J. F. MONNOT.

PROCESS OF MAKING COMPOUND METAL BODIES.

APPLICATION FILED FEB. 18, 1907. RENEWED MAY 5, 1910.

972,630.

Patented Oct. 11, 1910.

2 SHEETS—SHEET 1.

Fig. 1,

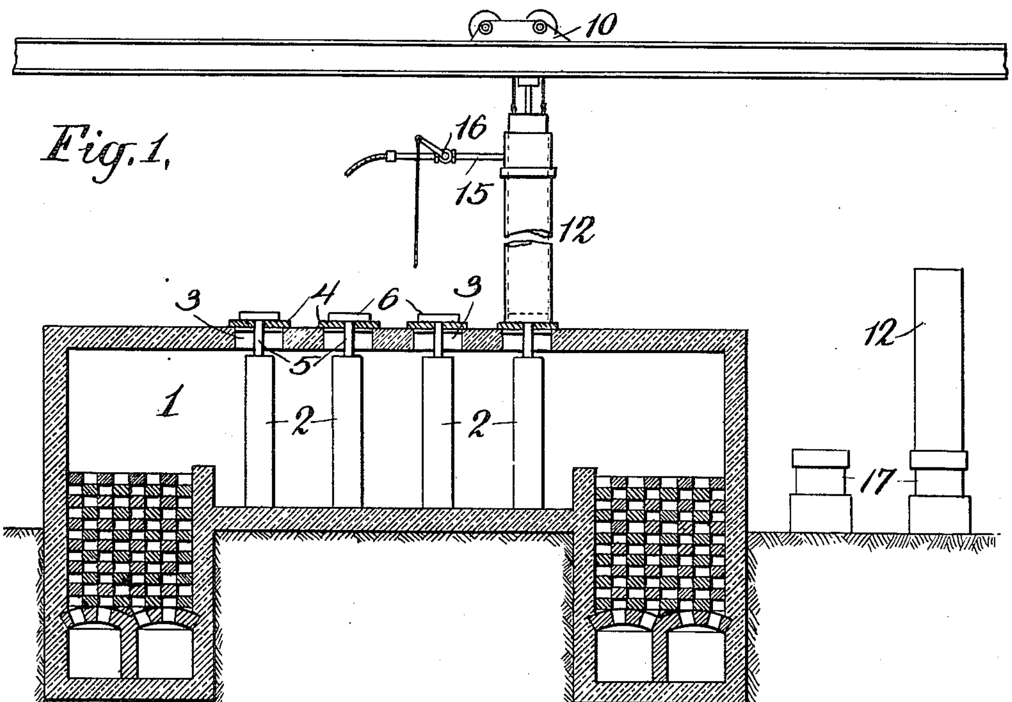


Fig. 2,

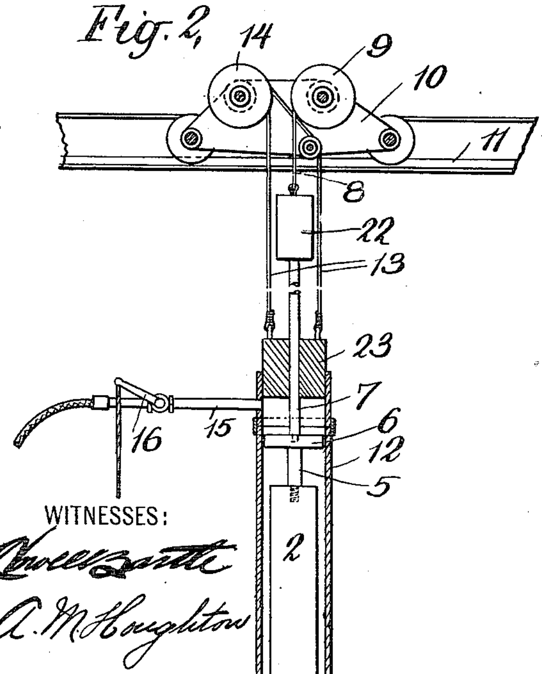
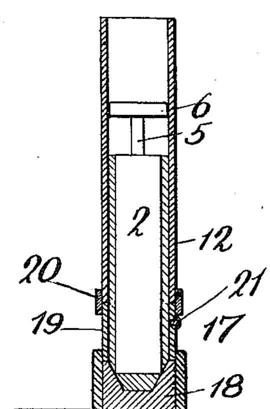


Fig. 3,



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2 SHEETS—SHEET 2.

