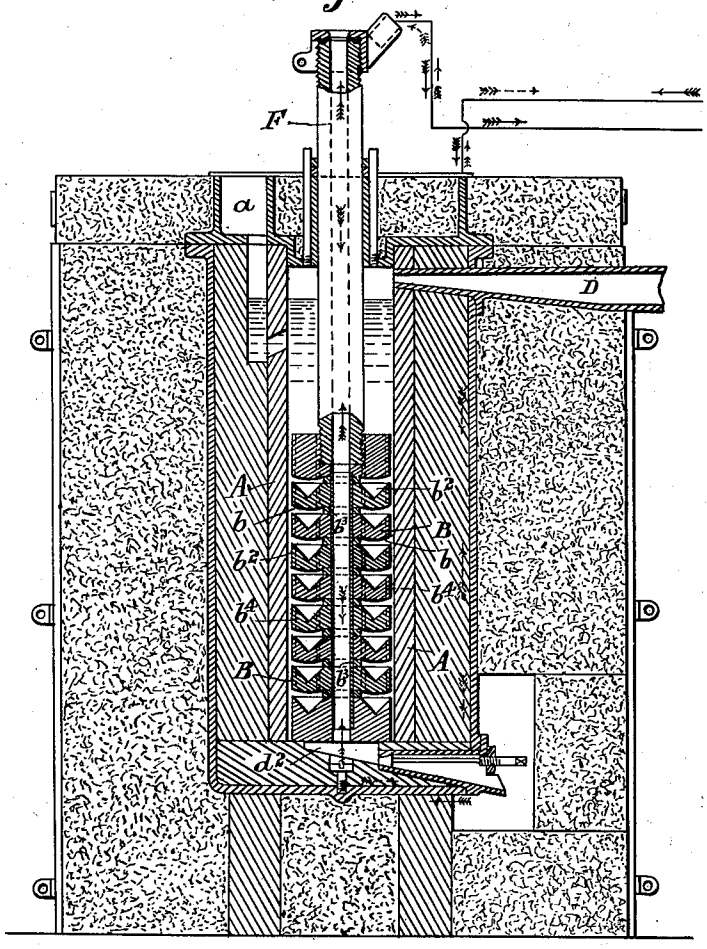
Jan. 12, 1926. 1,569,606

E. A. ASHCROFT

APPARATUS FOR ELECTROLYZING FUSED SALTS OF METALS AND RECOVERING THE METALS AND ACID RADICLES

Filed Feb. 6, 1924. 5 Sheets-Sheet 1

Fig. 1.



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Filed Feb. 6, 1924 5 Sheets-Sheet 2

