.—Hot Rolling—Nickel Sheet and Monel Metal.

(*Courtesy, Messrs. The Mond Nickel Co., Ltd., London.*)

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the steel "Staybrite," that is being extensively used in chemical engineering.

With regard to the effect of nickel in ordinary steel, it is found that amounts up to 15% increase its strength and toughness, whilst 25% causes it to be rustless and non-magnetic. When used in steels in conjunction with chromium, nickel confers increased strength, greater resistance to corrosion, remarkable ductility and resistance to shock. The resistance to corrosion is retained even when heated to high temperatures. In consequence, nickel-chromium steels are being used in civil engineering, bridge construction, sewage works, dredges and all kinds of submerged fittings. In mechanical engineering these steels are used in the construction of refrigerators, liquefaction apparatus, laundry plant, pumping apparatus and conveyors, whilst in the manufacture of chemical plant they are finding wide application. Lastly they are used in shop-furnishing, including shop-fronts and in bathroom fittings, frying pans, etc.

Certain iron-nickel alloys have gained importance. Permalloy (80% nickel) when used as a casing of submarine cables increases the rate of cable communication from the usual 300 signals to 1,500 signals per minute. Invar, an alloy containing about 36% of nickel, is characterised by the fact that heating does not cause it to expand to any appreciable extent, a rod 1 inch in length expanding only 0·000,001 inch per 1° C. rise in temperature. This makes it of service in measuring-tapes, in clocks and watches and in the construction of the aluminium alloy piston, where it is used to prevent expansion that would cause seizing. A similar alloy, but containing 12% of chromium, is known as Elinvar, which is likely to be adopted in making single metal balances in high grade watches and chronometers. Another alloy is platinite, 46% nickel, which expands to about the same extent as platinum and glass.

Nickel-silver, with which we are familiar in domestic articles, contains no silver. The name "nickel-silver" is applied to a variety of alloys of nickel, copper and zinc. Regarding light alloys, the one known as Y alloy, containing 92·5% of aluminium, 4% of copper, 2·0% of nickel and 1·5% of magnesium, retains its excellent mechanical properties at elevated temperatures to a greater extent than other aluminium alloys. It therefore finds application in the building of high efficiency internal combustion engines. Yet another nickel alloy that has found considerable favour (especially in the United States) is Monel metal. It resists most forms of corrosion and consists of about 67% of nickel, 28% of copper and 5% of other metals. It takes a high polish and has a silvery lustre. It is easy to manipulate, has the strength, toughness and ductility of steel and resists corrosion better than either copper or bronze.

One of the difficulties arising from the use of steel in tools, and especially in those used for cutting at high speed, is that the heat developed at the cutting edge causes the steel to soften. The incorporation of tungsten, the most important of the rarer metals, in the steel prevents this softening. Tungsten steels can be used up to white-heat without losing their cutting power. A tool made of carbon steel could not cut at a rate faster than 30 feet per minute without overheating, whereas the new tungsten steel tools can work continuously at 10 times that speed. High speed steels contain from 14% to 25% of tungsten, 2% to 7% of chromium, 0·5% to 1·5% of vanadium and 0·6% to 0·8% of carbon. Up to about 4% of cobalt is sometimes introduced and a little of the rare metals, molybdenum and uranium, is sometimes substituted for some of the tungsten. Both tungsten and chromium increase the hardness, toughness and red-hardness of the steel, while the rare metal, vanadium, behaves as a general stimulant and heightens still more the beneficial effects of the other alloying elements.

A note here on the metal, tungsten, will be of interest. It occurs in nature in the combined state with oxygen and other metals, chiefly iron, manganese and calcium. More than one-half of the natural supplies is mined in the British Empire. From the ore, " wolframite," a tungstate of iron and manganese ferro-tungsten is obtained, and this is used in the manufacture of tungsten-steels. Most of the tungsten is used for this purpose, though it has another important use, namely, as filaments in gas-filled electric lamps. Tungsten filaments, which can be drawn to less than one-fiftieth part of a millimetre in diameter, do not melt until the extraordinarily high temperature of 3080° C. is reached. The gases used for filling electric bulbs are either nitrogen or the rare gas, argon, at low pressures. Recently tantalum was used extensively in the filaments, but this metal is now rapidly being superseded by tungsten. One disadvantage of the use of pure tungsten filaments is that after a time they become fragile owing to the crystals of tungsten increasing in size. To overcome this, however, small additions of another rare metal, thorium, are included before drawing the filament. The use of thorium is of interest, as it is the oxide of this metal which incandesces in the ordinary gas mantle—a subject which but a few years ago marked such a great advance in the history of lighting, thanks to the indefatigable Count Auers von Welsbach. Although the technical use of thorium oxide will probably gradually decline on account of the tendency to adopt electric lighting, it is likely that new uses for it will be found. The source from which thorium is obtained is monazite sand, found largely on the shores of Ceylon. In this ore there is also to be found a number of other rare metals for which very little use has hitherto been found. Alloys of these metals, the chief of which is cerium, with about 30% of iron now constitute the sparking substance, "flint," so-called, of cigarette lighters, which owing to the production of a spark when rubbed, kindles the wick. For this reason they are called pyrophoric alloys.

