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J. F. MONNOT.

COMPOUND METAL BODY AND PROCESS OF PRODUCING SAME.

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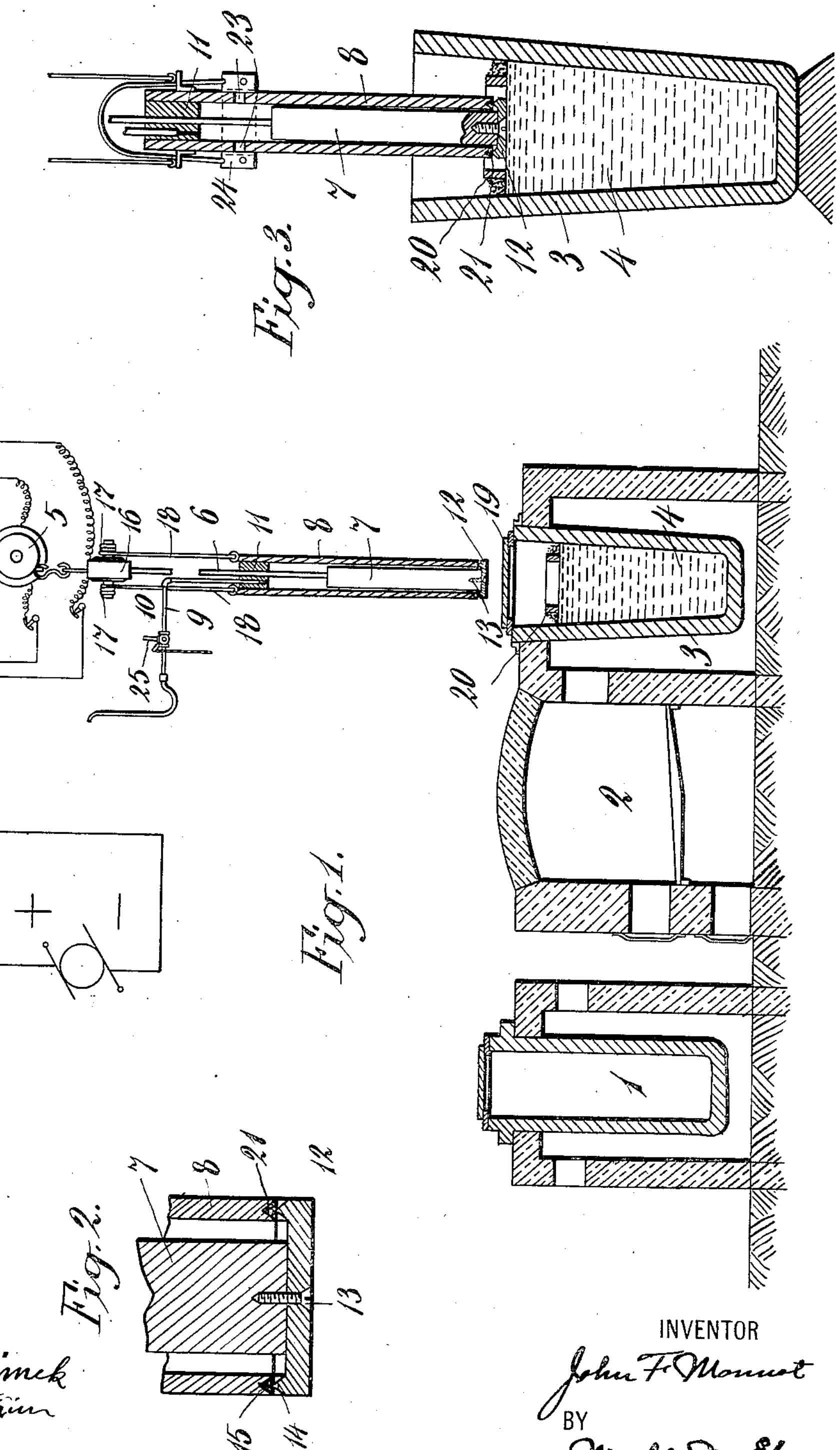

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COMPOUND METAL BODY AND PROCESS OF PRODUCING SAME.

