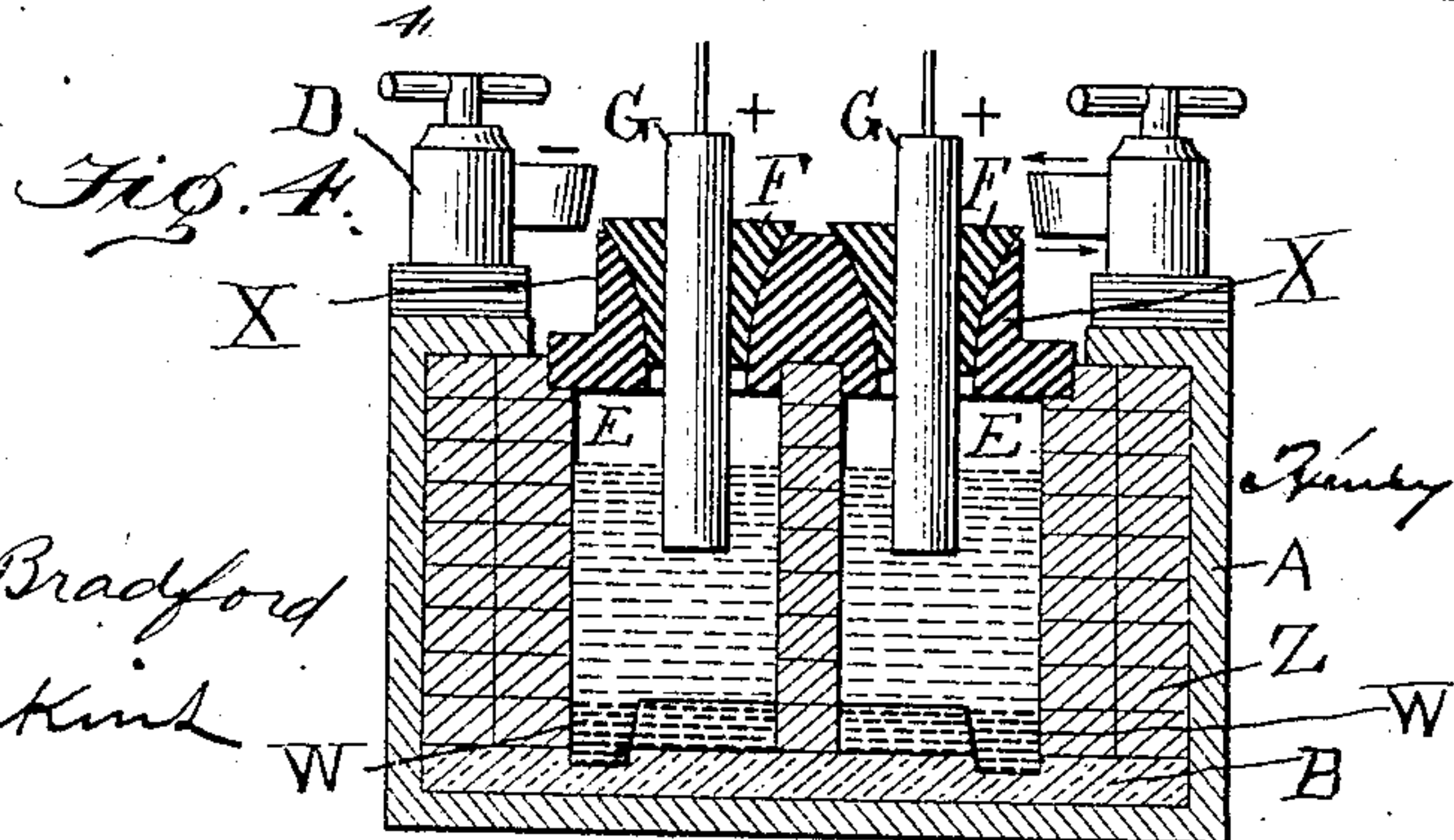
