him some details of the iridium plating process. I sent him an outline of the method, describing the use of the iridium hydrate in lieu of a soluble anode. He replied at once that I anticipated him inasmuch as he had just worked out the same plan to solve the platinum plating problem after a year of hard labor. It was a source of great regret to us both for in neither case had the method been devised without much thought and labor, although it is so simple. Dr. Wahl read his paper on platinum plating before the chemical section of the Franklin Institute, on May 20, 1890, in which he made generous mention of my work. I regret that I could not have saved him so much labor; but owing to my relations to the corporation for which I was making the investigations, I have been unable to publish the results sooner.

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ALUMINUM.

BY R. L. PACKARD.

(*Continued from page 236.*)

Metallurgical use.—The quantity of aluminum used in this country in the manufacture of iron and steel castings is probably from twenty-five to thirty per cent. of the total production. In Europe it is estimated by Professor Wedding to be fifty-four per cent. This use, as was explained in the last number of this series, consists in adding from 0.10–0.15 per cent. of aluminum to iron or steel just before casting, by which blow-holes are prevented and sounder castings are produced. This use is becoming general. The beneficial effect, as was shown by experiments referred to last year, is due in part at least to the deoxidizing action of aluminum upon carbon monoxide at a high temperature, a reaction which was demonstrated directly between the metal and the gas. This subject has not yet received an exhaustive examination. For this purpose it would be necessary to know the composition of the iron or steel operated on in each case and make comparative tests on the different specimens. It is also probable that the method of melting employed has an effect on the result.

A detail of manipulation in the method of applying aluminum, especially in casting for steam and pump cylinders and other castings intended to resist high pressures, is reported in *Dingler's poly. J.*, (**284**, No. 11, 255). The addition is made by first forming a mixture of aluminum and iron, which is effected by placing the proper quantity of heated aluminum in the bottom of a small ladle, running some iron into the ladle from the furnace, and waiting until the mixture begins to stiffen. Then the iron to be operated on is run into a large ladle and the iron-aluminum mixture is poured into it, whereby an intimate mixture of the whole is effected. For 100 kilograms of iron to be operated on 200 grams of aluminum are used (= 0.20 per cent.). The iron is not poured at once from the large ladle, but is allowed to stand until it is orange-yellow and a thin film begins to form on the surface. As soon as this occurs the film is removed and the iron is poured. The mold should be kept full. No reason is assigned for this procedure, but it appears that iron containing aluminum is inclined to shrink excessively and that this tendency must be obviated by pouring as cold as possible.

According to a paper read by Mr. J. W. Langley, at the Glen Summit meeting of the American Institute of Mining Engineers, the practice in the United States in pouring ingots is as follows: The aluminum, in small pieces of one-fourth or one-half pound weight, is thrown into the ladle during the tapping, shortly after a small quantity of steel has already entered it. The aluminum melts almost instantaneously and diffuses with great rapidity throughout the contents of the ladle. The diffusion seems to be complete, for the writer had never seen the slightest action indicating want of homogeneity of mixture, all of the ingots poured from one ladle being precisely alike so far as the specific action of the aluminum was concerned. The quantity of aluminum to be employed will vary slightly according to the kind of steel and the results to be attained. For open-hearth steel, containing less than 0.50 per cent. carbon, the amount will range from five to ten ounces per ton of steel. For Bessemer steel the quantities should be slightly increased, *viz.*, seven to sixteen ounces. For steel containing over 0.50 per cent. carbon, aluminum should be used cautiously; in general between four and eight ounces to the ton. If these statements are put in the form of percentages, it will at once be seen how extremely minute is the quantity of aluminum which causes such marvelous results, for the numbers are:

4 ounces = 0.0125 per cent	....	= 1-8000
5 ounces = 0.0156 per cent	....	= 1-6500
8 ounces = 0.0250 per cent	....	= 1-4000
16 ounces = 0.0500 per cent	....	= 1-2000

Soldering.—From the articles which occasionally appear in the trade journals, both in this country and in Europe, and the patent list, it appears that the difficulties of soldering aluminum have not been overcome. Some of the new solders are introduced here without comment.

