

No. 886,757.

PATENTED MAY 5, 1908.

H. S. BLACKMORE.

ART OF REDUCING ALUMINUM AND OTHER METALS.

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Fig. 1.

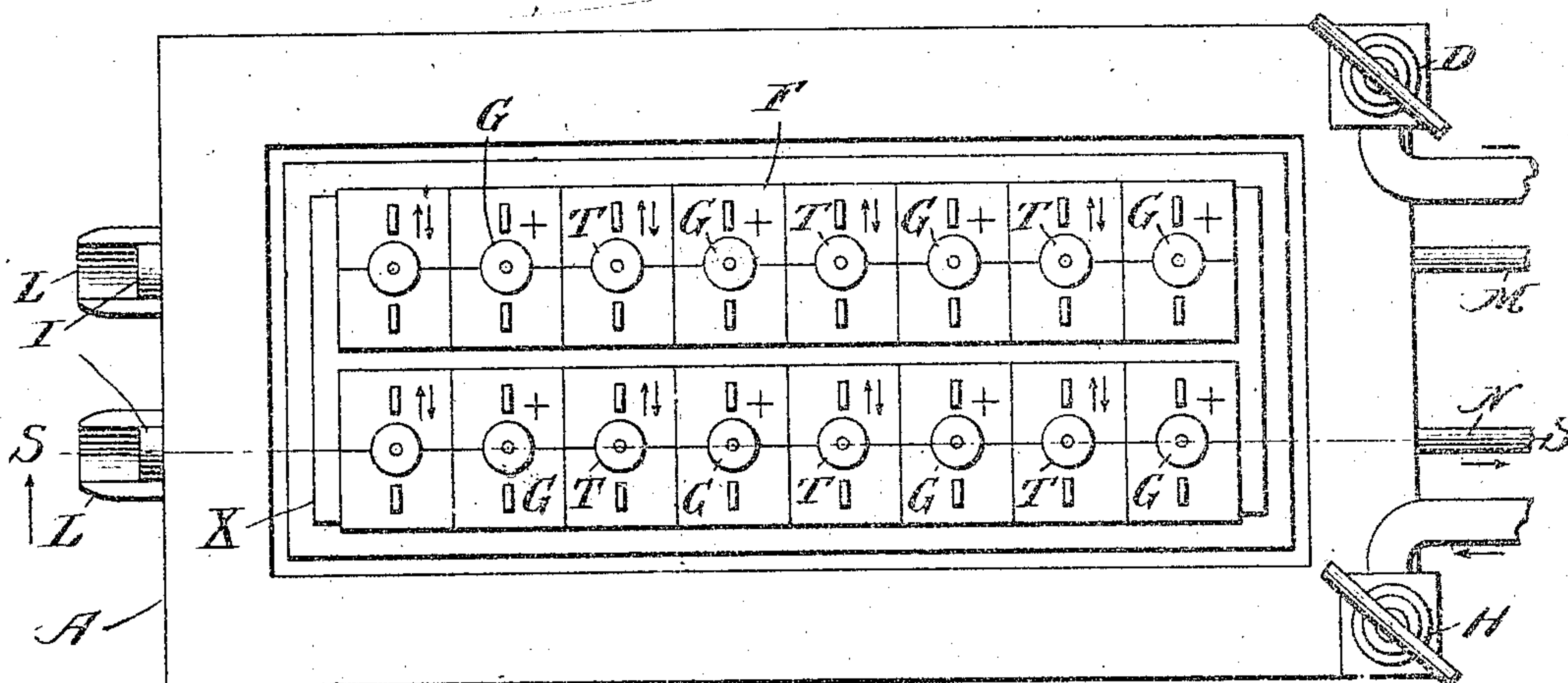
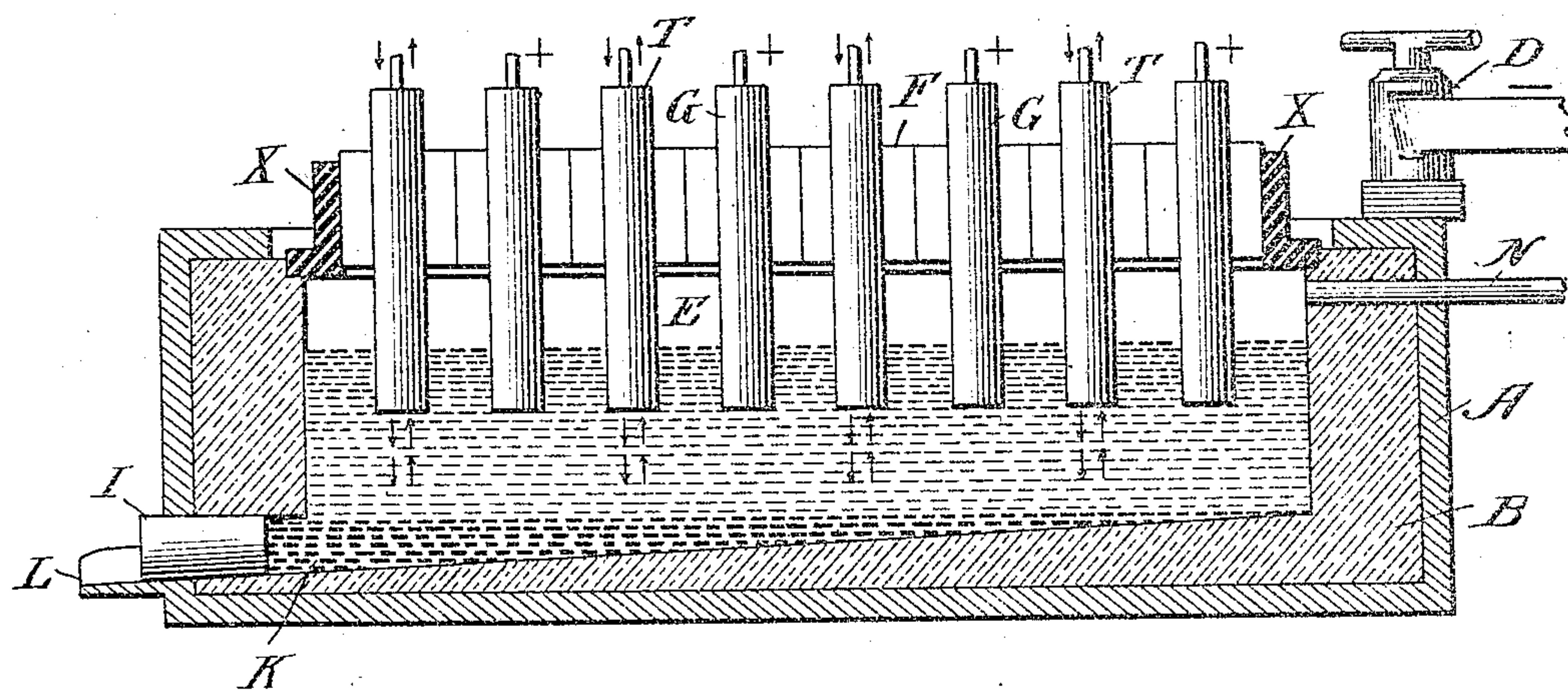