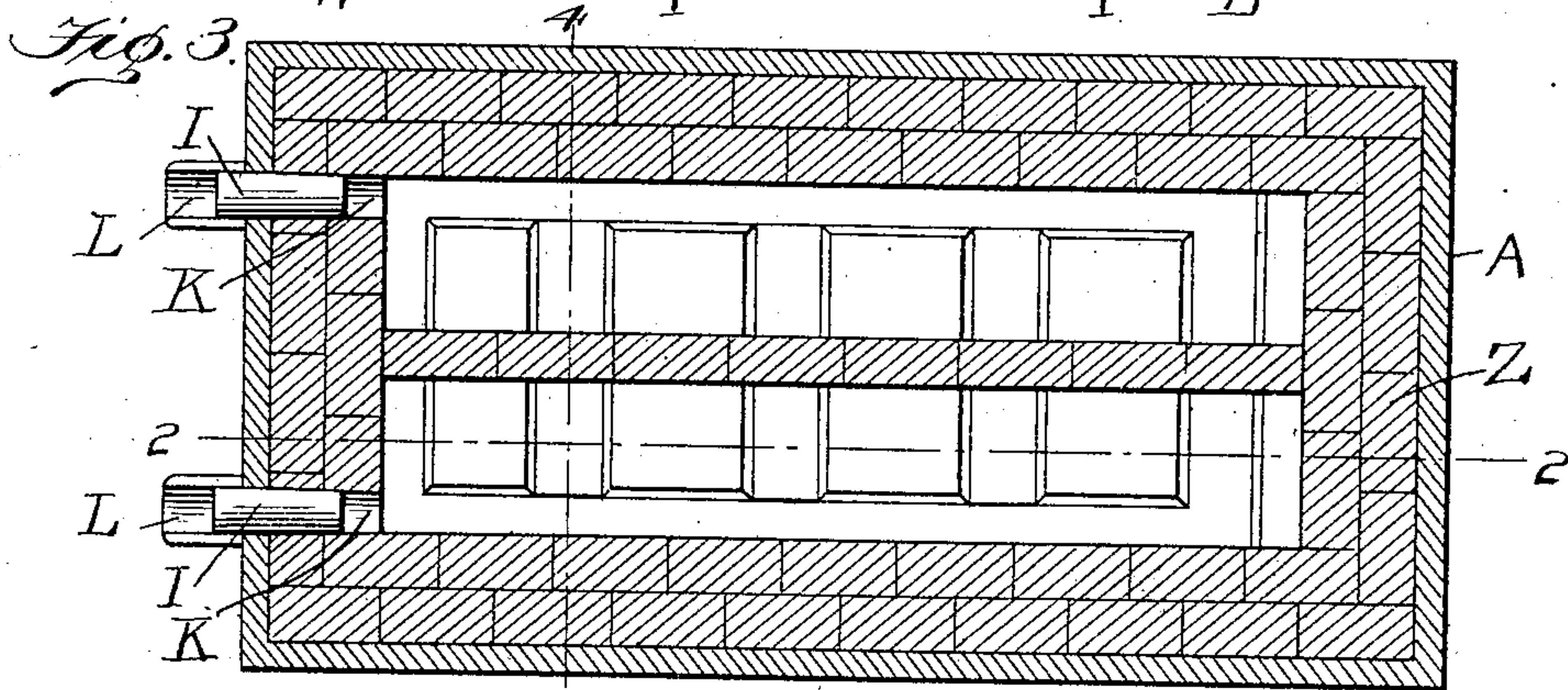
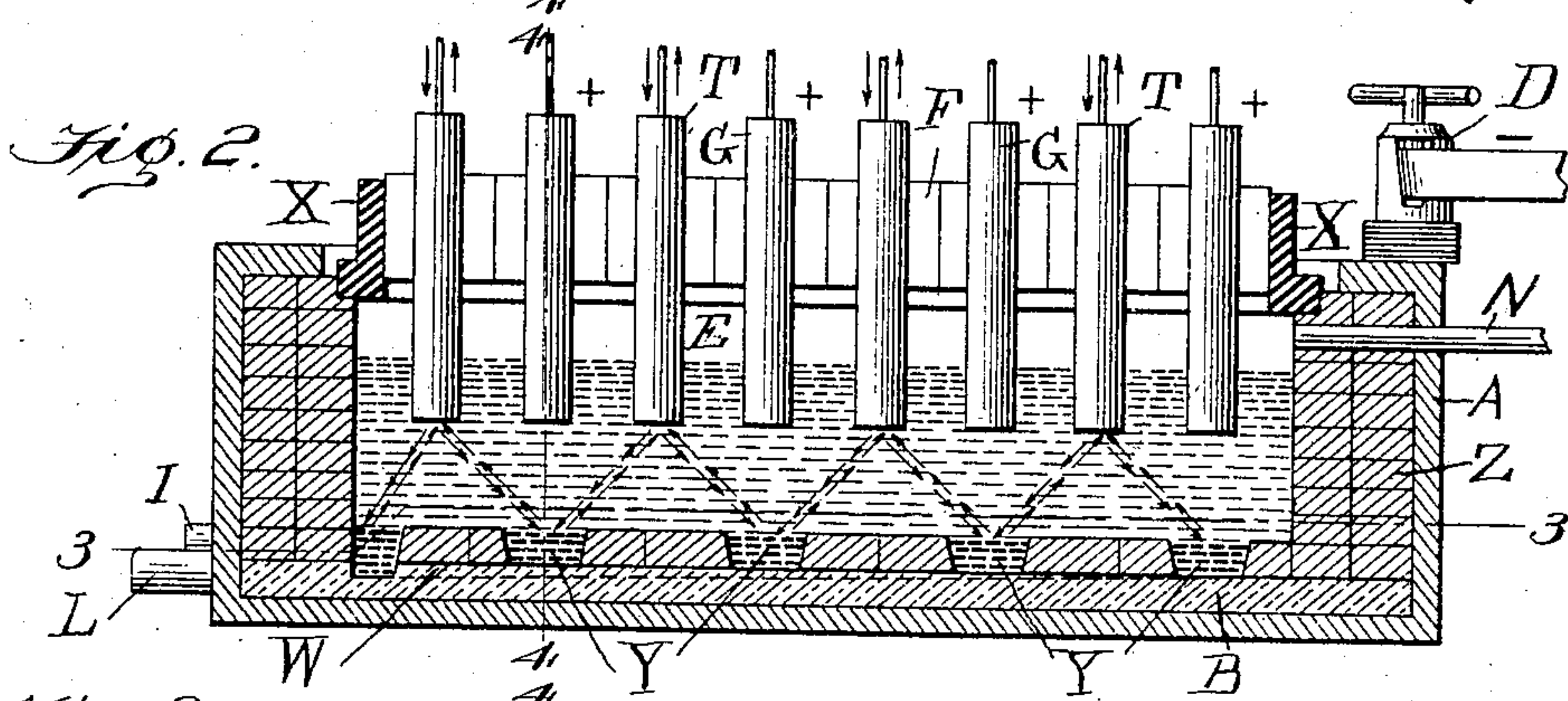
