

J. F. MONNOT.

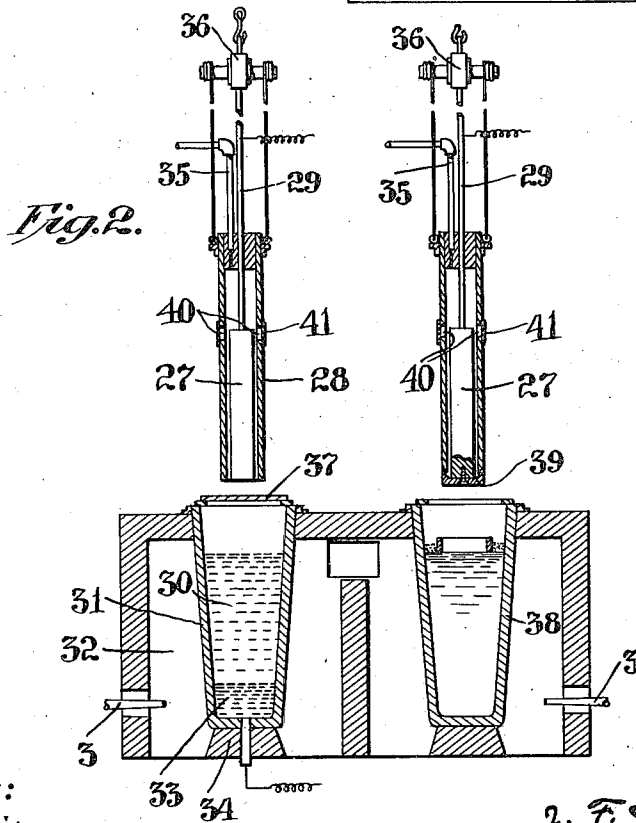
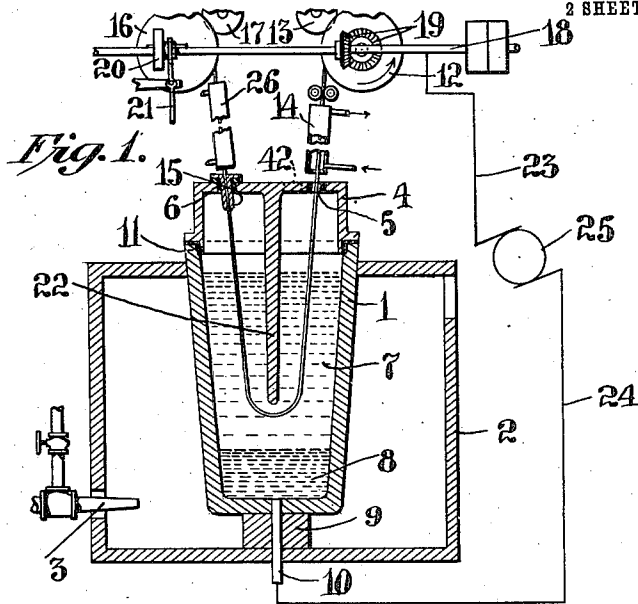
PROCESS OF AND APPARATUS FOR MAKING CLAD METALS.

APPLICATION FILED DEC. 23, 1908.

1,004,673.

Patented Oct. 3, 1911.

2 SHEETS—SHEET 1.



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2 SHEETS—SHEET 2.

Fig. 3.

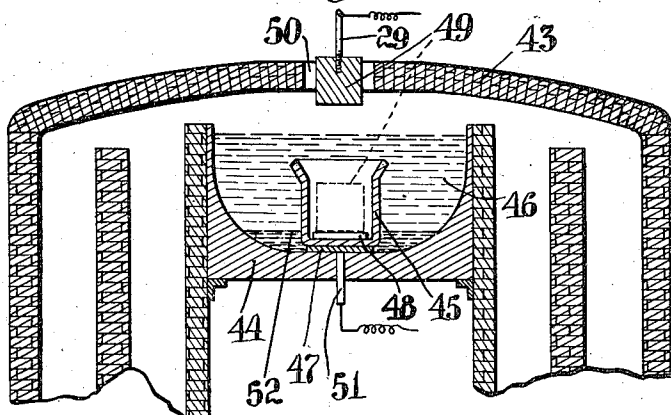


Fig. 4.