Much has been written in this chapter on rustless steels. If these can be produced at economic rates and as a consequence receive universal application, then the ever-present nuisance of corrosion of steels will have been overcome. At present the rusting of steel is the source of a colossal amount of waste, despite the unceasing efforts to combat it by the application of paint. As long as carbon steel remains in use efforts must be made to prevent its corrosion. Perhaps the only satisfactory method is to coat the ferrous metal with an adherent film of some untarnishable metal. Two methods are in use: (1) the application of a thin layer of either tin or zinc by immersion of the iron, after suitable chemical cleaning, in a molten metal bath; (2) the electro-deposition of some incorrodible metal, again after the iron or steel surface has been thoroughly cleaned and prepared.

The coating of iron sheet with tin is familiar to everybody in the case of ordinary "tins" or canisters. Whilst the tin film remains adherent no rusting occurs, but as soon as the slightest amount of iron surface becomes exposed then corrosion sets in at an even greater rate than if no tin coating had been applied. This is equally true of the zinc layer applied by dipping sheet iron into molten zinc—the resulting metal being known as galvanised iron. Occasionally zinc plating is carried out with the aid of the electric current from a solution of zinc sulphate. The metal, zinc, occupies a very important place in modern civilisation. High grade zinc is easily rolled into sheet form and then constitutes a valuable roofing material.

Great strides have recently been made in the process of winning zinc from the original ore, zinc blende (zinc sulphide), at Broken Hill in Australia. There is always found with this ore much useless siliceous matter or gangue. After grinding to a suitable consistency the raw material is placed in tanks of water to which substances such as eucalyptus oil, creosote oil, copper sulphate, are added. These form adherent oily films on the ore particles, so that on blowing air through the tank a froth is formed and at the same time certain ores rise to the surface and float, and thus are separated. In this way ores rich in zinc, i.e., zinc concentrates, can be separated. From these zinc concentrates "spelter" and sulphuric acid are manufactured. Spelter is a somewhat impure zinc and usually contains a small percentage of lead. It is the material used in galvanising iron.

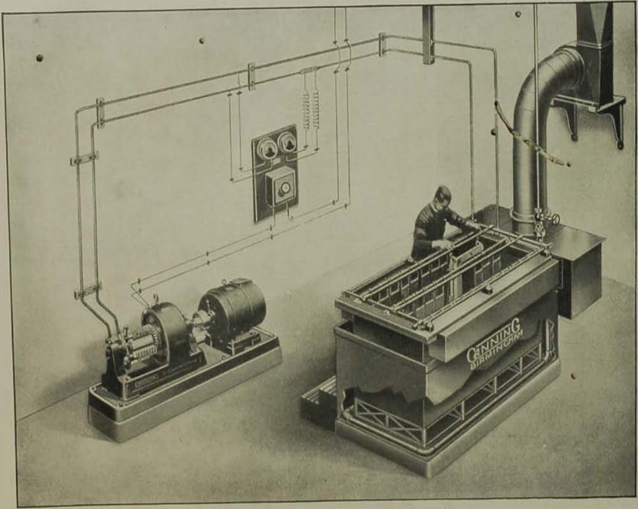

Fig. 55.—Chromium-plating Equipment.
(*Courtesy, Messrs. W. Canning & Co., Ltd, Birmingham.*)

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In certain zinc ores there occurs small quantities of a similar metal known as cadmium.