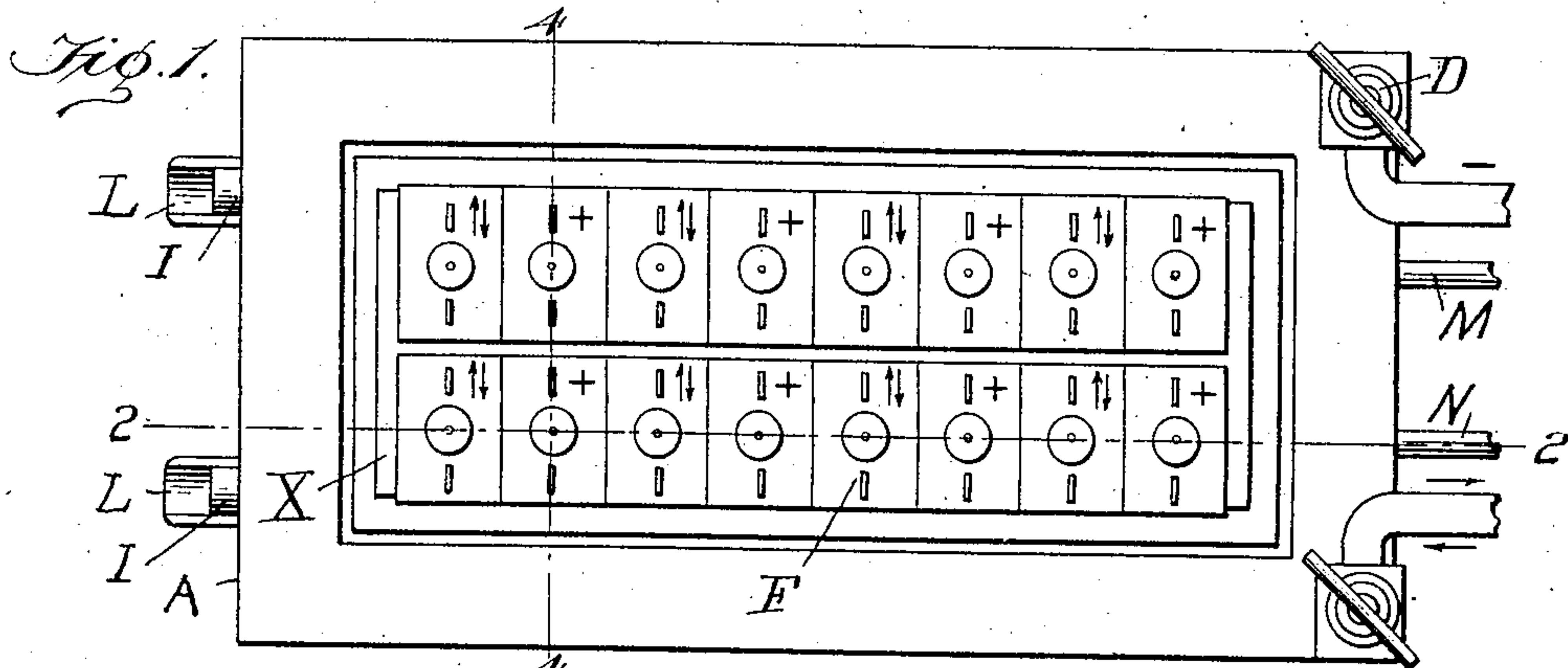