Fig. 5,

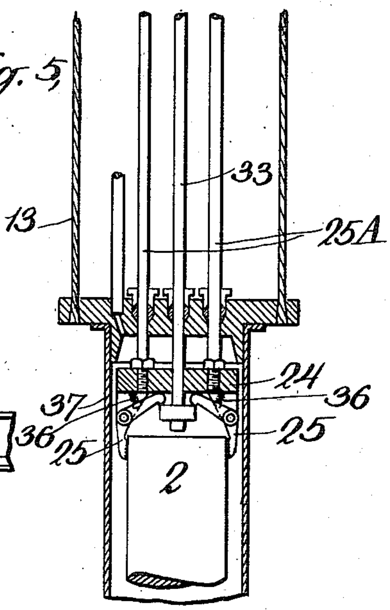


Fig. 4,

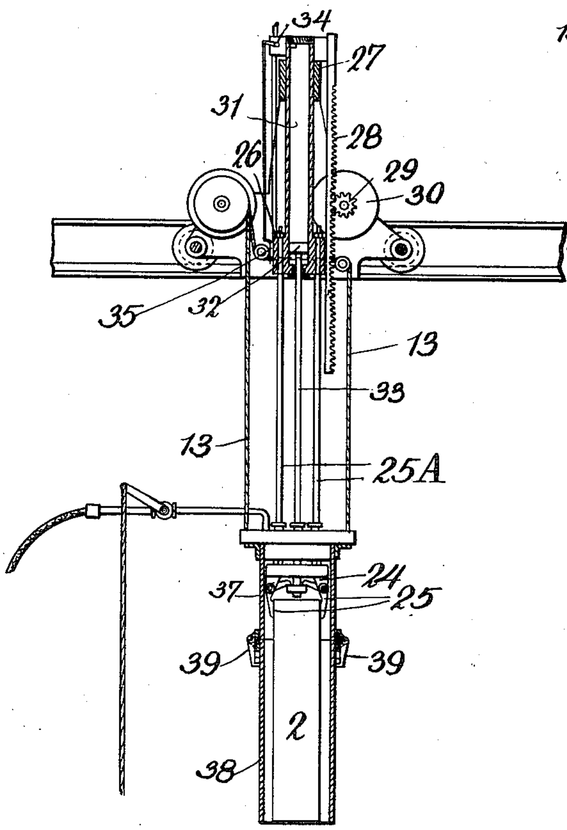
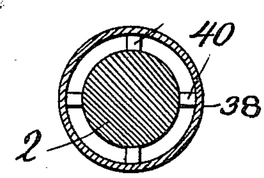


Fig. 6,



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PROCESS OF MAKING COMPOUND METAL BODIES.

972,630. Specification of Letters Patent. Patented Oct. 11, 1910.

Application filed February 18, 1907, Serial No. 358,007. Renewed May 5, 1910. Serial No. 559,483.

To all whom it may concern:

Be it known that I, John F. Monnot, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented a certain new and useful Process of Making Compound Metal Bodies; and I do hereby declare the following to be a full, clear, and exact description of the same, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to processes of making compound metal bodies and consists in a method of firmly and permanently welding together unlike metals to form compound metal articles, such unlike metals comprising on the one hand steel and ferrous metals, and similar iron-like metals such as cobalt, nickel and the like, and on the other hand the high melting non-ferrous malleable and ductile metals like copper, silver, gold, aluminum, platinum and the like; all as more fully hereinafter set forth and as claimed.