Fig. 2.



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# UNITED STATES PATENT OFFICE.

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## ART OF REDUCING ALUMINIUM AND OTHER METALS.

No. 886,757.

Specification of Letters Patent.

Patented May 5, 1908.

Original application filed August 22, 1904, Serial No. 221,748. Divided and this application filed November 14, 1905.  
Serial No. 287,315.

*To all whom it may concern:*

Be it known that I, HENRY SPENCER BLACKMORE, a citizen of the United States, residing at Mount Vernon, in the county of Westchester and State of New York, have invented certain new and useful Improvements in the Art of Reducing Aluminium and other Metals, being a division from Serial No. 221,748, (Patent No. 775,060,) of which the following is a specification.

The object of my invention is to reduce metals from their oxids and produce alloys thereof, in a rapid, efficient, and economical manner; and it consists, essentially, in liquefying compound metal oxids or compounds of metal oxid with other metals by the action of molten oxids of more electropositive metals with reference to oxygen, subjecting such metal oxids or compounds thus liquefied below their normal melting point to the action of an electrolytic current capable of dissociating them with or without the employment of electrodes capable of uniting with the electronegative constituents evolved.

My invention relates particularly to the production of aluminium alloys from metal aluminates, but is not confined thereto, as it may be applied to the reduction of many other metals and production of other alloys.