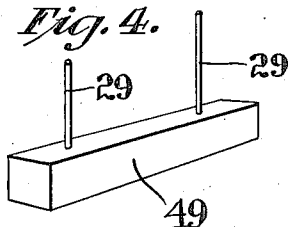
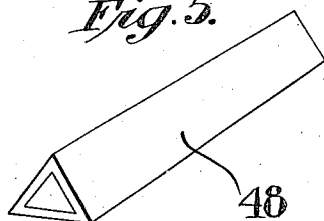


Fig. 5.



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UNITED STATES PATENT OFFICE.

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PROCESS OF AND APPARATUS FOR MAKING CLAD METALS.

1,004,673.

Specification of Letters Patent.

Patented Oct. 3, 1911.

Application filed December 23, 1908. Serial No. 469,016.

To all whom it may concern:

Be it known that I, JOHN F. MONNOT, a citizen of the United States, and a resident of the city of New York, county of New York, and State of New York, have invented certain new and useful Processes of and Apparatus for Making Clad Metals, of which the following is a specification.

This invention relates to processes of and apparatus for producing clad metals; and it comprises a process of producing clad metals wherein a core or base of ferrous or like metal is given a dense, cohering, impervious coating of an unlike, high-melting, ductile metal by electrodepositing said unlike metal thereon in a molten state; all as more fully hereinafter set forth and as claimed.

It is desirable for many purposes to secure coated metals having a base or core of a relatively stiff and strong metal, such as iron or steel, covered with a coating of one of the nobler metals, such as copper, silver, gold, brass, bronze, etc. In the prior art, these coated metals have generally been produced by electrodepositing the coating metal from an aqueous solution, as by galvanically depositing copper upon iron from a copper sulfate solution, silver from a cyanid solution, etc. Metals thrown down under these conditions, however, do not give satisfactory coatings for many purposes, being invariably crystalline, porous and of little real adhesion. In depositing copper from copper sulfate solution for instance, it comes down as a coating consisting of crystals with intercrystalline lines or interstices.

In the plating operation the tendency of course is for each succeeding molecule of copper to be thrown down on a preceding molecule rather than on the iron, and this tends to accumulate the copper in the form of crystals with spaces or interstices between them. The coating moreover, has but the weakest possible adhesion to the underlying metal and steel thus coated with copper will not stand working. In forming commercial electro-plated goods, it is therefore necessary to produce the finished articles and then electroplate. It is not possible to electroplate a large bar or billet of steel and then co-extend the metals to the desired shape and size. The porous copper coating has not sufficient adherence to the base to

withstand this operation, neither is it of physical character such as adapts it for extension. Nor is it usually practicable to put on a very thick coating of copper; coatings thick enough to permit great extension. The same objections apply to coatings of gold, silver, brass, and bronze, produced from aqueous solution. Aluminum cannot be electrodeposited from aqueous solution.

In the prior art there have been many attempts made to produce thick coated articles which would permit extension by simply casting a non-ferrous base metal against the base metal. These attempts however, have not been successful for the reason that there is a pronounced lack of affinity between iron or the ferrous metal on the one hand and the copper-like metals on the other hand, under ordinary casting conditions, so that merely casting the one against the other does not produce any union, even if both metals be clean-surfaced during the operation, something which is difficult to obtain under working conditions. This lack of affinity at the ordinary casting temperature of the non-ferrous metal, also obtains at lower temperatures, and it has therefore proved impracticable to produce any union between solid bodies of these metals. The ferrous and the non-ferrous metals are too unlike to permit of the production of any weld union between them in the manner in which weld unions may be effected between like metals, as for instance, iron and steel. I have, however, discovered that this lack of affinity between these two classes of metals which exists at comparatively low temperatures disappears at higher, and by the use of sundry expedients I can produce weld-like unions between these unrelated metals. For instance, if a non-ferrous metal be contacted with the ferrous metal in a highly heated molten condition, several hundred degrees above its ordinary melting or casting temperature, it readily "wets" the same and produces therewith a union which, after cooling the joined metals, closely resembles a weld union. The union between the metals thus joined resists discovery by the action of cleaving tools, such as a cold chisel, the action of violent temperature changes, as in heating and quenching, and the action of mechanical force. It therefore is, or is

