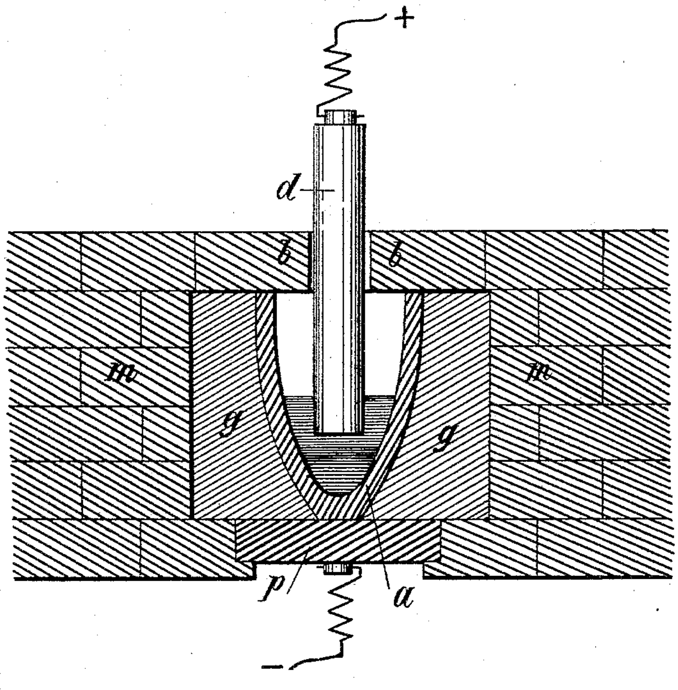
(Specimens.)

P. HÉROULT.

PROCESS OF PREPARING ALUMINIUM BRONZE AND OTHER ALLOYS.

No. 387,876. Patented Aug. 14, 1888.



Witnesses:
Benj. F. Cowl.
Geo. E. Frick.

Paul Héroult,
Inventor:
by Louis Bagger & Co.
attys.

N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

PAUL HÉROULT, OF LAUFFEN-UHWIESEN, SWITZERLAND.

PROCESS OF PREPARING ALUMINIUM-BRONZE AND OTHER ALLOYS.

SPECIFICATION forming part of Letters Patent No. 387,876, dated August 14, 1888.

Application filed December 27, 1887. Serial No. 259,100. (Specimens.) Patented in France April 15, 1887, No. 170,003; in Belgium April 16, 1887, No. 77,100, and in England May 21, 1887, No. 7,426.

To all whom it may concern:

Be it known that I, PAUL HÉROULT, a citizen of the Republic of France, residing at Lauffen-Uhwiesen, in the Republic of Switzerland, have invented certain new and useful Improvements in a Process of Preparing Aluminium-Bronze and other Alloys, (for which I have obtained a patent in Belgium, No. 77,100, dated April 16, 1887, and a patent in France, application being made April 15, 1887, numbered 170,003, and for which an application for an English patent was made May 21, 1887, numbered 7,426,) of which the following is a specification.

This invention has reference to an improved process of producing aluminium alloys by the heating and electrolytical action of an electrical current upon the oxide of aluminium (alumina Al_2O_3) and the metal with which the aluminium is to be alloyed.

The process involves the fusion of the oxide and the metal by the requisite degree of heat derived solely from an electric current, and at the same time the electrolysis of the oxide, whereby oxygen is liberated and passes to and unites with a carbon electrode serving as the anode, the product of the resulting combustion passing off by suitable openings in the containing-vessel, while the disassociated metallic aluminium passes to the fused metal and unites with it to produce the desired aluminium alloy.