In carrying out my invention for the production of aluminium alloys I take oxids of lithium and calcium in proportion of about four of the former to one of the latter and fuse the same by any economical means, such as heat externally applied or preferably by the passage of an alternating electric current through the same between electrodes, the said alternating current being of such character that it will not yield metal from the substances fused thereby. Then after fusion I add to the bath an aluminate of the metal an alloy of which with aluminium is desired, which readily dissolves therein, and simultaneously subject such dissolved aluminate, which has been liquefied below its normal melting point by the action of the associated solvent substances, to the action of a current of electricity capable of electrolyzing the liquefied aluminate and yielding or liberating an aluminium alloy therefrom.

It should be noted that the solvent bath of metal oxids employed in the reduction of metals must consist of oxids of metals which have a greater affinity for oxygen than do the metals desired to be reduced or alloys thereof produced, the principal metals having greater

affinity for oxygen than aluminium being lithium, calcium, and magnesium. I prefer, however, to form the solvent bath for the reduction of aluminates of a mixture or combination of lithium and calcium oxids, as before stated, for the reason that the lithium oxid reduces the density or specific gravity of the calcium oxid, as well as its melting point, and allows the aluminium alloy liberated within its mass by decomposition of the aluminate to readily settle to the bottom thereof, so that it can be withdrawn from time to time, as desired, without fear of loss by oxidation, which would result should the metal remain suspended within a more dense molten material for any length of time, whereby it might reach the surface through circulation and burn in the presence of the oxygen of the air and also prevents final loss of metal, which might otherwise remain mixed with the fluxes on cooling. Lithium oxid and calcium oxid may be employed *per se* as a solvent bath; but I prefer the mixture as aforesaid and for the reasons noted.

In carrying out my process for the production of aluminium alloys I prefer to employ an apparatus as illustrated in the accompanying drawings, in which—

Figure 1 is a plan or top view; and Fig. 2 is a longitudinal vertical section on the line S—S, Fig. 1.

In referring to the figures aforementioned, the letter A designates a box or receptacle, preferably of iron, lined with a substance, such as carbon B, in such a manner as to form a receptacle for the substances to be reduced and solvent chemical bath therefor, in which is an electric conductor and a resistant, preferably of fusible nature, such as aluminium, and lithium, and calcium oxids in proportion of about four of the former to one of the latter and communicating with the electrodes. The material, such as the mixture of lithium and calcium oxids, as before stated, is introduced in the apparatus through the openings E, which are closed by the insulating covers or plugs F passing in the insulating cover X, through which passes the electrodes G and T, which electrodes preferably consist of or contain carbon. The box or receptacle A is connected as cathode, while the electrodes G are connected as anode, when employing a direct current in an electric circuit for electrolyzing or dissociating aluminium oxid or other metal-containing oxy-compound.



In starting the apparatus I pass through the alternate carbon rods or electrodes T and the carbon lining of the box A an alternating electric current of such character that it will not yield metal from the substances employed and start an arc between the said electrodes T and the inside of the receptacle of the carbon-lined box A by separating the said electrodes T slightly from contact with the carbon lining of the receptacle and then feed in lithium and calcium oxids, which quickly become fused and accumulate in the carbon-lined receptacle, communicating with the electrodes T, through which after fusion the current of electricity passes as the electrodes are separated farther and farther from the interior of the carbon-lined receptacle and through which between the electrodes the alternating current passes, producing heat enough to fuse and maintain fusion of the solvent chemical bath without decomposition. I then introduce from time to time into the molten chemical bath through the openings E by removing the insulated covers or plugs F a metal aluminate, such as copper aluminate, which almost immediately becomes liquefied by the action of the solvent bath. As the metal aluminate, such as copper aluminate, becomes liquefied by the action of the chemical solvent bath I pass through the molten bath a direct or electrolytic current of electricity between the anodes G and the carbon lining B, which constitutes the cathode. By this procedure I am enabled to maintain a fluid condition of the solvent bath at a temperature below the normal melting point of the metal aluminate by the action of an alternating current incapable of yielding metal from the substances employed, while the whole of the direct current may be employed or utilized for electrolytic purposes in dissociating or electrolyzing the metal aluminate which has been liquefied by the action of the chemical bath below its normal melting point. The great advantage gained by such operation will be seen when the cheapness with which an alternating current may be produced, transmitted, and employed for heating purposes is compared with the more expensive direct current, which more expensive direct current may be wholly employed for the purpose of electrolytical dissociation in the liberation of the aluminium alloy without loss. The aluminium alloy or other metal reduced is withdrawn from time to time, as desired, through the tap-hole K and trough L by removing the plug I, the gaseous by-products escaping through the conduits N M.