The method of forming protective layers on steel by electro-deposition consists of placing the article to be plated in a solution of a suitable salt of the particular metal and connecting it to the negative terminal of a source of direct current. The current is led into the electrolytic bath through another metallic plate placed in the solution at some suitable distance from the article. By passing a current under suitable conditions an adherent metallic layer will be deposited on the article, though many difficulties may arise in obtaining complete uniformity of the layer over the whole surface. The metal which is generally applied to iron and steel surfaces is nickel. Great care is necessary in the electro-deposition of this metal or there will ultimately result a metallic film which cracks and peels off. Even though the nickel layer may betray no evidence of cracking there is a possibility of its being porous. It is now becoming customary to superimpose on nickel-deposits yet another electrolytic deposit, namely one of chromium. Unfortunately the method of depositing now practised, though giving excellent surfaces, involves the use of a solution of chromic acid. This acid is very poisonous and is apt to pass into the air in the vapours issuing from the bath, and thus to become dangerous to the lives of the operatives. For this reason, outlets through which these vapours are sucked by electric fans are placed immediately above the bath. Another metal that is gaining much prominence as supplying a protective coating is cadmium, a comparatively rare metal. Besides providing good protection, it is somewhat soft, and in the coating of aircraft parts this is turned to

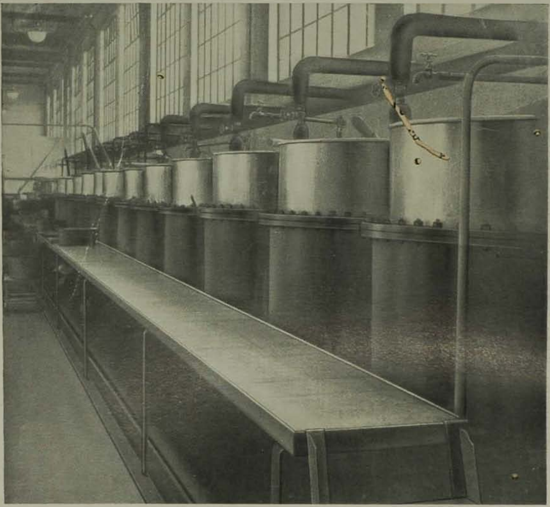

FIG. 56.—Pure Nickel Sauce Boilers at Works of Messrs. Crosse & Blackwell (Manufacturing), Ltd., Branston-on-Trent. Each 100 gallons capacity.
(*Courtesy, Messrs. The Mond Nickel Co., Ltd., London.*)

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an advantage. It enables the parts to be electroplated separately. On assembling and fixing tightly together they form closely fitting joints as the soft cadmium coverings prevent the admission of water and air, with their corroding tendencies. The high price of cadmium will probably prohibit its general application. Electro-deposited copper is sometimes used as an undercoating for chromium, and there are indications that electro-deposits of tin and zinc may eventually be adopted for special purposes. Platinum furnishes an excellent protective layer, and if this metal should continue to fall in price there are distinct possibilities of platinum plating becoming adopted more generally than is the case at present.

The extraction and refining of nickel is full of interest. It happens that the nickel-copper ores found in the Sudbury district of Ontario contain small proportions of precious metals, which include platinum, palladium, rhodium, ruthenium, osmium, iridium and some gold and silver. The carbonyl process of refining nickel, which was invented by the late Dr. Ludwig Mond and is being worked at Clydach in South Wales, gives residues which contain relatively little of these precious metals, but the more modern electrolytic method of refining nickel in progress at Port Colborne, in Ontario, is yielding as by-products concentrates with as much as 50% of these metals. In consequence, there has been established at Acton, London, a precious metals refinery by the Mond Nickel Co., in which it is estimated that approximately 300,000 ounces of the present world consumption, 400,000 ounces, will be produced. It is interesting to recall that in 1914, 300,000 ounces was the output of Russia, although in 1924 this figure had fallen to 80,000.

FIG. 57.—General View of the Lochaber Works of Messrs. The British Aluminium Co., Ltd., showing Pipe Line in Background to supply the Works with Water Power.

(Courtesy, Messrs. The British Aluminium Co., Ltd., London.)

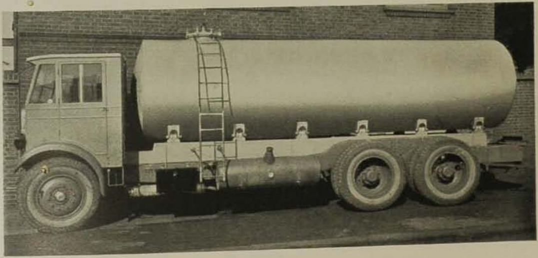

FIG. 59.—A Single Compartment Aluminium Tank. 2,160 gallons.