No. 894,162. Specification of Letters Patent. Patented July 21, 1908.

Original application filed September 6, 1906, Serial No. 333,570. Divided and this application filed April 13, 1907. Serial No. 367,985.

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 certain new and useful Improvements in Compound Metal Bodies and Processes of Producing Same; 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 producing compound metal bodies and to a novel product, and consists in a method of uniting layers or strata of unlike metals, *i. e.*, metals or alloys of unlike chemical nature, whereby such metals and alloys are united as firmly and permanently as weld-united layers of iron or steel, for example; also in the product produced. The union between metals which are unlike in the above sense, produced according to the method herein described, is in all respects equivalent to the most perfect weld possible, insofar as the subsequent behavior of the united bodies of metal is concerned; for which reason, and because the term "weld" is the one which would most naturally be applied to such a union, by those skilled in the art, I term such union hereinafter a "weld", without intending thereby to limit or confine myself to any particular theory as to the actual nature of the union between the unlike metals.

By the method herein described it is possible to produce compound metal ingots, and also manufactured articles of compound metal, such as plates, sheets, rods, tubes, wire and the like.

It is well known that it is very difficult to unite, permanently, unlike metals; and particularly to unite a ferrous metal, such as wrought iron and the various steels, or metals like nickel and cobalt, with metals of a non-ferrous nature, such as copper, silver, gold, aluminum, etc. I have found, and it is a matter of common knowledge and experience, that iron and copper, iron and silver, iron and aluminum, and similar pairs of unlike metals, cannot be weld-united or equivalently united by casting the copper, silver, aluminum, etc. at the ordinary casting temperatures of such metals, against the surface of an iron or steel object to be coated.

The fundamental discovery upon which my new process rests is, that while unlike metals of high fusing temperature, such as those named above, do not weld readily or at all under ordinary conditions of metal working, nor by casting one of the metals at ordinary casting temperature against an unlike metal likewise of high casting temperature; yet if the metal so cast be heated, before casting, far above its melting point and ordinary casting temperature, and be cast at such abnormally high temperature, the lack of affinity between the metals observed at lower temperatures disappears, and the unlike metals contacted at such high temperature unite readily to form a union of an autogenous, permanent character equivalent to a true weld. Metals such as copper, silver and aluminum, at such a high temperature, are in a condition which for the sake of a name may be called a supermolten condition and display extraordinary chemical and physical activity, readily uniting with gases and other bodies, and also with wholly unlike metals, such as iron and the various grades of steel; and I believe that the same is true generally of other metals of relatively high melting temperature, such as gold, nickel, cobalt, etc. While the fact is as stated, I am unable to give a definite explanation of the phenomenon. Possibly it is due to disassociation of proximate molecules of the metals which still persist at and near the melting point.

It is commonly believed by physicists that ultimate molecules of most substances in the solid state are associated to form larger complex molecules—an association which persists to some extent after fusion, but steadily diminishes with increase of heat; and that the influence of heat upon chemical reactivity is due to this phenomenon. This peculiar increase of chemical reactivity of certain molten metals and concomitant heightening of their affinities for certain other metals, whether these affinities be molecular, atomic or physico-chemical, which occurs on raising their temperature much above the point where they become molten, if heretofore observed, has not to my knowledge been applied to the uniting of unlike metals of the classes herein contemplated; the sole attempt of experimenters in the field of uniting unlike metals by casting one such metal against the other having been to heat the metal to be cast to a point where it will remain liquid long enough to fill the mold completely, and, sometimes, to heat to or nearly to its melting point the metal against which the molten metal is cast. I am not, however, aware that any attempt has ever been made to produce temporarily between the contacting surfaces of the metals to be joined at the instant of casting the extremely high temperature utilized in the hereinafter described method.