Fig. 1a

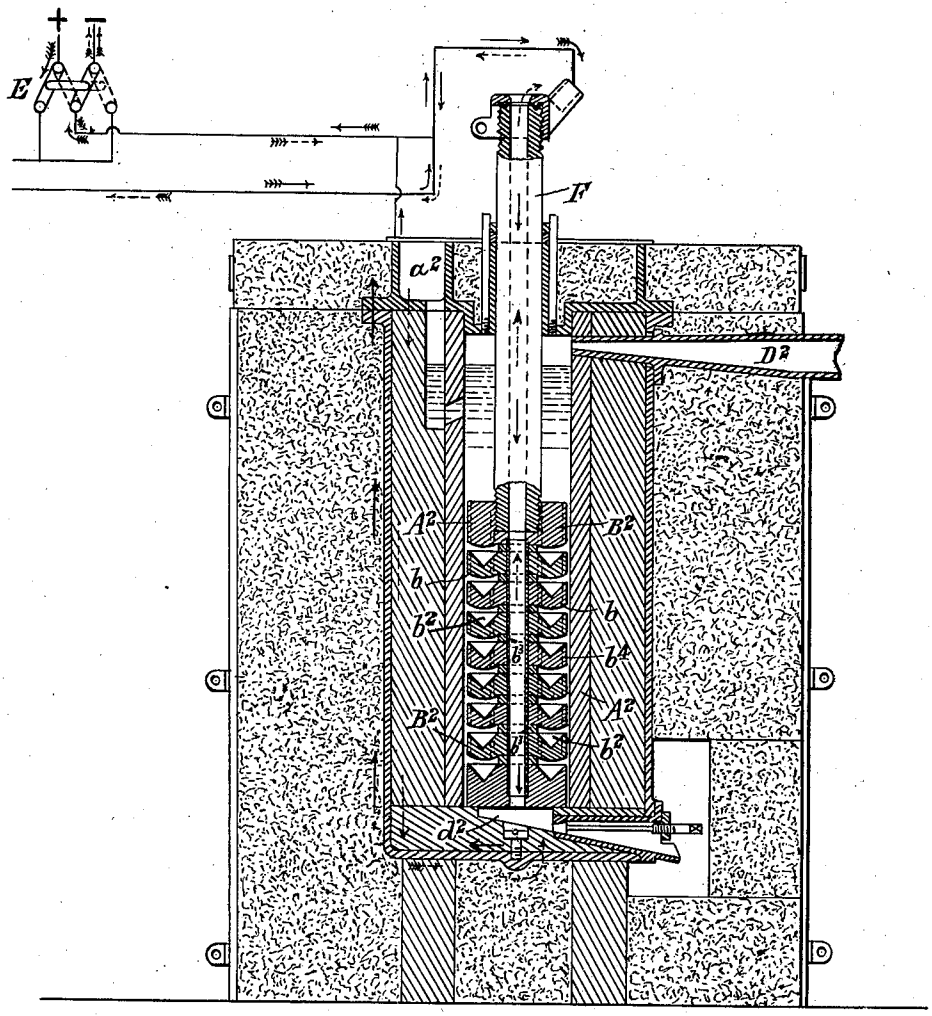

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Fig. 2.