Alumina is a refractory oxide, and cannot be conveniently melted in a vessel by external application of heat unless a flux be used, and to such use there are serious objections, which it is one object of my invention to obviate. Thus the flux may contain elements which will undergo electrolysis before the oxide, in which case not the product desired—namely, aluminium—but some other substance (depending upon the character of the flux) will be produced; or the flux may contain substances such as phosphorus, iron, silicon, &c., which will enter into the product and deteriorate it; or the flux may increase the resistance of the bath, thus increasing the demands for power. I have tried many fluxes and found this to be the case with all of them. Again, the flux may evolve gases, which will settle on the carbon anode and tend to polarize it and by preventing free access of the oxygen to the carbon increase the resistance and the cost of production. For instance, I have used cryolite (which can be fused by external heat without a flux) as an electrolyte, and also as a flux in connection with alumina, but have found it objectionable, because it evolves fluorine, which does not, like the oxygen evolved from alumina, combine with the carbon anode and pass off, but settles upon it with the effect above mentioned. Moreover, the use of a flux must always leave the quantity and quality of the product to be obtained uncertain, unless the character and composition of the flux used in each operation are positively known.

The desirableness, for reasons of economy, of applying electricity to the reduction and alloying of metals and ores through its electrolytical action instead of through its great heat-producing energy solely has long been known, and has led me by a series of experiments to the adoption of my herein-described process for producing aluminium alloys, which involves, first, the use of commercially-pure alumina alone as the electrolyte in suitable apparatus; second, a certain arrangement of the electric circuit used, so as to place a carbon anode at a point where the energy evolved by its combustion will be conserved and made to assist in the process and where facility can be most easily given for carrying off the product of that combustion; third, the employment of the metal with which the aluminium is to be alloyed and the molten alloy as the cathode, and, fourth, an orderly method of starting and sustaining the operation, so as to make it practically continuous—that is to say, without any determined period. The objects sought for were, first, greater economy of production, and, second, a reliable standard of purity in the product; and I have combined the elements and conditions herein described, in the relations described, so as to constitute a process or method of operation for producing the desired alloy with the highest economy.

My invention consists, therefore, in an electrolytical process, whereby, without the necessity of any external application of heat or the use of any flux, the aluminium is reduced from its oxide and simultaneously compounded with the metal with which it is to form an alloy by the passage of an electric current through a circuit consisting of, first, a source of electricity; second, proper conductors, (including a carbon electrode serving as the anode;) third, the metal to be alloyed, and, fourth, a carbon vessel or crucible containing the oxide of aluminium and metal to be treated.

The process and method of operation will be better understood by reference to the accompanying drawing, in which I have shown, in vertical section, one form of an apparatus adapted for this process, which, however, is intended merely as explanatory of my invention, for I desire it to be understood that I do not limit myself to any particular form or construction of apparatus.

Reference being had to the simple apparatus illustrated in the drawing, the letter *a* designates a crucible or containing-vessel of carbon, into which dips a carbon rod, *d*, forming the positive electrode. The crucible or vessel rests upon a conducting-plate, *p*, and is surrounded by powdered carbon, *g*, which fills the space between the crucible and the container *m*. The positive electrode or carbon rod *d* passes through an opening in the cover *b b*, and is capable of adjustment vertically by any suitable means, so that the depth of immersion of the carbon rod into the electrolytic bath may be regulated according to requirement. The cover *b b* is provided with suitable openings for feeding material to the crucible and for the escape of gases, and a tap-hole is also provided for withdrawing the molten metal or alloy and furnished with a plug or other means for closing it. A suitable conduit for the molten alloy should also be arranged in connection with the tap-hole, so that the process may be conducted in a continuous manner. The result is that, the anode being suitably adjusted and the current flowing, the metal and the alumina are fused, the alumina is decomposed by electrolysis into its constituent elements, and its disassociated aluminium unites with the metal used to produce the desired alloy—for example, aluminium-bronze, where copper has been used.

I have obtained satisfactory results by using a current of large quantity and low tension, as follows—that is to say, in a crucible having an internal depth of twenty centimeters, its top being fourteen centimeters in diameter with a carbon anode five centimeters in diameter, a current of four hundred ampères, and from twenty to twenty-five volts.

The depth of immersion of the anode *d* must be regulated during the operation as the level of the copper or other alloyed metal in the crucible varies and to compensate for the carbon consumed. This can be effected in various ways—for instance, by simply suspending the anode higher or lower.