equivalent to, a weld union. Methods of uniting these unlike metals resting upon this discovery, are described and claimed in my Patent No. 853,716. The coating metal may be applied in one or more operations. A clean steel billet may, for instance, be preliminarily filmed with a welded-on coating of copper by dipping into a superheated bath of molten copper, withdrawn and covered with a cohering (as distinguished from adhering) film of copper and subsequently have a further mass of copper cast thereagainst at a more convenient casting temperature. The copper of the second body will of course unite readily with the copper of the described film. The whole mass of copper coating may be applied as a single body of supermolten metal. In either operation it is not desirable that the contact of the steel with highly heated copper be long prolonged since this is apt to result in alloying and contamination, both of the steel and of the copper. In practicing the operation stated, the film may be of one metal and the second body of another. For instance a clean steel billet may be film-coated with copper and subsequently have silver, gold, brass, or bronze, cast thereagainst, these other metals uniting readily with copper at comparatively low temperatures.

In the present invention I have devised another method of producing a similar type of union between the ferrous metal and the non-ferrous metal.

In making copper clad steel, this method, briefly stated, comprises producing a clean metallic surface on the object to be coated and making it a cathode in a fused bath containing dissolved copper, a body of copper being preferably used as an anode. The temperature of the fused bath is kept above the melting point of copper so that the copper is separated in a coalescent liquid form. The steel object which may be a billet, bar or wire, being a cathode does not suffer oxidation in the bath and preserves its clean metallic surface, assuming such a surface if it have it not already, and having a current passing through it, is apparently in a different condition, chemically or physically, which allows the molten copper to wet it and unite with it in a way which is apparently not practicable with ordinary molten copper of the same temperature. Under these conditions, the copper thrown down by the electric current, instead of forming distinct crystals or spaced bodies of copper on the surface of the steel, as is apt to be the case in electro-deposition of solid copper from an aqueous bath, spreads over it and wets the surface of the steel, forming a union therewith which is the same as, or is equivalent to, the weld union produced by the more highly heated or "supermolten" copper of the described invention. Without

a special apparatus allowing the formation of a thick body of molten copper around the steel, it is not easy in this manner to produce the full thickness of the coating, since from a suspended steel cathode the molten copper beyond the quantity sufficient to form a film-like wetting coating would be apt to drip off. Such apparatus may of course easily be devised. Such a wetting coating is however, sufficient for many purposes and in any event, with the steel once film-coated further copper may be easily attached thereto.

In another application Sr. No. 391,674 filed Sept. 6, 1907, I have described and claimed a process of producing sound castings from copper and other metals which comprises casting the molten metal through a deep body of molten flux or wiping material, whereby the surface of the falling metal is wiped or washed and cleansed of all oxid and other impurities. In thus washing the molten metal, of course considerable oxid of copper dissolves. This flux or slag washing can be usefully employed in producing coated bodies of metal, since the metal thus cast is clean surfaced and well adapted for forming unions. Such a method with certain modifications, is well adapted for combination with the present method. As stated, the flux, which may be a slag, through which the copper is cast, dissolves considerable copper, which copper it readily yields under the influence of an electrolyzing current to any suitable cathode. If, therefore, a body of suitable ferrous metal be placed in a suitable mold contained in or submerged in a body of flux or slag, holding dissolved copper, and the current passed through it, using the billet as a cathode, the billet becomes coated with the described cohering weld film. Without removing the mold further copper can now be cast down through the layer of the flux or slag into contact with the filmed billet and will unite readily with the film thereon. As the copper descends through the deep layer of molten wiping material particles of oxid upon its surface are wiped or dissolved off, and serve to maintain the copper content of such flux or slag. If the billet, as is usually the case, is contained in a mold casing, upon pouring the copper for the cast on coating the slag is completely displaced and may be collected in any convenient manner and used for a further operation.

As will be seen, in the film coating operation, a portion of the copper dissolved in the flux is removed and precipitated upon the billet as the filmed layer of copper, impoverishing the bath to that extent. The copper content of the bath, however, is replenished in casting fluid copper through it, by solution of oxid, while in turn the flux by its solvent and wiping action cleans the

copper so cast and places it in a proper physical condition to unite at once in a true metallic union with the copper of the film coating.