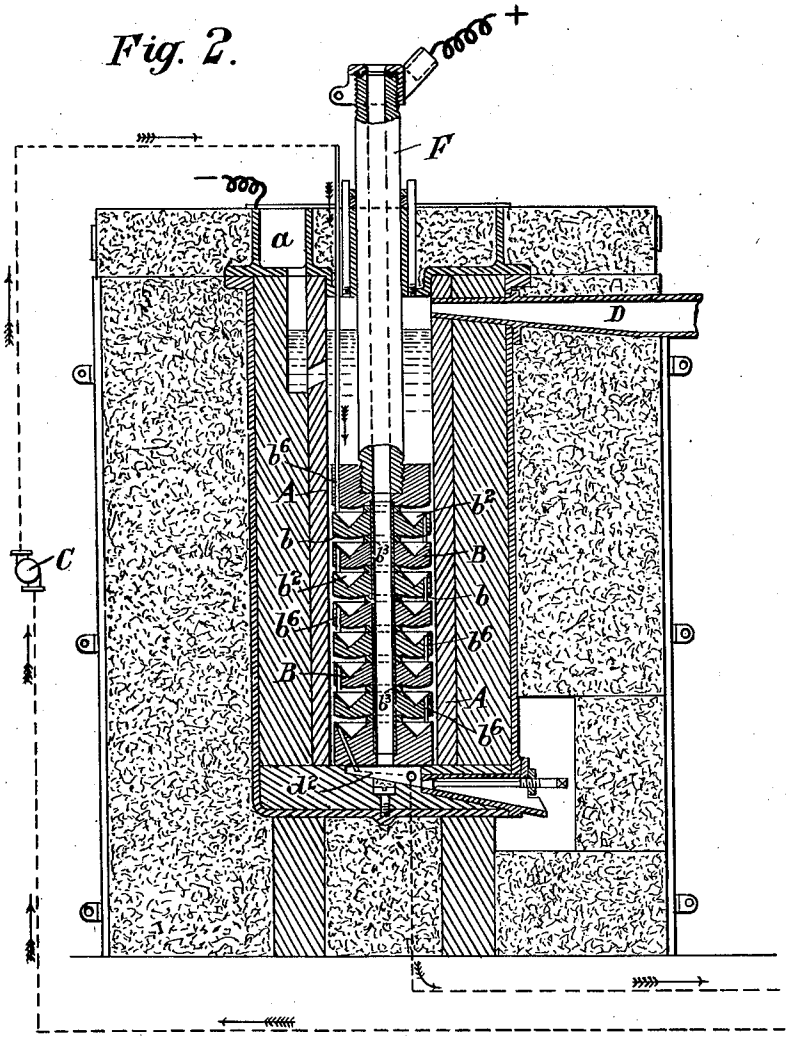

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Fig. 2a

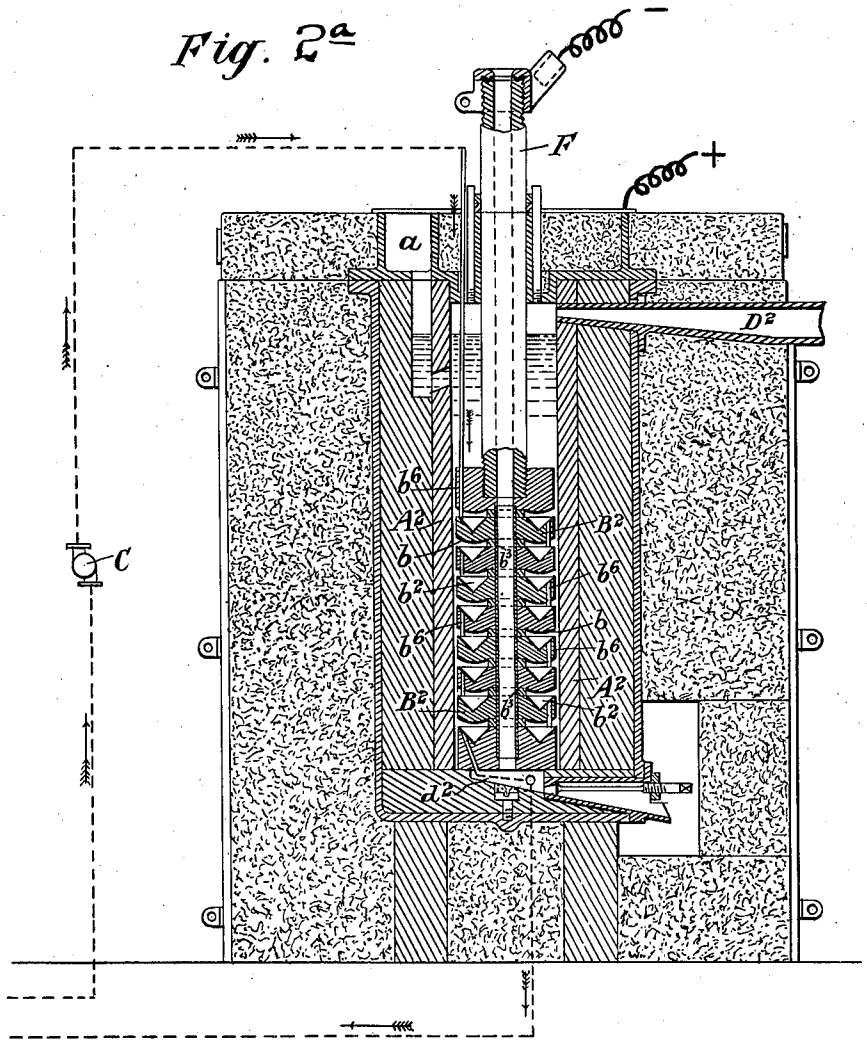

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Fig. 3.