When lithium and calcium oxids are fused together to form my preferable solvent bath for aluminates, as hereinbefore described, they appear to combine to form a solvent

bath which dissolves the aluminate without further combination or reaction or, in other words, is inert thereto. By adding copper oxid with aluminium oxid or copper aluminate to the solvent oxy-bath, copper-aluminium alloys may be produced by electrolysis, or by adding aluminates of other metals or mixtures of other oxids of metals to which aluminium oxid acts as acid other aluminium alloys may be produced. I can also employ instead of aluminates or compositions of aluminium oxid with other metals the oxid or oxids of other metals combined with other metals the alloys of which are desired so long as their reduction is performed in a bath of solvent oxids of metal having greater affinity for oxygen than the metal or metals the alloy of which is desired.

My invention, specifically stated, therefore, consists in exposing a molten body of metal oxids to the action of an electrolytic current capable of selectively separating two or more of the metals therefrom without reducing the metal having greater affinity for oxygen, while replenishing the bath from time to time with an oxy-compound of the metal or metals desired, the solvent bath in which the electrolysis of the metals is performed consisting of fused oxy-compounds of metals having greater affinity for oxygen than the metal or metals desired.

It has nowhere in prior art been anticipated to form a bath for aluminates or compounds of metal oxid with other metals by fusing the combined oxids of metals and liquefying the metal compound, the metal or alloy of which is desired, below its normal melting point by adding it to the fused oxid bath and subjecting the metal compound thus dissolved to the action of a direct current of electricity capable of yielding or liberating the metal by electrolysis, whereby the aluminate or other metal oxy-compound may be reduced continuously by supplying it from time to time to the fused oxid solvent bath as increments are reduced to a metallic state as formed by my process. By maintaining a relatively low voltage of the direct or electrolytic current the aluminates, &c., may be readily dissociated, liberating aluminium or other alloys without deteriorating or decomposing the solvent oxid bath because of the greater affinity of the metals of the solvent bath for oxygen.

A further important and novel feature of my process is that I fuse and maintain fusion of the solvent chemical bath by the action of an alternating electric current or one incapable of yielding metal passed through the same between electrodes and reduce the metal from the oxy-compound contained in the fused bath by the action of an electric current capable of yielding metal therefrom.

Instead of employing as a chemical solvent



bath fused lithium and calcium oxids, or what may be termed "lithium calcate" or substance containing the same, as herein set forth I can employ fused lithium glucinum  
 5 oxids or lithium glucinate or substance containing the same in cases where particular lightness or low specific gravity of the bath is desired, or I can employ fused lithium  
 10 hydrogen oxids or lithium hydrate, hydrogen being considered as a metal, or I can mix or combine any oxid or oxids or compositions thereof or employ any oxy-compound of  
 15 metal in a fused condition as a chemical bath in which the reduction of metal is performed, so long as the said fused bath consists of an oxy-compound or compounds of metal hav-  
 20 ing greater affinity for oxygen under the existing conditions than the metal desired, and the direct or electrolytic current is so regulated as to decompose or liberate metal or  
 25 metals therefrom having less affinity for oxygen than the metal or metals of the fused bath under its existing condition without departing from the spirit of my invention.

In the reduction of refractory metal oxids, such as aluminates dissolved in a molten bath of chemicals, as hereinbefore set forth, the refractory metal oxy-compound is dissolved by the solvent action of the fused  
 30 chemical solvent, and its liquefaction below its normal melting point is accomplished by the direct solvent action of the chemical bath without the expenditure of either heat or electrical energy to accomplish its fusion.  
 35 The liquefaction of refractory metal oxid is therefore accomplished by means other than the action of an electric current.