It is a matter of common knowledge that it is practically impossible to weld together ferrous metals of the class which have a pronounced affinity for carbon (for example, form carbids readily) with the unlike non-ferrous metals of high melting point of the copper and noble metal groups of metals having little or no affinity for carbon (for example, do not form carbids readily). For many purposes, however, ferrous metal bases coated with these relatively expensive, relatively inoxidizable metals are desirable and many attempts have been made in the prior art to produce them. It is quite a common expedient to attempt to make a union between these unlike metals by simply casting them together at the ordinary casting temperature of the non-ferrous metals, but such attempts have not been crowned with practical success, by reason of the lack of affinity existing between such ferrous metals and such non-ferrous metals at the ordinary casting temperature of the latter. Quasi-unions have frequently been produced in which the two unlike metals were, so to speak, merely stuck together, but not a union of the nature of a weld; a coherence as distinguished from an adherence. Such compound metal bodies therefore have always permitted ready separation of the joined metals by mechanical force, temperature changes and the like. A cold chisel or similar cutting tool readily finds and follows the line of junction, nor will such articles withstand heating and quenching in water. Co-extension of the joined metals by rolling, wire-drawing, hammering and the like have been frequently practiced to a certain degree; to an extent wherein the coating non-ferrous metal has still sufficient thickness to give it mechanical strength enough to support itself. In other words, taking copper on steel, a compound ingot made by the prior simple casting process would frequently permit of co-extension to a certain extent, the copper forming, so to speak, a tubular shell around the steel core. When the extension, however, went beyond this point and the copper became a mere film, of insufficient thickness and strength for its own support, it readily stripped from the wire. This defect has precluded the manufacture of relatively thin film-like coatings upon steel objects to form finished coated articles by relatively cheap large-scale processes and for such coated articles it is now the usual practice to coat each finished article separately by electrolytic or like process. Electrolytic coatings, however, when thin, readily exfoliate and at any thickness are porous, permitting ready permeation of dampness, gases or other corroding agencies to the underlying metal.

It is the purpose of the present invention to provide a simple cheap and ready method of forming dense, hard impermeable welded-on coatings of the less oxidizable metals upon the described ferrous and similar metals.

In other applications Sr. Nos. 281,680 and 333,570, I have described and claimed broadly, methods of forming welded-on coatings of the character described depending on the fact that the lack of affinity between ferrous and non-ferrous metals at the ordinary casting temperature of the latter, disappears when said non-ferrous metals are raised to a degree relatively high above their melting points, a temperature which I have called, for lack of other name, the "supermolten" condition. The stated non-ferrous metals when in the supermolten condition readily "wet" and combine with cleaned surface of ferrous metals, producing a firm, permanent and indestructible union between the two metals, and when the liquid metal solidifies forming a weld union which resists destruction or discovery by cutting tools, which cannot be broken by violent temperature changes and which does not rupture along the line of junction upon repeated flexure of the joined metals. It is, as will be seen, a union similar in all characteristics to that produced by a good weld between pieces of ferrous metals, and I therefore call it a weld union without necessarily committing myself to any theory as to its exact chemical or physical nature. It may be that the contact of the supermolten copper, for instance, produces a tenuous film-like alloy film of copper and steel upon the steel surface; it may be that the thinly fluid copper, which is so fluid at the supermolten temperature that it readily finds otherwise undiscoverable fissures and flaws in the steel, flows molecularly into the intra-molecular lacunae on the surface of the steel, producing, so to speak, a molecular interlocking such as probably occurs in ordinary welding; and many other plausible explanations are possible. But I content myself with noting the fact of the existence of the strong permanent union described without committing myself as to theories of its nature.

I have now discovered that a union of similar character may be produced in a different way. If a mass of copper or nonferrous metal of the kind described, be placed in an ingot mold of suitable shape, and a clean steel billet heated to what is called a "dripping" temperature (*i. e.*, the extreme white heat at which particles from the surface of the metal begin to drip down,) be contacted therewith, a similar union results, probably because the intensely heated steel raises the temperature of proximate layers of copper or the like to the necessary supermolten degree. It is of course necessary in this operation that the bulk of the coating metal, which is ordinarily of high heat conductive capacity, be not so great as to cool down the steel at the line or surface of union before the union can take place. However, the amount of coating metal (copper, for instance) required to produce coatings of the thickness ordinarily desired, is not sufficient, when confined in a suitable ingot mold, to diminish the temperature of the metals below the uniting point.

It is best to first clean preliminarily the core or billet to be coated (usually a bar or block of steel); which may be done advantageously by means of a sandblast or like mechanical means, followed, if desired, by pickling. The core or billet so prepared is then heated to the described temperature under circumstances precluding oxidation, and when so heated is transferred to the mold containing the coating metal, under circumstances precluding oxidation. But the preliminary cleaning is not necessary in all cases, because owing to the high temperature to which the billet or core is heated, the outer layer will be, or may be, melted off, thus carrying away the usual layer of scale or oxid on the surface of iron and steel, and exposing a clean metallic surface; and since the heating and transfer of the core to the coating metal are both conducted under circumstances precluding oxidation or other contamination, as hereafter described, the surface once clean cannot become contaminated again. The low heat conductivity of steel allows the surface to be raised to or nearly to a melting temperature before the interior becomes dangerously soft. With the surface at a dripping heat any scale or oxid which may be present drips off leaving a clean metallic surface and when this clean, dripping billet is raised into an atmosphere of producer gas, as it preferably is, it cannot become re-oxidized as its superficial temperature lowers, the producer gas indeed reducing any oxid which may form. When pickling is resorted to, as it may be at times nevertheless, it is best performed with an acid giving an iron compound readily volatilizable, such as hydrochloric or hydrofluoric acid. Pickling may of course be done electrolytically, the stated acids being generated on the core or billet to be cleaned used as an anode in an electrolyte of a suitable salt solution.