Copper and steel may be taken as a pair of unlike metals affording a typical example. Copper, at its ordinary casting temperature, displays practically no affinity for the totally unlike metal, steel, hardly "wetting" it and forming no union with it which will withstand tools or heat changes, even if it be cast at such ordinary casting temperature against the surface of the steel and held there during solidification. The best union that can be formed in this manner, so far as known, is a mere adhesion or "sticking together" of the two metals, and not a true cohesion. The metals so united will separate subsequently during working or by the action of heat or shock, or can be separated readily by means of a tool. In a way, it may be said that the two metals behave as if their surfaces were merely fitted together and not really united. But if copper at the so-called "supermolten" temperature above referred to be contacted with the steel and held against the surface thereof during solidification, the temperature of the molten metal being allowed to fall as soon as true "wetting" is effected, a union is formed which is absolutely permanent and as strong as a true weld, the metals so joined being inseparable by change of temperature or by shock; and a cold chisel or like tool, applied along the line of juncture of the two metals, will not follow said line readily as it would if the metals were merely "stuck" together, but tends to dig into the one metal or the other. Nor will reheating the joined metals to a red heat and quenching in water result in separation of the metals. The union thus produced is equivalent to what, in the case of united bodies of steel and iron, is called a weld. As to the nature of the union thus produced, uncertainty exists; but it is known that when the process is properly carried out changes in the joined metals, if any, are confined to an excessively thin film between the proximate surfaces, the main portions of the bodies of joined metals possessing their ordinary properties. It may be that the union between the metals is a mere result of thorough "wetting" of the steel by the copper; a molecular contact and coherence between adjacent molecules of copper and steel similar to that which unites the molecules of copper and the molecules of steel each among themselves; or, again, it may be that the uniting layer is of a different composition from the joined metals and is an alloy of such metals, chemically or physically combined, a mixture, or solution. The existence of such an alloy film seems probable, because in the carrying out of the process certain evidences of slight solution of the iron in the copper, such as might naturally accompany an alloying inter-action, have been observed; but whether or not an alloy film is formed, and without restricting myself to the theory that any true alloy is formed, it is convenient to term the uniting layer between the joined metals, for the sake of a name, an "alloy film", and I use said term in this sense hereinafter.

Whatever the nature of the alloy film or uniting film, it is capable of indefinite extension since an ingot of two metals joined thereby may be extended to any desired extent, even to the thinnest sheets or wire, without the union failing, without the separation of the two metals, and without the development of flaws, pores or seams therein or therebetween, and even with substantial maintenance of the original relative proportions of the two metals; all of which shows that the original union between the two metals still persists in the coextended ware produced by working the ingot, even down to thin sheets and wire.

In the case of copper, the supermolten temperature appears to be from 2500° to 2800° Fahrenheit or higher. The supermolten temperature of silver is about the same; that of aluminum is somewhat lower. The temperatures named have not been determined with absolute accuracy, it being well known that it is difficult, if not impossible, to measure temperatures in the neighborhood of or exceeding 2000° F. with even approximate certainty and accuracy; but I have endeavored to determine these temperatures with the best pyrometers readily obtainable, and believe the figures given to be substantially correct. In practice, it is not necessary to know accurately the temperature of the supermolten metal, as it is easy to test the molten metal from time to time, as it is being heated up, by dipping therein a test piece of the metal to be coated, withdrawing it under circumstances precluding oxidation, and allowing the adhering film of molten metal, if any, to cool. When the molten metal forms on the article so dipped a coating which, when cold, possesses the qualities of the alloy film or welding film above recited, it is known that the supermolten temperature has been reached; but even then it is desirable to heat the metal somewhat hotter still, in order that there may be a margin of temperature available. In practice, the workmen engaged in carrying out the process become able to tell by the appearance of the molten metal when the proper supermolten temperature has been reached, without the necessity of testing continually.

The process herein described forms a specific modification of the process specifically claimed in my application Sr. No. 333,570 of which this is a division, upon which Patent No. 853,716, dated May 14, 1907, has issued and is described therein. As an illustration of the process claimed herein, I will describe the uniting of silver to steel. The difficulty, or even impossibility, of uniting steel and silver by a joint equivalent to a weld between two pieces of steel, by methods heretofore known, is well recognized. And I will suppose that it is a steel ingot which is to be coated with silver, and that all surfaces of the ingot are to be coated with a substantial thickness of silver, and then the coated ingot extended by rolling, hammering, or the like, to form sheets, rods, or other extended ware.