Chloride of silver has been recommended as a solder. It is to be finely powdered and spread along the junction to be soldered and melted with the blow-pipe. Mr. Joseph W. Richards makes an alloy of aluminum one part, zinc eight parts, tin thirty-two parts, and phosphor-tin, containing five per cent. phosphorus, one part. The aluminum is first melted, then the zinc is added, and finally the tin, which has been melted separately and mixed with the phosphor-tin. The alloy is poured into small bars for use. The object is to provide in the phosphorus a powerful reducing agent to prevent the formation of the film of oxide which usually prevents the intimate contact of the opposed surfaces. (United States patent 407,789, October 5, 1891.) Another formula is, cadmium fifty parts, zinc twenty, tin thirty. The zinc is first melted, then the cadmium is added, and finally the tin (*Dingler's polyt. J.*, **284**, No. 6, 144). Electroplating the surfaces with copper and then applying the solder was mentioned last year.

Other solders which have been used are composed of:

	I. Per cent.	II. Per cent.	III. Per cent.	IV. Per cent.	V. Per cent.
Aluminum	12	9	7	6	4
Copper	8	6	5	4	2
Zinc	80	85	88	90	94

In making these solders the copper should be melted first, the aluminum then added, and the zinc last. Stearin is used as a flux to prevent the rapid oxidation of the zinc. When the last metal is fused, which takes place very quickly, the operation should be finished as rapidly as possible by stirring the mass, and the alloy should then be poured into an ingot mold of iron, previously rubbed with fat. The pieces to be soldered should first be cleaned thoroughly and roughened with a file and the solder placed on the parts in small fragments, the pieces being supported on a piece of charcoal. The place of juncture should then be heated with the blast lamp. The union is facilitated by the use of a soldering tool of aluminum. This last is said to be essential to the success of the operation. Alloy I is recommended for small objects of jewelry; alloy IV is said to be best adapted for larger objects and for general work, and is that most generally used. The successful performance of the act of soldering appears to require skill and experience, but the results obtained are said to leave nothing to be desired. Soldering tools of copper or brass should be avoided, as they would form colored alloys with the aluminum and solder. The skillful use of the aluminum tool, however, requires some practice. At the instant of fusion the operator must apply some friction, and, as the solder melts very suddenly, the right moment for this manipulation may be lost unless the workman is experienced.

Alloys.—It is regretted that no statistics of the production of aluminum bronze and ferro-aluminum in this country can be given for 1891. Both of these valuable alloys have been produced by the Cowles Electric Smelting and Aluminum Company for a number of years, and have found their way into the market on a considerable scale. The ferro-aluminum made by this company was used as a vehicle for adding aluminum to iron and steel in making sound castings when that method was first introduced. Aluminum bronze is coming into use in Germany for torpedoes on account of its strength and non-corrodibility, and for telephone wires. It was estimated that 280,000 kilograms would be used during 1892. The five per cent. bronze has been used for some time for nozzles of gas motors on account of its non-oxidizable character, and the twelve per cent. bronze is used for the pins of needle guns, for which purpose it is said to be better than steel.

The number of patents which have been granted for aluminum alloys, either where that metal forms a minor ingredient or has small quantities of other metals added to it for special purposes, shows that experimenting in this direction is increasing. As yet much of this experimenting is done without definite knowledge or aim on the part of inventors. Doubtless, in time, valuable conclusions may be derived from this kind of work, after rigid experiments with a definite purpose or idea have been undertaken. Of alloys formed with a specific purpose in view, that containing a small quantity of titanium, and another containing silver, were described last year. Others are mentioned in a lecture by Mr. Hunt, president of the Pittsburg Reduction Company, whose statements are valuable because they are based on knowledge and experience. He says :

"The alloys of from two and one-half to twelve per cent. aluminum with copper have so far achieved the greatest reputation. With the use of eight per cent. to twelve per cent. aluminum in copper we obtain one of the most dense, finest-grained, and strongest metals known, having remarkable ductility as compared with its tensile strength. A ten per cent. aluminum bronze can be made in forged bars with 100,000 pounds tensile strength, 60,000 pounds elastic limit, and with at least ten per cent. elongation in eight inches. An aluminum bronze can be made to fill a specification of 130,000 pounds tensile strength and five per cent. elongation in eight inches. Such bronzes have a specific gravity of about 7.50, and are of a light yellow color. For cylinders to withstand high pressures such bronze is probably the best metal yet known.

"The five to seven per cent. aluminum bronzes have a specific gravity of 8.30 to 8, and are of a handsome yellow color, with a tensile strength of from 70,000 to 80,000 pounds per square inch, an elastic limit of 40,000 pounds per square inch. It will probably be bronzes of this latter character that will be most used, and the fact that such bronzes can be rolled and hammered at a red heat with proper precautions will add greatly to their use. Metal of this character can be worked in almost every way that steel can, and has for its advantages its greater strength and ductility, and greater power to withstand corrosion, besides its fine color. With the price of aluminum reduced only a very little from the present rates, there is a strong probability of aluminum bronze replacing brass very largely.