Obviously, using the described process, apparatus of widely varied form may be employed. The mold may, for instance, be submerged in a body of molten flux containing copper, a billet therein filmed electrolytically and copper cast down through the flux into the mold. The necessary body of flux for submerging the molds may be contained on the hearth of an ordinary reverberatory furnace. Using a high silica slag or flux the hearth may be sand lined. Or a body of molten cupriferous flux or slag may be contained in a large crucible and a suitable mold casing containing the billet (suitable contacts being provided) may be submerged therein and after the filming, copper may be cast down into the mold through the flux. The flux in the mold displaced by the copper overflows into the outer crucible. The full amount of copper for the coating may be produced electrolytically, but in such case suitably shaped apparatus must be used adapted to maintain a layer of fluid copper. For instance, a two part casing may be employed, this casing being adapted to contain a deep body of melted flux and being divided by a low vertical wall, terminating below the surface of the flux, into two compartments. In the one compartment, which is a mold, the billet is suitably supported to give a space about it for the requisite layer of molten copper. In the other compartment is a body of molten copper. Upon now making the billet a cathode and the body of copper an anode, copper will be transferred from the anode to the cathode and, being molten when deposited, will fill the space about the billet. In all these operations the iron being a cathode, any oxid upon its surface will be reduced and a clean surface of iron automatically produced. It is always, however, well to sand blast and otherwise cleanse the billet before the operation, to remove cinder, and oxid in forms which are not readily reduced.

The fused bath containing dissolved copper may be any of a number of substances, its particular composition not mattering greatly. A suitable bath may be made of a mixture of silicate of soda, borax, and a little fluorspar in which is dissolved black oxid of copper, copper millscale, etc. Or it may be any of the ordinary silicate slags. Borax may be used; fluorspar and other fluorids may be employed. During the operation the bath should be maintained at a temperature somewhat above the melting point of copper, but it need not reach the described supermolten temperature of copper. A temperature of 2000° F. is suitable.

Within the vessel and surrounded by the flux is preferably placed a body of the coating metal, such body being, naturally, in a molten condition. This body of molten metal is made an anode. Contact therewith to form the electric circuit may be through the walls of the vessel, where this is made of graphite or other conductive material, or may be otherwise produced. The cathode is the billet, wire, bar or other body to be coated, and this cathode is dipped in, or otherwise contacted with, the molten body of flux containing dissolved copper. Under these conditions, upon passage of the current, copper deposits on the ferrous metal body, but the temperature of the bath being above the melting point of copper, the deposit is in the liquid form. The drops of copper so produced spread over and thoroughly wet the surface of the article, uniting therewith to form an intimate union of the character desired. A current of about 5 volts and 20 amperes per square foot of cathode surface is frequently suitable. If a steel billet or bar be so treated it may be removed from the flux bath as soon as the deposited copper has formed a continuous film therefrom and may then have any desired amount of copper cast against this filmed surface, either before cooling or after cooling and reheating in a mold. In reheating care should be taken to avoid oxidation of the filmed surfaces. By a suitable arrangement of the apparatus, as by placing the billet in a depression, the full amount of copper desired for the coating may be deposited thereon, but this is not ordinarily desirable. Where it is desired to secure a relatively thin coating of copper upon a wire, the wire may be simply passed through the molten flux bath, wherein it acts as a cathode, and the desired amount of copper directly attached thereto. On wires it is frequently not desirable to have more than a thin coating or more than such as will cohere in a liquid state. After thus coating, however, it is usually desirable to give the coated wire a further reducing pass by suitable mechanism to pack the coating and render it uniform. The wire before coating may be preliminarily heated in a lead bath or any other suitable way, as by passing through a hot tube, may thence be passed through a flux bath to clean it, thereafter through the described molten copper-containing bath to give it the coating, and then cooled a little and drawn through a die. Enough copper may be deposited very quickly by the above methods to permit several reductions. This process is also applicable to the coating of structural shapes, sheets, etc., first scaling either with steam or rotary burnishing scratch brushes, and then cleaning in the flux bath. The operation may be the same as with wire. The

process is in fact applicable to all purposes in which a thin coating is to be applied to a finished article, a structural shape, for example, or to something near a finished article.