The process is begun with a comparatively small charge of the metal, which is fused by the current, and afterward metal and alumina are added either continuously or at intervals, as required, care being taken that sufficient metal is added, so that the alloy may be of sufficient density to insure its remaining at the bottom of the crucible *a*. A sufficiently thick layer of alumina must, after the beginning of the operation, be maintained over the fluid alloy to prevent short-circuiting, which would occur should the alloy rise so as to connect with the carbon anode.

The circuit is at all times so arranged that the alloying metal, when it has been fused, will serve as the negative electrode, this being an important element of my method, and care must be taken and means employed for the purpose of enabling the operator to know at all times during the operation the distance between the anode and the cathode.

The economical efficiency of my process requires that the crucible or containing-vessel for the bath shall be as highly refractory and conductive as possible and that its substance shall contain nothing which being given off will tend to deteriorate the product. I have selected carbon for this purpose, which, in addition to the other essential conditions named, increases its conductivity with increase of temperature. So far as I am aware, no other material fulfills these essential requirements, and the conductivity of all other materials decreases with increase of temperature.

The process above described enables any desired alloys of aluminium—as, for instance, ferro aluminium, aluminium-steel, aluminium-brass, &c.—to be produced, provided their specific gravity is not less than that of the aluminium or raw material, and also provided the metals employed shall be such as will not be vaporized at the melting-point of alumina.

An important commercial advantage results also from the use of alumina (Al_2O_3)—namely, that the oxygen evolved passes immediately to the carbon anode, where it is burned. On account of this free burning the anode possesses the advantage of a "soluble" electrode—that is to say, it is continually being consumed during the reduction by the oxygen disengaged from the oxide treated. From this combustion it results, first, as already stated, that no polarization of the anode takes place, and the surface of the carbon is always kept clear from whatever might impede the passage of the current or the free access of the oxygen to the carbon; second, that heat energy is involved, which tends materially to maintain the temperature requisite for keeping the elements in the proper state of fusion, and, third, that some electrical energy, corresponding in direction with and which materially aids the current from the dynamo or other source of electricity in its work, is derived from the consumption of the anode. Thus for three equivalents of the anode consumed I obtain two equivalents of aluminium.

Another important advantage of my method and process is that such a degree of heat only as is requisite to fuse the materials is called for, and the high temperature demanded when other than electrolytical processes are employed is avoided. From this results an important saving of electrical energy and security to the apparatus from the effects of excessive heat. The process being electrolytical and the positive pole being of carbon, the evolution of oxygen takes place at that point only, and does not take place at any part of the apparatus where injury might result—as, for example, at the walls of the carbon-crucible.

Having thus fully described my invention, I claim and desire to secure by Letters Patent of the United States—

1. The herein-described process of producing aluminium alloys by electrolysis in which carbon is the anode, the fused metal to be alloyed with the aluminium the cathode, and the fused alumina without a flux the electrolyte.

2. The herein-described process of producing aluminium alloys by electrolysis in which carbon is the anode, the metal to be alloyed with the aluminium the cathode, and alumina fused without a flux the electrolyte, said cathode and electrolyte being fused and maintained in a state of fusion by the electric current.

3. The herein-described electrolytic process of producing aluminium alloys, which consists in melting and electrolytically decomposing alumina located between a positive electrode of carbon and a negative electrode of the metal with which the aluminium is to be alloyed, said alumina and metal both being melted by the electric current, substantially as set forth.

4. The process of making aluminium alloys, which consists in feeding the metal with which the aluminium is to be alloyed and alumina without a flux to a carbon-crucible, electrically fusing the bath so constituted, and simultaneously electrolyzing the alumina in the presence of the carbon anode and the fused metal.

5. The continuous process of making aluminium alloys, which consists in feeding the metal with which the aluminium is to be alloyed and alumina without a flux to a carbon-crucible, electrically fusing the bath so constituted, and simultaneously electrolyzing the alumina in the presence of the carbon anode and the fused metal, and supplying the material and withdrawing the alloy without interruption of the process.

In testimony whereof I sign this specification in the presence of two subscribing witnesses.

PAUL HÉROULT.

Witnesses:
EMIL BLUM,
GEORGE L. CATLIN.