The surface of the steel ingot is first brought to an absolutely clean metallic surface by sandblasting or other suitable mechanical method of removing scale, oxid, and the like, and then customarily is pickled. In pickling I preferably use hydrochloric or hydrofluoric acid, as these acids form on the steel surface a non-oxygenated closely adhering protective coating of chlorid or fluorid, which volatilizes readily at a later stage in the operation, exposing an absolutely clean and fresh metallic surface to the supermolten metal. In pickling the steel may form an anode of an electric couple, when desired.

After pickling, it is best to heat the ingot preliminarily before contacting the same with the supermolten metal, to avoid abstraction of undue amounts of heat from the supermolten metal. One method of conducting this preliminary heating will be described hereafter, but others may be used. Customarily, I do not heat the ingot preliminarily above a red or low yellow heat. The heated ingot is then transferred to and immersed in a bath of supermolten silver, being protected from oxidation as hereinafter described, during the transfer. A few seconds contact of the supermolten metal with the heated ingot usually suffices for the silver to unite with the steel—the exact time depending somewhat upon how hot the steel was heated preliminarily; experience soon teaches the workmen how long the contact of the steel with the supermolten metal should continue. The surface of the steel ingot probably at once assumes the temperature of the supermolten copper. When the entire coating is to be formed from the metal of the supermolten bath, I then segregate from the main body of the supermolten metal a layer thereof, in contact with the surface of the ingot, of sufficient thickness to form the desired coating, according to the method described in my Patent 851,684, dated April 30th, 1907, and withdraw the ingot and segregated layer of molten metal and cause the latter to solidify on the surface of the ingot, under conditions affording pressure between the solidifying metal and the base or core. If the segregated or cast-on silver layer forms an annulus surrounding the core, the self-compression of the silver due to its contraction during solidification and cooling is ordinarily sufficient. And in an application for Letters Patent filed May 23, 1905, Sr. No. 261,739, I have illustrated and described means for applying positive pressure from an external source during solidification and cooling.

In the accompanying drawings I illustrate, rather diagrammatically, apparatus such as may be used in carrying out my process.

In said drawings:—Figure 1 represents a sectional view of one form of apparatus for carrying out the said process. Fig. 2 shows in detail section the construction of bottom plate and lower portion of casing preferably employed. Fig. 3 shows a sectional view of another form of casing which may be employed.

In Fig. 1, 1 is a preliminary heating chamber for the ingot or core, 2 a furnace for heating a crucible 3, containing a body of supermolten coating metal 4. 5 designates a power hoist, here shown as an electrical hoist, mounted on a suitable track so that it can be moved from place to place; and from said hoist is suspended, by means of a porter bar 6, the ingot 7, which is the object to be coated. Said ingot is shown surrounded by a casing 8 having an internal diameter slightly larger than the external diameter of the ingot, and to said casing is connected a pipe 9, a portion of which is flexible, said pipe provided with a three-way valve 10. This pipe and the valve 10 are provided for supplying to the casing, when desired, an atmosphere of indifferent or neutral gas, such as producer gas. Casing 8 has a weighted head 11 which insures that when the casing is lowered into the molten metal it shall sink therein to the desired depth. 12 designates a bottom plate for the casing arranged to be secured to the ingot 7 itself, by means of a screw 13. Said bottom plate is provided with a raised rib or ring 14 matching a corresponding groove 15, in the lower edge of the casing, and adapted to coact with said groove to make a tight joint. For raising and lowering the casing 8 with respect to the ingot 7, a special hoist 16, suspended like porter bar 6 from hoist 5, is provided. It has, in the form shown, two winding drums 17 upon which are wound cables 18 connected to opposite sides of the casing, so that said casing may be raised and lowered truly vertically.

I customarily provide the crucible with a loose removable cover 19, which cover is designed to exclude air from the molten metal so far as possible, and is removed only when and so long as necessary to lower an ingot and casing into the crucible, or to inspect the molten metal, or for similar reason. To further exclude air from the surface of the molten metal, I cover so much of its surface as possible with a layer of charcoal, a ring 20 of refractory material which floats on the surface of the molten metal serving to maintain a clear space in the center for the passage of the ingot and casing.