In the case of wire rods, sheets, etc., the process may, as seen, be continuous, the metal to be coated being fed continuously through the coating bath. It may be guided by rollers which will also form means for carrying current to the material. The particular mechanism employed in the present process however is not very material.

Other high-melting ductile non-ferrous metals may be united to ferrous metals in the manner described. It is, however, somewhat troublesome so to apply gold and silver owing to the difficulty of securing baths of these two metals which will stand very high temperatures. With a bath of fluor-spar containing some calcium chlorid however, and an anode of silver or gold, enough metal will dissolve in a fused bath to permit deposition. The process is, however, more particularly applicable to copper. Aluminum may also be advantageously deposited in a similar manner, using a bath of fused fluorides or the like and replenishing the aluminum content by additions of bauxite or other form of alumina. More simply, a fused anode of aluminum may be employed. In the accompanying illustration I have shown more or less diagrammatically sundry apparatus of the many types adapted for use in the described process.

In said drawings: Figure 1 shows a central vertical section of apparatus adapted for use for coating wire and like flexible material. Fig. 2 shows a central vertical section of apparatus for coating billets and the like. Fig. 3 shows a central vertical section of apparatus for coating large billets, the same being supported horizontally. Fig. 4 shows a perspective elevation of a billet such as shown in Fig. 3. Fig. 5 shows a detail perspective view of one of the refractory-covered spacing pieces 48.

Referring first to Fig. 1, 1 designates a crucible, the main portion of which is contained within a furnace 2 provided with suitable heating means, for example, a liquid fuel burner 3. This crucible is provided with a cover 4 having in it suitable openings 5 and 6 for the entry and exit of the wire or the like to be coated. In the crucible is a body of molten flux 7 and beneath it a body of molten coating metal 8. The crucible is supposed to be constructed of some electrically conductive material, for example, homogenized or compacted graphite. This crucible I have shown supported upon a suitable pedestal 9 of graphite or the like and provided with an electric connection 10 whereby electric current may be passed through the crucible. The crucible

cover 4 is insulated electrically from the crucible itself by insulating material 11 adapted to withstand high temperatures; for example, mica insulation. The wire to be coated, which is supposed to be drawn from a suitable source, is passed between feeding rolls 12 and 13 through a heating tube 14 and through the orifice 5 of the cover into the body of flux, and then out through the sizing die 15 to carrying off rolls 16 and 17; the wire forming a loop within the crucible. I have indicated driving means for rolls 12 and 16, comprising a shaft 18 driving roll 12 by bevel gears 19, said shaft also carrying a friction roll 20 working against the face of roll 16 as a friction disk, so as to drive said roll, this friction roll 20 being movable toward or from the center of roll 16 by a suitable lever 21, so that the speed of drive of roll 16 may be regulated as necessary to preserve the loop of the wire in the crucible.

The crucible cover may be provided with a downward projection 22 which insures that a sufficient length of the wire shall remain immersed in the flux; any tightening of the wire due to contact with this projection being immediately observable to the operator, who will then regulate the rate of drive of roll 16 so as to maintain a loop of length sufficient to clear projection 22.

Suitable means are provided for connecting the wire to the electric circuit; for example, one conductor 23 of the circuit, may be electrically connected to shaft 18, the other conductor 24 being connected to the terminal 10 of pedestal 9. 25 designates a suitable electric generator.

The voltage of current used will ordinarily be low and the current density comparatively high. The current may, for example, be of five volts and of ten to twenty amperes per square foot of surface of metal within the flux. Through the pipe 14 a suitable heated gas, for example, hot producer gas, may be passed to initially heat the wire. In carrying out the process with this apparatus the wire, fed forward by rolls 12 and 13, and initially heated in tube 14, passes into the flux bath and there has deposited upon it molten copper which combines with the surface of the wire to form a coating, the thickness of this coating being determined by the sizing die 15 through which the wire passes immediately after emerging from the flux, being then fed off by rolls 16 and 17. After passing from the sizing die the wire may pass through a tube 26 containing cold producer gas or other non-oxidizing atmosphere to avoid oxidation of the heated film coating formed; the wire being cooled during its passage through this tube to below the temperature at which it is actively oxidized by air.