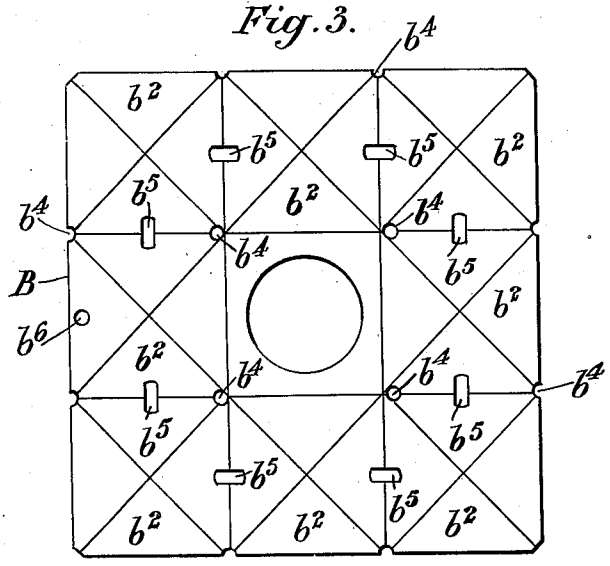
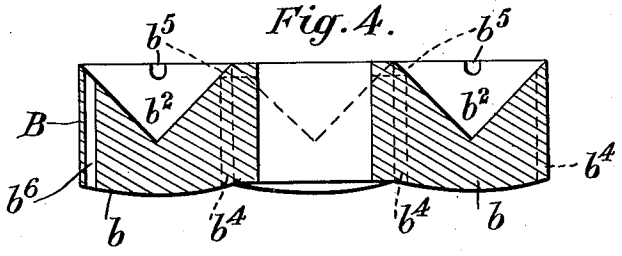


Fig. 4.



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Patented Jan. 12, 1926. 1,569,606

UNITED STATES PATENT OFFICE.

EDGAR ARTHUR ASHCROFT, OF LONDON, ENGLAND.

APPARATUS FOR ELECTROLYZING FUSED SALTS OF METALS AND RECOVERING THE METALS AND ACID RADICLES.

Application filed February 6, 1924. Serial No. 690,969.

To all whom it may concern:

Be it known that I, EDGAR ARTHUR ASHCROFT, a subject of the King of Great Britain, residing at 32ª Liverpool Street, in the city of London, England, and at "Waye", near Ashburton, South Devon, England, have invented new and useful Improvements in, and Apparatus for, Electrolyzing Fused Salts of Metals and Recovering the Metals and Acid Radicles, of which the following is a specification.

My present invention is an improvement upon, or a modification of, the invention which is the subject matter of application for Letters Patent Serial No. 551,306 and bearing date the 10th day of April A. D. 1922.

I have found that the multiple-couple electrolyzers which I have invented and claimed under my said application are adapted for, and can, by suitable modification, be employed with advantage in, recovering, from fused salts, metal lighter than the fused electrolyte, such, for instance as magnesium from fused magnesium chloride, by processes in accordance with Letters Patent No. 1,359,653 granted to me and dated the 26th day of November A. D. 1920.

I will, for the purpose of description, presume that my present invention is to be used for the obtainment of metallic magnesium from chloride of magnesium in accordance with my aforesaid Patent 1,359,653 from which its analogous applications will also be understood.

In adapting the said multiple-couple electrolyzers for such purpose I employ a suitable modification of the electrodes thereof either in one electrolyzer, or in a pair of electrolyzers, which, or both of which, can be used alternately as a primary and as a secondary electrolyzer; or I can employ two electrolyzers, one being used as a primary electrolyzer for the production of the alloy of magnesium and some suitable heavy metal (such for example as lead) and magnesium and the other being used as a secondary electrolyzer for the production of the metallic magnesium, the alloy being passed from one electrolyzer to the other by any suitable means for causing the said alloy to pass successively, or circulate, through the electrolyzers. In this latter case the electrodes of the secondary electrolyzer may be of iron, or steel, whilst those of the primary electrolyzer may be of carbon, or graphite.