To assist in forming a tight joint between the bottom plate and casing, I provide in the groove 15 at the bottom of the casing packing material 21.

As an alternative to the above described apparatus for carrying out my process, I may use that shown in Fig. 3, which is much the same as that above described except that the casing 8 is provided with inlets 23 in its sides, said inlets arranged to be closed at will by a sliding shield or valve 24. In carrying out the process with this apparatus the casing without the bottom plate 12 thereon is placed over the heating chamber 1, said casing being at the time filled with a protective atmosphere as above described, and the porter bar is lowered down through the casing, secured to the ingot or core to be coated and raised up into said casing again with the said ingot or core. The casing with the core 7 within it, is then moved to one side, the bottom plate 12 applied, and then the casing is moved over the crucible 3 containing supermolten coating metal, and is lowered into said supermolten metal; the valve or closure 24 being raised as the openings 23 come to the surface of the molten metal so that said casing fills through said openings 23. The casing with ingot and molten metal within it is then raised and the molten metal allowed to cool as before. In carrying out the process in this, the protective atmosphere within the casing when the filling holes 23 are open, protects the surface of the ingot and the molten metal which enters the casing against oxidation; and in fact no air can enter the casing, because the holes 23 are submerged in the molten metal almost instantly after the closure 24 is raised, and during the possible brief instant while said openings are open but not completely submerged the outrush of gas from the casing will prevent the entrance of air.

To hasten the filling of the casing with molten metal, and to prevent trapping of gas in the molten metal as it solidifies, I preferably apply suction to the outlet 25 of valve 10, having first set said valve so as to cut off the entrance of gas and to place outlet 25 in communication with the interior of the casing. This is done, however, only after the molten metal has commenced to flow in. And when necessary or expedient, I reduce the fluid pressure upon the joint between the bottom plate and casing, while raising either the casing shown in Fig. 1 or the casing shown in Fig. 3, by applying suction to the outlet 25 of valve 10.

The coated ingot produced in either of the ways above described is usually worked, as by rolling (either at once, or after submission to a "soaking" heating to bring all the parts to a uniform temperature), to condense the metal of the coating and to extend it to shapes desirable for future working, such as bars, rods, and plates. In such extension the joined metals extend together without rupture of union between them and the final article usually contains the same relative proportion of coating and base as the finished ingot.

Instead of forming the coating of silver from the supermolten bath altogether, I may apply merely a film coat in said bath, withdrawing the ingot into the casing without dropping the latter, after said ingot has been exposed to the supermolten metal for a few seconds, and then transferring the casing with the ingot therein to another bath of molten metal and forming on the film-coated ingot a substantial coating of metal by segregation from such second bath or otherwise. This method of forming a coating by double-dipping is specifically claimed in my said application No. 333,570, of which this is a division.

The core or base or ingot coated as described in this specification need not be iron or steel, but for most purposes an iron or steel base or core will be preferred. Hence in certain of the following claims I specify steel as the metal of such core or base; and this term "steel" I employ generically to designate all forms of iron, including not merely ordinary carbon steel, both low-carbon or mild and high-carbon or hard, but also wrought iron (the properties of which are nearly identical with those of mild steel) and various compound steels, such as tungsten steel, titanium steel, vanadium steel, chrome steel, nickel steel, manganese steel, cobalt steel; also substantially pure iron—*i. e.*, the chemical element Fe, substantially free from carbon and other metalloids or impurities and modifying ingredients.

In any of the methods of uniting unlike metals above described, the excessively high temperature of the abutting layers of unlike metals exists only temporarily as the heat of the molten metal "soaks" into the steel core, while the heat of the molten metal is transferred outwardly by the cooling of the casing walls, and no opportunity is afforded for detrimental action upon either the main body of the steel or that of the molten metal. Such changes as take place, or may take place, in either metal, are only in the excessively thin joining layer between; and since, as already explained, I do not limit myself to any theory of how the union between the unlike metals takes place, therefore I do not assert positively, that when the operation is properly performed, any change of the two metals, or either of them, at the point of juncture, actually takes place. As previously explained, the time of contact of the steel and silver or other coating metal used, while such silver or other coating metal remains in the supermolten condition, is very brief, for long contact of the two metals with the silver or other coating metal in the very high reactive condition afforded by the supermolten temperature, would of course be detrimental to both. By limiting to a few seconds the period of contact of the metals while one of them is in the supermolten condition, I limit to extreme thinness the joining layer of alloyed, mixed, interpenetrating, or otherwise-united metals.