In the form of apparatus shown in Fig. 2, 130

a billet 27 contained within a suitable mold casing 28 and supported by a porter bar 29 is arranged to be lowered into a body of flux 30 contained within a crucible 31 in a furnace 32; this crucible having at its bottom a body of molten coating metal 33 and resting upon a pedestal 34 forming one terminal of an electric circuit; the porter bar 29 forming another terminal of this circuit as indicated.

10 The billet 27 may have been preheated, and to avoid oxidation of its surface prior to contact with the flux, the mold casing 28 may contain producer gas or like protective atmosphere supplied through a pipe 35, all as described in my Patent No. 853,716. 36 designates a suitable hoist by which the billet and the mold casing may be lowered or raised, together or separately, as desired.

The cover 37 of crucible 31 having been removed, the billet 27 is lowered from the casing into the flux 30, for a sufficient time to permit the deposition of the desired coating on the surface of the billet; such coating being electrodeposited, as previously described. The billet is then withdrawn into the mold casing 28, oxidation of the film coating being prevented by the non-oxidizing atmosphere in said mold casing, and the mold casing is then moved over another crucible 38 contained in furnace 32, which crucible contains molten coating metal, copper for example, this body of molten metal being at about ordinary casting temperature. A bottom plate 39 is applied to the mold casing and the casing with the coated billet within it is then lowered into the molten metal in crucible 38 until the openings 40 in the sides of the mold casing are submerged in the molten metal; a strip of suitable closing material 41 (asbestos paper or the like is a suitable material) which heretofore has covered said openings, being stripped off just before this portion of the casing passed into the crucible; the molten metal then fills the casing, forming a cast-on coating which unites with the film coating already formed on the billet 27.

Further quantities of copper or other coating metal may be supplied to the crucibles 31 and 38 from time to time, through the open tops of these crucibles; the metal supplied to crucible 31 may be copper mill-scale and the like (black oxid of copper) or may be copper filings, turnings, chips, etc.

55 The copper supplied to crucible 38, should preferably be melted and then supplied to the crucible in the molten condition.

In the form of apparatus shown in Fig. 1, the cover 4 may be provided with a charging opening 42, through which fresh quantities of coating metal may be supplied from time to time.

In the form of apparatus shown in Fig. 3, I have indicated a furnace 43 of the re-

verberatory type, adapted to be heated regeneratively or otherwise, as desired, and provided with a deep hearth 44 adapted to contain the mold 45 together with a body of flux or slag 46 sufficiently deep to completely submerge the mold. The mold 45 rests upon a pedestal 47 forming an electric terminal. Said mold is first placed on the hearth, being submerged in the flux, and being held down in any suitable manner, and within it are placed suitable spacing pieces 48 to support the billet the desired distance above the bottom of the mold. These spacing pieces may for example, be iron bars covered with fire clay or other suitable material to prevent them from acting as electric conductors, although it is not material if some electric current be transmitted through these spacing pieces to the billet to be coated, since the voltage of the current used is low and the area of contact of these spacing pieces with the billet is small.

The billet to be coated, 49, is lowered into the mold 45 through a suitable opening 50 in the roof of the furnace, and as it enters said crucible it displaces part of the flux previously within the mold; the flux so displaced flowing out into the main body of flux in the hearth of the furnace. The electric current passing from the terminal 51 through the mold and flux still within the mold, to the billet, causes deposition on the surface of the billet of molten copper or other coating metal, such copper being derived from the layer of molten metal 52 at the bottom of the hearth or from copper dissolved in the flux 46; and the entire desired coating may be formed in this manner or, and preferably, if a thin coating has been formed, molten copper is poured into the mold, through the opening 50 to fill the mold, the copper so cast uniting with the film coating already formed on the surface of the billet.

The hearth of the furnace may be a sand hearth, such as is well known in furnace practice, if the slag used be one high in silica; and thereby waste of electric current is avoided.

Since copper and like metals sometimes tend to deposit unevenly upon iron and steel, the article to be coated may be dipped in a solution of copper sulfate or other suitable salt, to give it a thin or "striking" coating of chemically-deposited metal, and then a further coating may be deposited in the flux bath, as above described.

What I claim is:—

1. The process of providing one metal with a cohering, dense, impervious coating of another metal which comprises making a high-melting metal body a cathode in a bath of fused electrolyte containing a dissolved ductile high-melting different metal, such

bath being maintained at a temperature above the normal melting point of such high-melting dissolved metal.