(Courtesy, Messrs. The Aluminium Plant and Vessel Co., Ltd., London.)

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We shall conclude this chapter with some remarks on aluminium and certain other light metals and alloys. To-day, aluminium is a commonplace metal of general utility, although it was not until 1909 that the metal was produced at an economic rate. It was first isolated in 1825 by Oersted in Denmark, but the first step towards the modern method did not come until 1886, when Héroult in France and Hall in the U.S.A. evolved very similar electrolytic methods. Some idea of the growth of aluminium production since 1913 will be obtained from the following official statistics. Since that year the world's consumption of copper has increased by 72%, of zinc by 45%, of tin by 46%, but during the same period the consumption of aluminium has increased by 310%.

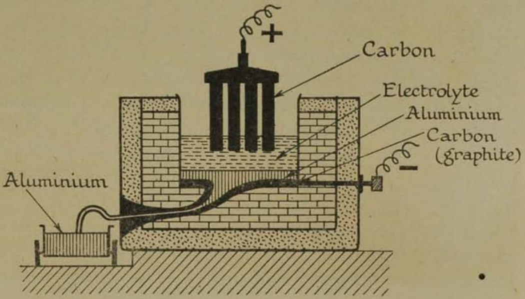

Fig. 58.—Cell for the Electrolytic Production of Aluminium.

Although aluminium happens to be one of the most abundant elements in the earth's crust, the only mineral at present used is bauxite, a hydrated oxide, which is found chiefly in France and British Guiana. Metallic aluminium cannot be prepared electro-

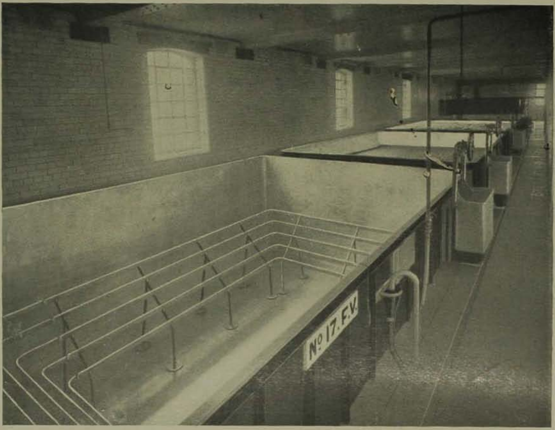

FIG. 60.—Aluminium Fermenting Vessels used in a Bolton Brewery. They are made of Thick Sheets of Aluminium welded together so as to provide a dead smooth interior surface, the exterior being reinforced with Mild Steel Stanchions.

(*Courtesy, Messrs. The Aluminium Plant and Vessel Co., Ltd., London.*)

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lytically from solutions in water, but can be if dissolved in a suitable molten solvent. The solvent now used is cryolite, a double fluoride of aluminium and sodium, which is found naturally in Greenland. It may also be readily prepared by chemical methods. After the bauxite has been purified and dried it is admixed with cryolite and subjected to electrolysis in a cell (Fig. 58) in which the cathode and anode are of carbon. The anodes are made of petroleum coke, i.e., the residue obtained in the distillation of heavy crude oil. The charge is melted and maintained in the fused state by the heat developed consequent upon the reactions taking place. The molten aluminium collects at the bottom of the cell from which it is periodically drawn.

Aluminium prepared in this way is of 99·2% purity, and is used for rolling into sheets for the manufacture of cooking utensils, motor body work and so on. Bulk for bulk aluminium is less than one-third of the weight of copper, and slightly more than one-third of the weight of iron. The moderately good tensile strength of aluminium can be considerably enhanced by alloying with it other metals in amounts that rarely exceed 10%. Usually these metals are either copper or zinc or both. Silicon finds application in making aluminium alloys that have rather special casting properties coupled with considerable ductility. Duralumin is alloy that is used in airship and aeroplane construction. In addition to 95% of aluminium it contains 4% of copper and ½% of each magnesium and manganese. Both aluminium and its alloys offer great resistance to corrosion. Actually, corrosion sets in with great rapidity and there is formed on the surface a tenacious film of aluminium oxide which protects the metal from further attack. Usually this film is so thin as not to impair the lustrous appearance of the metal. In special cases such a film is actually formed on the surface by electrolysis.

Two other light metals, magnesium and beryllium, are assuming increasing importance, and it may be that with advances in aircraft construction these metals may assume considerable importance.