In an application filed June 19, 1908, Sr. No. 439,284, I have claimed compound or clad metal articles comprising a coating of copper, silver, gold, aluminum, and like metals, alloyed with ferrous metals, weld-united to ferrous metals, and a process of making such articles.

What I claim is:—

1. The process of producing compound bodies of unlike metals welded together which consists in contacting a surface of one such metal with a supermolten mass of an unlike metal and confining a portion of the metal from such supermolten mass, of substantial thickness, in contact with such surface and causing it to solidify thereon.

2. The process of producing compound bodies of unlike metals welded together which consists in contacting a surface of one such metal with a supermolten mass of an unlike metal, segregating from said mass of supermolten metal a substantial layer thereof immediately adjacent to such surface and withdrawing such segregated layer and the body against the surface of which it is confined and causing such segregated layer to solidify against such surface under conditions affording pressure between such solidifying layer and the surface against which it is cast.

3. The process of producing compound bodies of ferrous and non-ferrous metals welded together which consists in contacting the surface of a ferrous-metal object with a molten mass of a metal of the other such group having a melting point above 900 F., such second metal maintained at a temperature much above its melting temperature, confining a portion of such molten metal, of substantial thickness, in contact with such ferrous-metal surface, and causing it to solidify thereon.

4. The process of producing compound bodies of unlike metals welded together which consists in contacting the surface of a steel object with a supermolten mass of silver, and confining a body of molten silver of substantial thickness in contact with such surface and causing it to solidify thereon.

5. The process of producing compound bodies of unlike metals welded together which consists in contacting a surface of a steel object with a supermolten mass of silver and confining a portion of the metal from such supermolten mass, of substantial thickness, in contact with such surface and causing it to solidify thereon.

6. The process of producing compound bodies of unlike metals welded together which consists in contacting a surface of a steel object with a supermolten mass of silver, segregating from said mass a substantial layer thereof immediately adjacent to such surface and withdrawing such segregated layer and the steel object together and causing said segregated layer to solidify against said object under conditions affording pressure between such solidifying object and the steel object.

7. The process of producing compound bodies of unlike metals welded together which consists in contacting a surface of one such metal with a supermolten mass of an unlike metal and confining a portion of the metal from such supermolten mass, of substantial thickness, in contact with such surface, limiting the action of the supermolten metal on the solid metal by withdrawing such confined layer and the object against which the same is from the heating influence of the supermolten metal and causing such layer of molten metal to solidify.

8. The process of producing compound bodies of unlike metals inseparably united, which consists in contacting a surface of a steel body with a supermolten mass of silver, limiting to infinitesimal thickness the uniting layer thereby formed by limiting to a brief period the time of contact between the metals while one of them remains in the supermolten condition, and causing a layer of the silver to solidify on the steel surface.

9. As a new article of manufacture, a ferrous base having a welded-on poreless dense coating of silver united thereto by a union resisting temperature changes, cutting tools and mechanical stresses, said silver coating having the properties of metal set from a fluid state.

10. As a new article of manufacture, a ferrous metal having inseparably united thereto a poreless dense silver coating, said silver coating having the properties of metal set from a fluid state.

11. As a new article of manufacture, a ferrous metal having a coating of silver united thereto by a joining layer of the two metals

of infinitesimal thickness, said silver coating having the properties of metal set from a fluid state.

12. As a new article of manufacture, an extended metal article comprising a ferrous metal base and a continuous poreless, dense coating of silver weld-united thereto, by a union resisting temperature changes, cutting tools and mechanical stresses, said ferrous base and silver coating having been extended together.

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

JOHN F. MONNOT.

Witnesses:
J. F. KINDER,
H. M. MARBLE.