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H. S. BLACKMORE.
PROCESS OF PRODUCING METALS AND ALLOYS.
APPLICATION FILED NOV. 15, 1904.



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PROCESS OF PRODUCING METALS AND ALLOYS.

SPECIFICATION forming part of Letters Patent No. 786,185, dated March 28, 1905.

Application filed November 15, 1904. Serial No. 232,828.

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 Processes of Producing Metals and Alloys, 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 metal oxids or compounds of metal oxid with other metals by the action of molten oxids of still 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 does 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. Fig. 2 is a vertical longitudinal section through line 2 2 of Fig. 1 and Fig. 3. Fig. 3 is a horizontal section through line 3 3 of Fig. 2. Fig. 4 is a vertical transverse section through line 4 4 of the aforesaid figures.

Referring to the figures before mentioned, the letter A designates a box or receptacle, preferably of iron, lined on the bottom with a conductive substance, such as carbon B, and at the sides with a non-conductive lining Z, such as magnesia brick. This non-conductive magnesia brick is also built upon the carbon or conductive bottom B in such a manner as to expose the carbon bottom only in channels beneath the electrolytic electrodes G and insulating the alternating current as applied

through the electrodes T in such a manner that it is deflected to a point from the said electrode T to a point beneath the electrodes G in such a manner as to maintain the substances within the receptacle in a molten condition by action of the alternating current, so that the direct current as applied through the electrodes G may be utilized to its greatest extent for the purpose of electrolytic dissociation. This magnesia brick and carbon lining serve to form a receptacle for the substances to be reduced and the solvent chemical bath therefor, in which is an electric conductor and a resistant, preferably of a fusible nature, such as an aluminium alloy 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 a 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 pass 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 anodes when employing a direct current in an electric circuit for electrolyzing or dissociating the metal aluminates. In starting the apparatus I pass through the alternate carbon rods or electrodes G and the carbon lining at the bottom of the receptacle B an alternating electric current of such a character that it will not yield metal from the substances employed and start an arc between the said electrodes G and the carbon lining B by separating the said electrodes G slightly from contact with the carbon lining and then feed in lithium and calcium oxids, which quickly become fused and accumulate in the receptacle communicating with the electrodes G, through which after fusion the current of electricity passes as the electrodes are separated farther and farther from the carbon lining 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. When the solvent bath has become suitably fused, I break the alternating-current contact with the electrodes G and connect the same with the electrodes T, after which the current passes diagonally through the molten bath from the said electrodes to the channel exposing the conductive carbon B or containing a conductive substance communicating with the same, such as an aluminium alloy. The electrodes G are then connected with a direct or electrolytic current and introduced from time to time into the solvent 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 as exposed in the channels Y or aluminium alloy or other conductive medium in the said channel communicating with the carbon conductor 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 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 an 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 current may be wholly employed for the purpose of electrolytic dissociation in the liberation of the aluminium alloy without loss.

The aluminium alloy or other metal reduced accumulates in the channel Y beneath the anode G, from which it is withdrawn from time to time through the main channel or conduit W, the tap-hole K, and the trough L by removing the tap-hole plug I, the gaseous by-products escaping through the conduits M N.