It will be noted that the non-metal-yielding current employed for fusing and main-  
 40 taining the fusion of metal-containing substances employed in my process is passed through the fused substances between contacts in such a manner that its path is parallel to or with the path of the direct or  
 45 metal-yielding current. The advantage of disposing the non-metal-yielding current employed for fusion purposes parallel to or with the direct or metal-yielding current may be seen when it is understood that during the  
 50 employment of a direct current for fusion and electrolytic purposes should the metal-yielding current be checked for a short period the fused substances in the path thereof have a tendency to solidify and become non-  
 55 conductive, thereby insulating the electrodes from each other, occasioning great loss of time and energy to reestablish the flow of current between the same. Therefore by  
 60 so disposing the fusing or non-metal-yielding current that its path is parallel to or with the path of the direct or metal-yielding current the maintenance of the fusion of the substances is assured and the difficulty experienced in the prior art is obviated.

65 It will be further seen that by applying

the fusing or non-metal-yielding current in a path parallel to or with the metal-yielding current through the fused contents of the furnace, thereby traversing the fused contents with the distinctive currents in a parallel direction, common electrodes or contacts for the currents with the metal-containing substances may be employed, as shown at D and H, Fig. 1, which illustrates the metal-reduction pot, both as cathode for  
 75 the direct current and electrode or contact to the metal-containing substances for the alternating current, the pot acting as an electrode, thus constituting a common contact for both currents. The heating or fusing  
 80 current or currents employed may be alternating or any other form of polyphase current so long as they are non-metal-yielding.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The process of reducing metal from substances containing the same which consists in fusing the metal-containing substance by  
 90 passing a non-metal-yielding current through the fused material between contacts, and liberating the metal from its compound by the action of a metal-yielding current passed therethrough in a path disposed parallel to  
 95 or with the path of the heating or non-metal-yielding current.

2. The process of reducing aluminium from substances containing the same, which consists in fusing the aluminium-containing  
 100 substances by passing a non-metal-yielding current through the fused material between contacts, and liberating the aluminium from its compound by the action of a metal-yielding current passed therethrough in a  
 105 path disposed parallel to or with the path of the heating or non-metal-yielding current.

3. The process of reducing metal from substances containing the same, which consists in liberating the metal by the action of a  
 110 metal-yielding current while traversing the fused metal-containing substances between contacts with an alternating current parallel to the path of the metal-yielding current.

4. The process of reducing metal from substances containing the same, which consists in liberating the metal by the action of a  
 115 metal-yielding current while traversing the fused metal-containing substances between contacts with a non-metal-yielding current  
 120 disposed parallel to or with the path of the metal-yielding current.

5. The process of reducing metal from substances containing the same, which consists in liberating the metal by the combined ac-  
 125 tion of metal-yielding and non-metal-yielding electric currents, disposed through the metal-containing substances in a parallel path.

6. The process of reducing metal from substances containing the same, which consists  
 130



in liberating the metal by the combined action of direct and polyphase electric currents, disposed through the metal-containing substances in a parallel path.

5 7. The process of reducing metal from substances containing the same, which consists in liberating the metal by the combined action of direct and alternating electric currents, disposed through the metal-containing  
10 substances in a parallel path.

8. The process of reducing metal from substances containing the same, which consists in liberating the metal by the combined action of metal-yielding and non-metal-yielding electric currents, disposed through the  
15 metal-containing substances in a parallel path and communicated to the metal-containing substances through a common electrode.

20 9. The process of reducing metal from substances containing the same, which consists in liberating the metal by the combined action of direct and polyphase electric currents, disposed through the metal-containing substances in a parallel path, and communicated  
25 to the metal-containing substances through a common electrode.

30 10. The process of reducing metal from substances containing the same, which consists in liberating the metal by the combined

action of direct and alternating electric currents, disposed through the metal-containing substances in a parallel path, and communicated to the metal-containing substances through a common electrode.

35 11. The process of reducing aluminium from substances containing the same, which consists in liberating the aluminium by the combined action of metal-yielding and non-metal-yielding electric currents, disposed  
40 through the metal-containing substances in a parallel path.

12. The process of reducing aluminium from substances containing the same, which consists in liberating the aluminium by the  
45 combined action of direct and polyphase electric currents, disposed through the metal-containing substances in a parallel path.

13. The process of reducing aluminium from substances containing the same, which  
50 consists in liberating the aluminium by the combined action of direct and alternating electric currents, disposed through the metal-containing substances in a parallel path.

In testimony whereof I affix my signature  
55 in presence of two witnesses.

HENRY SPENCER BLACKMORE.

Witnesses:

H. N. JENKINS,  
C. M. FORREST.