The containing vessel, or chamber, of the electrolyzer, or of each electrolyzer, is preferably of considerable depth relatively to its length and width, or cross-sectional area, and the electrodes are constructed so as to contain alloy, they being, for instance, in the form of trays, (I will refer to them as trays) and are horizontally arranged, each tray being capable of holding a considerable amount of molten lead alloy (lead-magnesium alloy in the instance given) the under side of the trays being preferably made of a shape, which will facilitate the escape of the magnesium deposited on the electrodes, suitable openings, or passages being provided for the upward passage of the liberated magnesium and gases, the upper part of the electrolyzer being provided with an outlet for chlorine, an inlet for magnesium chloride and openings for enabling the produced magnesium to be collected.

When two electrolyzers are employed they are preferably arranged in one and the same electric circuit and can be operated by passing the electric current through the two electrolyzers alternately in opposite directions so that at first portions of the alloy carried at the upper sides of the electrodes will be the negative poles in one electrolyzer and the positive poles in the other electrolyzer, and vice versâ, when the current is reversed and therefore in the first electrolyzer chlorine will be liberated at the under surface of each electrode and will rise through the openings therethrough, and pass off to any required place whilst magnesium will be liberated at the upper surface of the alloy and enrich it, the electrolyte consumed being replaced to maintain a proper level during the electrolysis. At the same time, in the secondary electrolyzer, chlorine is generated at the surface of the alloy carried by the electrodes and combines with the magnesium of the alloy, whilst metallic magnesium will be liberated from the magnesium chloride at the under surface of the electrodes and rise to the surface in the electrolyzer and can be removed by any suitable means.

When the electrolysis has proceeded in this manner for the requisite time the electric current is reversed and the electrolyzers

which were primary and secondary become respectively secondary and primary electrolyzers. This reversal of the current may be repeated at any desired intervals by any suitable means, such as a reversing switch worked mechanically, or electrically, or by hand. The reversal of the current will make no alteration in the difference of potential in the combined electrolyzers as the rise of terminal voltage in one electrolyzer will compensate for the fall of terminal voltage in the other electrolyzer.

When the electrolyzers are employed each exclusively as either a primary, or as a secondary, electrolyzer, the alloy will be circulated from one electrolyzer to the other by allowing the alloy to descend in succession from one to another of the electrodes in the primary electrolyzer and thence to flow, or be raised, from the lower part of the electrolyzer and subsequently to pass through the secondary electrolyzer, there being in this case, no reversal of the electric current the circulating alloy becoming enriched in the primary electrolyzer and impoverished in the secondary electrolyzer.

I do not confine myself to the particular details hereinbefore described as they may be varied without departing from the nature of my invention. I may also employ my electrolyzers as aforesaid, separately, either as primary electrolyzers for the production of magnesium-lead alloy, or as secondary electrolyzers for the production of magnesium from such alloys. I may employ any other suitable heavy metal instead of lead and, instead of magnesium chloride, I may similarly electrolyze any other suitable salt of magnesium, or of other light metal, or admixtures of such salts with other salts.

Constructions and arrangements of the said multiple-couple electrolyzers in accordance with this invention are illustrated in the accompanying drawings, but I do not limit myself to the particular details illustrated.

Figures 1 and 1^a together constitute a vertical section of a pair of electrolyzers in accordance with this invention shewing, diagrammatically, electric connections arranged so that by reversal of the current the electrolyzers can be used alternately as primary and secondary electrolyzers.

Figures 2 and 2^a together constitute a vertical section of a pair of similar electrolyzers through which the alloy is circulated by any suitable means which are indicated diagrammatically, the electric current passing in series through the two electrolyzers.

Figures 3 and 4 shew, in plan and transverse section respectively, and drawn to a larger scale, one of the tray electrodes.

In the electrolyzers illustrated the containing vessel of one of the pair is marked A and the containing vessel of the other of the pair is marked A^2. The electrodes are marked B and B^2 respectively. The upper sides of the said electrodes constitute trays, or equivalent containers, for the alloy the lower sides of each tray, or equivalent container, being formed with convexities b, above the recesses, or pockets, b^2, in the upper side of the electrode next under it, but the undersides may be of any other suitable shape but preferably are such as will facilitate, as much as possible, the upward passage of alternately the chlorine and the magnesium equally throughout the fused magnesium chloride. The electrodes are insulated from each other which can be done by silica blocks some of which are seen at b^3.