2. The process of providing ferrous metal with a cohering, dense, impervious coating of copper which comprises making a ferrous metal body a cathode in a bath of fused electrolyte containing dissolved copper, such bath being maintained at a temperature above the melting point of copper.

3. The process of providing ferrous metal with a cohering, dense, impervious coating of cupriferous metal which comprises making a ferrous metal body a cathode in a bath of fused electrolyte containing dissolved cupriferous metal, such bath being maintained at a temperature above the melting point of such cupriferous metal.

4. The process of providing ferrous metal with a cohering, dense, impervious coating of another metal which comprises placing the ferrous metal in a bath of fused electrolyte containing a dissolved ductile high-melting metal and maintained above the melting point of such metal, and passing a current until the ferrous metal becomes covered with a layer of such other metal in a fluid state.

5. The process of providing ferrous metal with a cohering, dense, impervious coating of copper, which comprises placing the ferrous metal in a bath of fused electrolyte containing copper and maintained above the melting point of copper, and passing a current till the ferrous metal becomes covered with a layer of copper.

6. The process of providing ferrous metal with a cohering, dense, impervious coating of another metal, which comprises film-coating such ferrous metal with a layer of high-melting ductile metal by electrodeposition from a bath of fused electrolyte containing such metal in a dissolved state, and casting a further quantity of fluid metal into contact with the film-coating so produced.

7. The process of providing ferrous metal with a cohering, dense, impervious coating of another metal which comprises making such ferrous metal a cathode in a bath of a fused electrolyte containing dissolved copper and producing a film coating of copper thereon and casting a further quantity of metal in contact with the filmed surface.

8. The process of providing ferrous metal with a cohering, dense, impervious coating of another metal which comprises making such ferrous metal a cathode in a bath of a fused electrolyte containing dissolved cupriferous metal and producing a film coating of copper thereon and casting a further quantity of metal in contact with the filmed surface.

9. The process of providing ferrous metal with a cohering, dense, impervious coating

of another metal which comprises making such ferrous metal a cathode in a bath of a fused electrolyte containing dissolved copper and producing a film coating of copper thereon and casting a further quantity of copper in contact with the filmed surface.

10. The process of providing ferrous metal with a cohering dense, impervious coating of another metal which comprises film-coating a ferrous metal with a layer of a high-melting ductile non-ferrous metal by electrolysis from a bath of fused electrolyte and casting fluid metal through such fused electrolyte into contact with the filmed surface.

11. The process of providing ferrous metal with a cohering, dense, impervious coating of another metal which comprises film-coating a ferrous metal with a layer of copper by electrolysis from a bath of fused electrolyte and casting fluid metal through such fused electrolyte into contact with the filmed surface.

12. The process of providing ferrous metal with a cohering, dense, impervious coating of another metal which comprises film-coating a ferrous metal with a layer of copper by electrolysis from a bath of fused electrolyte and casting fluid copper through such fused electrolyte into contact with the filmed surface.

13. The process of providing one metal with a cohering, dense, impervious coating of another metal, which comprises maintaining within a suitable receptacle, a body of molten coating metal and in contact with it, a body of fused electrolyte, immersing in such electrolyte the article to be coated, formed of a metal unlike the coating metal, and making it the cathode of an electric circuit, and passing an electric current through said electrolyte and cathode.

14. The process of providing one metal with a cohering, dense, impervious coating of another metal, which comprises maintaining within a suitable receptacle, a body of molten coating metal and in contact with it, a body of fused electrolyte, immersing in such electrolyte the article to be coated formed of a metal unlike the coating metal, and making it the cathode of an electric circuit, and passing an electric current through said electrolyte and cathode, thereby producing a film coating of the coating metal on said cathode, and then casting a further quantity of coating metal into contact with the filmed surface.

15. The process of providing one metal with a cohering, dense, impervious coating of another metal, which comprises maintaining within a suitable receptacle, a body of molten non-ferrous high-melting metal and in contact with it, a body of fused electrolyte, immersing in said electrolyte the article to be coated, formed from ferrous

metal, and making it the cathode of an electric circuit, and passing an electric current through said electrolyte and cathode.