The highly heated core or billet having been transferred to the ingot mold containing the molten coating metal, is immersed in the molten metal and is carefully centered or otherwise located in its predetermined position in the mold, and the molten metal is allowed to solidify thereon. The conditions under which the operation is carried on are such that, knowing as I do that the coating metal is capable of reaching the so-called "supermolten condition" at a temperature lower than that of the core or billet when immersed in the molten metal, it is reasonable to suppose, and indeed is a practically inevitable conclusion, that the layer of molten metal in immediate contact with the said core or base upon first immersion, is raised almost instantly to the said supermolten condition and thereupon combines with the surface of said core or base by a union entirely analogous to that formed by surrounding a core or base with a mass of coating metal previously heated to such supermolten temperature, as described in my aforementioned applications.

While I am not limited to the use of any particular apparatus for carrying out my said process, in the accompanying drawings I have illustrated certain apparatus suitable and convenient for the purpose.

In said drawings: Figure 1 shows diagrammatically in sectional elevation a heating furnace for the cores or billets, with cores or billets therein, and also shows in elevation hoisting and conveying means and means for protecting the heated cores or billets from oxidation or other contamination while in transit and while being immersed in the coating metal. Fig. 2 shows a detail elevation and partial vertical section of one form of such hoisting, conveying and protecting apparatus. Fig. 3 shows a vertical section of the complete ingot mold with a core therein. Fig. 4 shows a detail elevation and partial section of an alternative form of hoisting and protecting apparatus; Fig. 5 a detail vertical section, on a larger scale, of the gripping mechanism thereof and of the protective casing, and Fig. 6 shows a detail transverse horizontal section through the lower part of such casing, indicating means for centering and guiding the upper end of the billet.

In said drawings, 1 indicates a suitable heating furnace and 2, 2 indicate cores or billets being heated therein. Said furnace has in its roof openings 3 normally closed by two-part covers 4. Each such billet has screwed into its upper end a short porter bar 5 provided with a guide and centering disk 6; and as indicated particularly in Fig. 2, each such disk is tapped from its upper side to permit a second and longer porter bar 7, forming part of the hoisting and conveying apparatus, to be screwed therein. Said porter bar 7 is weighted, for a reason hereinafter disclosed, and is suspended by means of a cable 8 from a suitable power hoist 9 mounted upon a wheeled truck 10 arranged to move upon a track 11. Surrounding this bar 7 is a casing 12 suspended by cables 13 from a hoist 14 mounted upon the same truck 10. This casing is open at the bottom, is adapted to receive through its bottom opening, and to contain, the billets 2, and is provided with means, such as a pipe 15 and valve 16, for supplying to it a non-oxidizing or indifferent atmosphere, such as producer gas made from charcoal and containing no marsh gas or other decomposable hydrocarbons.

The molten coating metal is contained within an ingot mold 17, such for example as shown in Fig. 3, adapted to receive the lower end of the casing 12, which latter then forms practically a continuation of the ingot mold. In the construction shown in Fig. 3, said ingot mold consists of a base 18 and cylindrical upper portion 19 of the same internal diameter as the casing 12, and a collar 20 adapted to receive the lower end of said casing 12 and make a tight joint therewith. There may be in the side of the cylindrical portion 19, just above the normal level of the molten metal, a gas-vent 21 which may be closed with a suitable clay or other plug just as the billet is lowered into the molten metal.

When one of the billets 2 has been heated in the furnace 1 to a suitable temperature, the hoisting and conveying apparatus is moved over it, the porter bar 7 lowered and screwed into the guide-disk 6, and then the casing 12, filled with the protective atmosphere as aforesaid, is lowered down to the two-part cover 4, the sections of said cover separated sufficiently to permit the billet to be raised, and then said billet is raised quickly into the casing 12, after which the sections of the cover 4 are replaced, the casing 12 is raised with the billet within it, and the whole conveying apparatus with the billet within the casing 12 is moved over the ingot mold 17, which has previously been filled with a quantity of molten coating metal, at suitable temperature, just sufficient to form the desired coating. In the case of copper or other coating metal which when molten is readily oxidizable, the molten metal is poled or treated with charcoal or a silicon compound to remove any trace of oxid, and its surface is then preferably covered with flux to exclude air.