The magnesium-lead alloy in both electrolyzers, in the arrangement shewn in Figure 1, is contained and remains in the pockets b^2 of the trays constituting the electrodes and, when the electric circuit is passed in the direction indicated by the full line arrows, the electrolyzer A^2 is the primary electrolyzer, magnesium chloride being fed into the hopper a^2 and chlorine passing through the passages b^4 in the electrodes B^2 and out of the electrolyzer at D^2. When this action has continued for the requisite time for the alloy in the pockets b^2 of the electrolyzer A^2 to have become enriched in magnesium to a sufficient extent, (say to an extent of four per cent, for instance) and the electrolyte having passed into the electrolyzer A through any suitable connecting passage, or communication, the alloy in the pockets b^2 of the electrolyzer A will have become depleted of magnesium to an equivalent amount and this magnesium, being lighter than the electrolyte rises therein and passes up through the passages b^4 in the electrodes B and can be removed from the surface of the electrolyte in any suitable way; for instance, by passing in further electrolyte and collecting the magnesium at the overflow D. The electrolyzer A, therefore acts as a secondary electrolyzer whilst the electrolyzer A^2 is acting as a primary electrolyzer. On the electric current being reversed (for instance by means of the reversing switch E) it passes through the electrolyzers in the reverse direction, as indicated by the dotted arrows, and the electrolyzer A then acts as the primary electrolyzer and the electrolyzer A^2 acts as the secondary electrolyzer.

The electrical connections and conductors are shewn diagrammatically only. They may be arranged in any suitable way so that, by manipulating the reversing switch E, the electric current will pass alternately through the metal casings and central conductors of the electrolyzers alternately in the direction indicated by the full line arrows and in the direction indicated by the dotted arrows, the

magnesium chloride being supplied alternately to the electrolyzer A at a, and the electrolyzer A^2 and a^2 when the electric current is reversed. The outlets and valves at a^2 allow of the contents being drawn from the electrolyzers when necessary.

Although I have shewn only one pile of electrodes in each electrolyzer there may be any suitable number of piles arranged in each electrolyzer in any suitable order, each pile, or any number of such piles, being in communication with lower and upper inlets and outlets in any convenient manner.

One of the electric conductors is connected to the top electrode of the pile, or of each pile, by a conductive rod F, the other electric conductor being in electrical connection with the lowest electrodes of the pile, or of each pile, in any suitable way and the electrolyzer is encased, or enclosed, in electrical-, and heat-, insulating material which can be done in a manner analogous to the manner in which it is done in the case of the multiple-couple electrolyzer of the parent patent application Serial No. 551,306 filed April 10, 1922. This will be evident from the accompanying drawings and requires no particular description here.

Figure 2 illustrates an arrangement wherein two electrolyzers, like those shewn in Figure 1, are arranged so that the electrolyzing current passes therethrough constantly in the same direction, one electrolyzer being used for enriching the alloy and the other electrolyzer being used for depleting the alloy which will be circulated in cascade down through the electrodes B, B^2, in the respective electrolyzers and through suitable passages taking the course indicated by the dotted lines and arrows, the molten magnesium chloride being passed into the electrolyzer A, at a, and enriching with magnesium the alloy therein, chlorine escaping at D at top and the alloy being pumped (pumps are indicated at C) up to, and passing through the inlet a^2 down through the electrolyzer A^2, wherein the magnesium, set free by electrolysis in the said electrolyzer, passes up to the top and can be removed, or be caused to pass off, by the action of the pumps, the alloy being continuously returned to the electrolyzer A, to be again enriched with magnesium from fresh charges of fused magnesium chloride and so on.

There are passages for the alloy, in staggered series, through the electrodes B and B^2. These passages are shewn as being constituted by small pipes b^5 passed through holes in the electrodes and extending up to the level of the surface of the alloy in the pockets b^2 and down to, or into, the alloy in the pocket below. The pockets in each electrode communicate with each other by passages b^2 also at a level with the surface of the alloy so that the alloy, in its course through the electrolyzers, maintains the pockets b^2 charged with alloy to the requisite level, the arrangement of the passages for the circulating alloy being such that it does not interfere with the ascending chlorine in the primary electrolyzer, or with the ascending magnesium in the other electrolyzer.