16. The process of providing one metal with a cohering, dense, impervious coating of another metal, which comprises maintaining within a suitable receptacle, a body of molten non-ferrous high-melting metal and in contact with it, a body of fused electrolyte, immersing in such electrolyte the article to be coated formed from ferrous metal, and making it the cathode of an electric circuit, and passing an electric current through said electrolyte and cathode, thereby producing a film coating of the non-ferrous metal on said cathode, and then casting a further quantity of non-ferrous metal into contact with the filmed surface.

17. Apparatus for coating metal objects comprising a receptacle having within it a body of coating metal and in contact therewith, a body of fused electrolyte, means for feeding metal to be coated into the electrolyte, in said receptacle, and for withdrawing the metal to be coated from such electrolyte, and means for passing an electric current through such electrolyte to such article to be coated as a cathode.

18. The process of providing one metal with a cohering, dense, impervious coating of another metal which comprises immersing a high-melting metal body in a solution of a salt of an unlike metal and thereby producing a striking coating of the unlike metal, and then making such metal body a cathode in a bath of fused electrolyte containing a dissolved ductile high-melting different metal, such bath being maintained at a temperature above the melting point of such high-melting metal.

19. The process of providing ferrous metal with a cohering, dense, impervious coating of copper which comprises immersing a body of ferrous metal in a solution of copper sulfate or other suitable copper salt and thereby producing a striking coating of copper on the ferrous metal, and then making such ferrous metal body a cathode in a bath of fused electrolyte containing dissolved copper, such bath being maintained at a temperature above the melting point of copper.

20. The process of coating steel with copper which comprises making a steel object a cathode in a bath of fused cupriforous electrolyte maintained at a temperature above the melting point of copper till a film-coating of fused copper forms.

21. An improvement in the art of electroplating metals which consists in performing the operation of electrolysis at a temperature as great as the melting point of the metal deposited.

22. The herein described method of electroplating which consists in heating a metal-containing solution to the melting point of

the contained metal, and employing such solution so heated as the electrolyte in depositing the metal upon another metal introduced into the cell as a cathode.

23. The herein described method of copper plating which consists in dissolving a copper salt in a flux which may be maintained in liquid state at the melting point of copper, bringing such solution to the melting point of copper and carrying on the operation of electrolysis at such temperature.

24. The herein described improvement in the art of copper plating which consists in performing the operation of electrolysis at a temperature as great as the melting point of copper.

25. The herein described method of coating iron with copper which consists in electroplating the one metal upon the other from an electrolyte maintained in liquid state at the melting point of the metal to be deposited.

26. The herein described method of forming and uniting bodies of different metals which consists in electroplating a body of one metal with the other metal from an electrolyte maintained at the melting point of the metal so deposited and forming upon the electro-plated surface an additional body of the metal which forms the deposit.

27. The herein described method of forming and uniting bodies of different metals which consists in electroplating a body of the one metal with the other from an electrolyte maintained at the melting temperature of the deposited metal and casting upon the surface of such electro-plated body an additional body of metal.

28. The herein described method of electroplating copper which consists in dissolving a copper salt in borax, raised to a temperature as high as the melting point of copper and performing the operation of electrolysis at such temperature.

29. The process of coating a ferrous metal which comprises depositing a coating of a metal at one temperature, then depositing a second coating of the same metal at a different temperature, one of the deposits being produced in a fused electrolyte at the temperature of the melting point of the metal deposited.

30. The process of coating a ferrous metal which comprises depositing a coating of copper at one temperature then depositing a second coating of copper at a different temperature, one of the deposits being produced in a fused electrolyte at the temperature of melting copper.

31. The process of providing ferrous metal with a cohering, dense, impervious coating of another metal which comprises film-coating a ferrous metal with a layer of copper by electrolysis from a bath of fused

electrolyte in a deep layer, and casting fluid metal through such deep layer of fused electrolyte into contact with the filmed surface.

32. The process of providing ferrous
5 metal with a cohering, dense, impervious coating of another metal which comprises film-coating a ferrous metal with a layer of copper by electrolysis from a bath of fused electrolyte in a deep layer, and casting fluid

copper through such deep layer of fused 10 electrolyte into contact with the filmed surface.

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

JOHN F. MONNOT.

Witnesses:

H. M. MARBLE,

FRANK E. RAFFMAN.