The casing 12, with the ingot or billet 2 within it, having been brought directly over said ingot mold 17, said ingot mold and billet are lowered together until the lower end of said casing fits within collar 20 and makes a tight joint with the ingot mold, forming, in fact, an upward continuation thereof. The billet 2 is then lowered to the bottom of the ingot mold, the molten metal rising as it is displaced, and filling the casing 12 to the top of the billet or other desired level; the vent 21, if provided, being closed as this is done. The lower portion of the ingot mold is provided with suitable means for centering the lower end of the billet—for example, is made conical or tapering. The casing 12 is centered with respect to the ingot mold by the collar 20, and the upper end of the billet is centered within the casing 12 by the disk 6. Accurate centering of the billet with reference to the coating to be formed is thereby insured. That the extreme lower end of the coated billet will be tapering, owing to the taper of the lower portion of the mold interior is unimportant, as in the rolling to which the ingot is subsequently subjected the coating will be spread so as to give equal thickness of coating throughout.

The molten metal having solidified around the ingot or billet so introduced into it, the coated ingot is forced out of the casing 12, and the latter is ready for use again; the operation having meanwhile been repeated numerous times with other casings and other ingot molds,—the hoists 9 and 14 being readily detachable from the casings 12 and porter bars 7, as shown.

The function of weight 22 on porter bar 7 is to force the billet down into the molten coating metal in case, as may often happen, the metal of the billet is of less specific gravity than the molten coating metal. The casings 12 have weighted heads 23 for the same reason.

In Figs. 4, 5 and 6 I illustrate alternative means for raising and lowering the ingot or billet to be coated, whereby tapping of the said billet at the top to receive the short porter bar 5 is avoided. In this construction, I provide within the casing a chuck 24 having gripping jaws 25 adapted to grip and hold the billets 2. This chuck is supported by rods 25A passing through packed orifices in the head of the casing, (though packing around these rods is not strictly necessary, as some leakage of the protective atmosphere around these rods is not objectionable) and at the top are connected to a slide 26 mounted in guides 27 in the truck 10 and provided with means for raising and lowering it—for example, a rack-bar 28 engaging a pinion 29 on the shaft of a hoisting motor 30. The slide 26 is provided with a cylinder 31 and piston 32, the piston rod 33 of which projects through the head of casing 12 and is provided with a collar beneath and adapted to engage and operate the bell-crank gripping jaws 25. Valves 34 and 35 are provided for admitting fluid under pressure above and below the piston 32 at will, and for permitting exhaust, as is common in pneumatic and hydraulic and like fluid-pressure hoists. So long as piston 32 pulls upward, it keeps the jaws 25 in gripping contact with the billet, and prevents slipping of the latter from said jaws. If the pressure below the piston 32 be relieved, said jaws are no longer held closed, and the weight of the billet will cause them to release said billet; springs 36 being provided, if desired, to facilitate or hasten release of billet. Pressure above piston 32 will cause the rod 33 to engage the top of the billet and force the same out of the jaws 25, if necessary, or force the billet down into the molten metal in the ingot mold. In this construction, the casing is best formed of relatively separable sections, 37 and 38, as shown, normally held together by convenient latches 39, and the upper end of each section 38 is provided with centering lugs 40, as shown in Fig. 6; the intention being that when the billet is pushed clear down to the bottom of the ingot mold and the molten metal has risen around it, said molten metal will come just to the top of the billet and to said centering lugs 40, and just below the joint between the upper and lower sections 37 and 38 of casing 12.

It will be obvious that the process and apparatus herein described are applicable to the coating of billets or cores of any desired cross-section, whether round, square, elongated in one direction (rectangular, for example) or irregular shape; and likewise that the ingot mold may be of any desired cross-section. This process and apparatus are therefore particularly suitable for producing coated slabs, plates, etc. The coating metal not being heated to the supermolten temperature prior to the introduction of the article to be coated therein, is not so subject to oxidation, contamination or deterioration as is supermolten metal, and is not so likely to absorb or dissolve and become contaminated with the metal of the core or base coated; a matter of such moment when electrical conductors, for example, are to be produced.