What I claim is:—

1. The method of effecting electrolysis of a light metal which comprises alloying the same with a heavy metal, decomposing the fused alloy simultaneously at electrolytic couples in electrical series below the surface of the fused electrolyte, and removing the light metal at the top of the melt.

2. The method of effecting electrolysis of a light metal which comprises alloying the same with a heavy metal, decomposing the fused alloy simultaneously at electrolytic couples in electrical series below the surface of the fused electrolyte, causing the disengaged light metal to rise through the several electrolytic couples to the top of the melt and there removing it.

3. The method of effecting electrolysis of a light metal which comprises alloying the same with a heavy metal, decomposing the fused alloy simultaneously at electrolytic couples in electrical series below the surface of the fused electrolyte, and discharging the light metal continuously as it rises to the top of the melt.

4. The method of effecting electrolysis of a light metal which comprises alloying the same with a heavy metal, decomposing the fused alloy simultaneously at electrolytic couples in electrical series below the surface of the fused electrolyte, and discharging the light metal continuously by overflow as it rises to the top of the melt.

5. The method of recovering a light metal which comprises alloying the same with heavy metal by multiple-couple electrolysis, and then decomposing the alloy by multiple-couple electrolysis to separate the light metal from the heavy metal.

6. The method of recovering a light metal which comprises alloying the same with a heavy metal by multiple-couple electrolysis, transferring the alloy to an independent electrolytic vessel and there decomposing the alloy by multiple-couple electrolysis and separating the light metal.

7. An electrolytic method which comprises passing electric current in series through a plurality of multiple-couple electrolytic cells, causing heavy and light metals to become alloyed in one cell, leading the alloy to a second cell and there decomposing the alloy for recovery of the light metal.

8. Apparatus for effecting electrolysis, comprising a plurality of multiple-couple

electrolytic cells, means for effecting a heavy metal light metal alloy in one cell, means for leading said alloy to a second cell, and means for effecting multiple-couple electrolysis of the alloy in the second cell to decompose the alloy for the recovery of the light metal.

9. An electrode for use in a multiple-couple electrolyzer, said electrode having a dished upper surface to form a container for electrolyte.

10. An electrode for use in a multiple-couple electrolyzer, said electrode having a dished upper surface to form a container for electrolyte, and being recessed to afford riser passage means to permit the upward flow of fluid therethrough.

11. An electrode for use in a multiple-couple electrolyzer, said electrode having a dished upper surface to form a container for electrolyte, and being recessed in the marginal area of the depression in the upper face of the electrode to afford riser passage means to permit the upward flow of fluid therethrough.

12. An electrode for use in a multiple-couple electrolyzer, said electrode having a dished upper surface to form a container for electrolyte, and being recessed to afford riser passage means to permit the upward flow of fluid therethrough, the lower face of said electrode being shaped to guide fluid to said riser passage means.

13. An electrode for use in a multiple-couple electrolyzer, said electrode comprising a plate-like member provided on its upper surface with a plurality of cup-like depressions to contain the electrolyte.

14. An electrode for use in a multiple-couple electrolyzer, said electrode comprising a plate-like member provided on its upper surface with a plurality of cup-like depressions to contain the electrolyte, and being pierced in the marginal areas of the several cups to afford riser passages for the upward flow of electrolytic products.

15. An electrode for use in a multiple-couple electrolyzer, said electrode comprising a plate-like member provided on its upper surface with a plurality of cup-like depressions to contain the electrolyte, and being pierced in the marginal areas of the several cups to afford riser passages for the upward flow of electrolytic products, the lower face of the electrode being shaped to guide upward flowing electrolytic products to said passages.

In testimony whereof I have signed my name to this specification.

EDGAR ARTHUR ASHCROFT.