"A small percentage of aluminum added to Babbitt metal gives very superior results over the ordinary Babbitt metal. It has been found that the influence of the aluminum upon the ordinary tin-antimony-copper Babbitt is to very considerably increase the durability and wearing properties of the alloy. Under compressive strain aluminum Babbitt proves a little softer than the ordinary Babbitt. A sample one and one-half inches in diameter by one and one-half high began to lose shape at a pressure of 12,000 pounds. A similar sample of the same Babbitt metal without the addition of the aluminum (having a composition of 7.3 per cent. antimony, 3.7 per cent. copper, and eighty-nine per cent. tin) did not begin to lose its shape until a compressive strain of 16,000 pounds had been applied. Both samples have stood an equal strain of 35,000 pounds. In comparative tests of the ordinary Babbitt metal and the aluminum Babbitt metal, the latter has given very satisfactory results.

"The following alloys have recently been found useful: Nickel-aluminum, composed of twenty parts nickel and eight parts aluminum, used for decorative purposes; rosine, composed of forty parts nickel, ten parts of silver, thirty parts aluminum, and twenty parts tin, for jewelers' work; sun bronze, composed of sixty parts cobalt (or forty parts cobalt), ten parts aluminum, forty (or thirty) parts copper; metalline, composed of thirty-five parts cobalt, twenty-five parts aluminum, ten parts iron, and thirty parts copper.

"Prof. Roberts Austin has discovered a beautiful alloy containing twenty-two per cent. aluminum and seventy-eight per cent. gold, having a rich purple color, with ruby tints.

"The addition of from five per cent. to fifteen per cent. aluminum to type metal composed of twenty-five per cent. antimony and seventy-five per cent. lead makes a metal giving sharper castings and a much more durable type."

Mr. A. H. Cowles makes an alloy for electrical purposes consisting of manganese eighteen parts, aluminum 1.2 parts, silicon five parts, zinc thirteen parts, and copper 67.5 parts. This alloy has a tensile strength of 26,000 kilograms and twenty per cent.

elongation. Its electric resistance is greater than that of "neusilber," and it is therefore especially applicable for rheostats. (*Chemiker-Zeitung*, March 12, 1892.)

Mr. C. C. Carroll makes an aluminum alloy for dentists' fillings, consisting of silver 42.3 per cent., tin fifty-two per cent. copper 4.7, and aluminum one per cent. It is reduced to powder and then forms an amalgam with mercury. (U. S. patent 475,382, May 24, 1892.)

Mr. Chas. B. Miller has patented an anti-friction alloy of lead 320 parts, antimony sixty-four, tin twenty-four, aluminum two. (U. S. patent 456,898, July 28, 1891.)

Mr. Thomas MacKellar has patented an alloy for type metal of lead sixty-five parts, antimony twenty, and ten parts of an alloy consisting of equal parts of tin, copper, and aluminum. The tin-copper-aluminum alloy is first melted, the antimony added to it, and the mixture is then added to the melted lead. (U. S. patent 463,427, November 11, 1891.)

An aluminum bronze alloy contains aluminum twelve to twenty-five parts, manganese two to five, copper seventy-five to eighty-five. It is the product of John A. Jeancon. (U. S. patent 446,351. February 10, 1891.)

The anti-friction metal (Babbitt metal plus aluminum) contains antimony 7.3 parts, tin eighty-nine, copper 3.7, with from ¼ to 2.5 parts of aluminum. It is patented by Alexander W. Cadman. (U. S. patent 464,147, December 1, 1891.)

Aluminum imported and entered for consumption in the United States from 1870 to 1891.

Years ending	Quantity, pounds.	Value.	Years ending	Quantity, pounds.	Value.
June 30, 1870......	.....	$ 98	June 30, 1882......	566.50	$ 6,459
" " 1871......	.....	341	" " 1883......	426.25	5,079
" " 1873......	2.00	2	" " 1884......	595.00	8,416
" " 1874......	683.00	2,125	" " 1885......	439.00	4,736
" " 1875......	434.00	1,355	Dec. 31, 1886......	452.10	5,369
" " 1876......	139.00	1,412	" " 1887......	1,260.00	12,119
" " 1877......	131.00	1,551	" " 1888......	1,348.53	14,086
" " 1878......	251.00	2,978	" " 1889......	998.00	4,840
" " 1879......	284.44	3,423	" " 1890......	2,051.00	7,062
" " 1880......	340.75	4,042	" " 1891......	3,906.00	6,263
" " 1881......	517.10	6,071			