The various coating metals which I particularly contemplate using, for example, copper, silver, gold, aluminum, copper alloys such as brass, bronze, aluminum bronze, etc., are all high melting ductile metals which can be worked with steel at steel working temperatures and all have melting temperatures above 500 C.; and it is desirable in most cases that the coating metal shall be one having a melting temperature above 900 F., since steel requires to be heated above such temperature for forging and hot-working generally. Hence such temperature forms a convenient means to distinguish such metals as I particularly contemplate using from metals of low melting point such as lead and tin which cannot be worked with steel at steel working temperatures. I have used the term "ferrous metal" to designate pure iron, iron (such as may be made, for example, by the Tropenas process), wrought iron, steel of various grades, including various compound steels, such as nickel steel, chrome steel, titanium steel, etc. The term "non-ferrous metals" designates the unlike metals, such as copper, silver, gold, platinum, aluminum, etc., to be used preferably as coating metals. The supermolten temperature of copper, as nearly as I have been able to determine it, is around and above 2500 F.; that of silver is in the same neighborhood; that of gold somewhat higher, and that of aluminum somewhat lower. The "dripping temperature" of iron or steel varies somewhat according to the amount of carbon in the steel and other well-known conditions, but is in every case, so far as I am aware, much above these supermolten temperatures.

What I claim is:—

1. The herein described process of weld-uniting unlike metals, which comprises heating a body of one such metal to a high white heat far above the melting temperature of the other metal under circumstances giving a clean metallic surface to said body, immersing said body so heated in a molten mass of the other such metal and causing such molten mass to solidify thereon.

2. The herein described process of weld-uniting unlike metals, which comprises heat-

ing a body of one such metal to a temperature above the supermolten temperature of the other metal under circumstances giving a clean metallic surface to said body, immersing said body so heated in a molten mass of the other such metal and causing such molten mass to solidify thereon.

3. The herein described process of weld-uniting ferrous metals and non-ferrous metals having melting temperatures above 900 F., which comprises heating a body of ferrous metal to a high white heat far above the melting temperature of such non-ferrous metal under circumstances giving a clean metallic surface to said body, immersing said body so heated in a molten mass of such non-ferrous metal and causing such molten mass to solidify thereon.

4. The herein described process of weld-uniting ferrous metals and non-ferrous metals having melting temperatures above 900 F., which comprises heating a body of ferrous metal to a temperature above the supermolten temperature of such non-ferrous metal under circumstances giving a clean metallic surface to said body, immersing said body so heated in a molten mass of such non-ferrous metal and causing such molten mass to solidify thereon.

5. The herein described process of weld-uniting ferrous metals and cupriferous metals having melting temperatures above 900 F., which comprises heating a body of ferrous metal to a temperature above the supermolten temperature of such cupriferous metal under circumstances giving a clean metallic surface to said body, immersing said body so heated in a molten mass of such cupriferous metal and causing such molten mass to solidify thereon.

6. The herein described process of weld-uniting ferrous metals and copper, which comprises heating a body of ferrous metal to a temperature above the supermolten temperature of copper under circumstances giving a clean metallic surface to said body, immersing said body so heated in a molten mass of copper and causing such molten mass to solidify thereon.

7. The herein described process of weld-uniting ferrous metals and non-ferrous metals having melting temperatures above 900 F., which comprises heating a body of ferrous metal to a high white heat under circumstances giving a clean metallic surface to said body, immersing said body so heated in a molten mass of such non-ferrous metal and causing such molten mass to solidify thereon.

8. The herein described process of weld-uniting ferrous metals and non-ferrous metals having melting temperatures above 900 F., which comprises heating a body of ferrous metal to a dripping heat and thereby removing oxid, preventing reoxidation, immersing said body so heated in a molten mass of such non-ferrous metal and causing such molten mass to solidify thereon.

9. The herein described process of weld-uniting ferrous metals and non-ferrous metals which consists in heating a body of ferrous metal to a high white heat far above the melting temperature of the non-ferrous metal under conditions precluding oxidation, transferring said body of ferrous metal so heated, while surrounded with a protective atmosphere, to a molten mass of such non-ferrous metal, and then immersing said body so heated in such molten mass and causing such mass to solidify thereon.

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

JOHN F. MONNOT.

Witnesses:

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H. M. MARBLE.