When fusing the solvent bath by passing an alternating or non-metal-yielding current through the same between the conductive medium in the channels Y and the electrodes T, the furnace is placed in electrical connection with the alternating current through the binding-post or clamp H, while the electrodes T communicate with the opposite side of the alternating-current generator. The electrolysis of the metal aluminate liquefied by the action of the solvent chemical bath is performed by connecting the furnace in a direct-current circuit as cathode through the binding-post D, the electrodes G communicating with the opposite pole of the direct-current generator and constituting the anodes during the passage of the current and electrolysis of the metal compound. The electrodes T and G are brought in communication with their various electric generators through metal rods connecting therewith attached to bus-bars by means of suitable clamps or other means. (Not shown.) The electrodes communicating with the fused substances consist, preferably, of carbon, which carbon electrodes when existing as anodes during electrolysis combine with the

oxygen evolved in contact with the same, passing off as gaseous carbonic oxids through the exit tubes or conduits M N.

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—such as chromates, vanadates, stanates, tungstates, molybdates, &c.—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 performed 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 incapa-

ble 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 solvent chemical 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 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 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 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 having 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 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 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. 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 maintaining 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 at an angle to the path of the direct or metal-yielding current. The advantage of disposing the non-metal-yielding current employed for fusion purposes at an angle to the direct or metal-yielding current may be seen when it is understood that during the 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-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 so disposing the fusing or non-metal-yielding current that its path is at an angle to the path

of the direct or metal-yielding current the maintenance of the fusion of the substances is assured and the difficulty experienced in prior art is obviated. This species of my process is clearly revealed and illustrated in Fig. 2 of the accompanying drawings and Figs. 4 and 6 of United States Patent No. 775,060, issued November 15, 1904.

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

1. The process of reducing metal and producing alloys thereof which consists in fusing an oxy compound of a metal or metals having greater affinity for oxygen than the metal desired, adding thereto an oxy compound of the metal desired with another metal an alloy with which is sought and subjecting the mass to the action of an electrolytic current capable of liberating the metals desired and replenishing the mass with more metal oxy compound from time to time as the bath is depleted thereof by reduction.

2. The process of reducing metals and producing alloys thereof which consists of fusing an oxy compound of a metal or metals having a greater affinity for oxygen than the metals an alloy of which is desired adding thereto a double oxid of the metals an alloy of which is desired and subjecting the mass to the action of an electrolytic current capable of liberating the said metals and producing an alloy thereof and replenishing the mass with more metal oxids from time to time as the bath becomes depleted thereof by reduction.

3. The process of reducing aluminium and other metals and producing alloys thereof which consists in fusing an oxy compound of a metal or metals having greater affinity for oxygen than aluminium or the metal an alloy of which is desired, adding thereto an aluminate of the metal an alloy of which is sought and subjecting the mass to the action of an electrolytic current capable of liberating the aluminium and other metal thereby producing alloy thereof and replenishing the mass with more aluminate from time to time as the bath becomes depleted thereof by reduction.

4. The process of reducing aluminium and producing alloys thereof which consists in fusing an oxy compound of a metal or metals having greater affinity for oxygen than aluminium, and adding thereto an aluminate of

a metal having less affinity for oxygen than aluminium, and subjecting the mass to the action of an electrolytic current capable of liberating the aluminium and metal having lesser affinity for oxygen, thereby producing alloys thereof, and replenishing the mass with more aluminate from time to time as the bath becomes depleted thereof by reduction.

5. The process of reducing metals and producing alloys thereof which consists in fusing an oxy compound of a metal or metals having greater affinity for oxygen than the metals an alloy of which is desired, the said fused mass containing oxy compounds of the metals an alloy of which is desired and subjecting the mass to the action of an electrolytic current capable of liberating the desired metals, thereby producing alloys thereof.

6. The process of producing an alloy of aluminium and copper which consists in fusing an oxy compound of a metal or metals having greater affinity for oxygen than aluminium or copper adding thereto copper aluminate and subjecting the mass to the action of an electrolytic current capable of liberating the aluminium and copper therefrom thereby producing alloys thereof.

7. The process of reducing metal from substances containing the same which consists in exposing a fused metal-containing substance to the action of a metal-yielding electric current while subjecting the fused substance to the action of a non-metal-yielding current passed through the same between electrodes, one electrode of which is in common with the metal-yielding-current electrode.

8. The process of reducing metal from substances containing the same which consists in exposing a fused metal-containing substance to the action of a metal-yielding electric current while subjecting the fused substance to the action of a non-metal-yielding current passed through the same between electrodes at an angle to the path of the metal-yielding current, and one of which electrodes is in common with the metal-yielding-current electrode.

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

HENRY SPENCER BLACKMORE.

Witnesses:

C. C. WRIGHT,
C. M. FORREST.