UNITED STATES PATENT OFFICE.

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CLAD METAL.

No. 927,372. Specification of Letters Patent. Patented July 6, 1909.

Application filed June 19, 1908. Serial No. 439,284.

To all whom it may concern:

Be it known that I, JOHN FERREOL MONNOT, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and valuable Improvements in Clad Metals; 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 clad metals; and comprises compound metal articles comprising a base of ferrous metal carrying a welded-on layer of a ferrous alloy of copper or like metal of high melting point permanently and indissolubly united thereto; all as more fully hereinafter set forth and as claimed.

In the prior art, many unsuccessful attempts have been made to provide the strong, stiff, cheap and malleable ferrous metals with surface coatings of copper, copper alloys and copperlike metals, such as silver and gold, by casting such coating metals in a molten state against the surface of the ferrous metal, or by casting the ferrous metal in a molten state against the non-ferrous metal, but by reason of the pronounced lack of affinity existing between iron and the iron-like metals on the one hand and copper and the copper-like metals on the other hand at the temperatures at which copper and like metals become liquid or plastic, and also because of failure to prevent oxidation of one or both of the metals, or to remove oxid formed, these attempts have failed to produce any permanent union, or the product has been so porous, filled with blowholes, and of uneven quality, as to be unmarketable. In coating ferrous metals, resort has generally, therefore, been had to electrolytic coating processes, but as electro-deposited metal is invariably porous, having intercrystalline spaces permitting access of corrosive vapors, gases and liquids to the underlying oxidizable ferrous metal, and has no more than a simple adhesion, as distinguished from a cohesion, to the base metal, electrocoated metals have not been found suitable for uses or situations where corrosion was likely. I have however discovered that this lack of affinity between iron and the iron-like metals, such as cobalt, nickel, etc., on the one hand and copper and the copper-like metals, such as silver and gold (and for the present purposes, aluminum may be here classed) and their alloys, which subsists at the common casting temperatures of copper, etc., and at the lower temperatures where copper is soft and plastic, disappears when these copperlike metals are raised to a temperature much above their melting points, allowing the production of good and permanent unions of a weldlike nature. At this elevated temperature, copper and like metals assume a peculiar condition which I have termed, for lack of another name, the "supermolten condition" in which they display much enhanced affinities, both chemical and physical.

Copper heated much above its melting point and contacted with a clean steel surface readily unites therewith to form a union which is in the nature of, if it be not actually, a weld-union. A layer of copper and a layer of steel so joined cannot be again separated by the action of cleaving tools, such as a cold chisel, the tool refusing to follow the line of union and veering off into the softer metal; nor can they be parted by even such a severe test as heating the joined metals to redness and quenching, or by destructive torsion. As to the nature of the union which subsists I cannot say, save that it appears to be in the nature of a weld-union such as can be produced between iron and iron or gold and gold. It may be that a tenuous layer of an alloy of the two metals occurs along the line of union; or it may be that the effect is merely due to some sort of molecular interlocking or interpenetration. Whatever the nature of this union, it is strong and permanent and permits almost indefinite coextension of the joined metals, with such ductile and malleable metals as copper and steel, in a direction parallel to the weld, as by drawing, rolling, spinning, stamping, etc., with substantial preservation of the initial ratio between the thicknesses of the layers of such metals. A three or four inch billet carrying a coating of, say 10 to 20 per cent. copper so joined may be rolled and drawn down to wire of hairlike thinness, or, say, to two or three thousandths of an inch in diameter without the copper coating perishing or exfoliating, and with substantial preservance of the initial ratio between copper and steel throughout the extension. In such extension, the relatively thin copper layer being compressed between the steel base to which it is welded (and by which it

is held against lateral movement) and the extending tool, assumes a peculiar condition of density and hardness throughout, comparable with the superficial condition of hard-drawn copper wire. The copper, having been attached in a liquid condition, shares in the property of liquids and set liquids of being poreless and dense; and, as stated, in coextension with the steel, it is still further compacted and hardened.

In a prior patent, No. 853,716, May 14, 1907, I have described and claimed a process of uniting iron and iron-like metals founded upon the properties of supermolten metals; and in application Serial No. 358,006, filed Feb. 18, 1907, and co-pending herewith, I have claimed copper-clad ferrous metal produced according to said process and having the described properties. In another co-pending application, Sr. No. 367,985, filed April 13, 1907, I have described and claimed a process of producing silver clad steel and the product thereof, while in copending application Serial No. 367,987, filed April 13, 1907, I have described and claimed gold-clad steel and the process of producing the same.

Similar products comprising ferrous and non-ferrous metals weld-united may be made by casting the ferrous metal, in a molten state, against the surface of the non-ferrous metal to be united thereto, according to the processes of my applications Sr. Nos. 343,033 and 438,396, in which processes adequate provision is made for preventing oxidation of the metals or either of them, or for removing any oxid which may form, or by the process of my application Sr. No. 358,007, wherein the ferrous metal highly heated, is immersed in the non-ferrous metal under conditions insuring an unoxidized surface, or by a process of W. M. Page, involving the action of heated vapors of metal like zinc or tin on the ferrous metal surface and the casting of molten copper-like coating metal against the surface so treated.

For many purposes, it is desirable to produce steel and ferrous metals clad with various alloys of low-melting metals, such as the cupriferous alloys like the various brasses and bronzes. As such low melting metals however do not well withstand the excessively high supermolten temperatures, which, in the case of copper, is 2400° to 2800° F., or higher, they are best attached by means of an expedient which consists in film-coating the steel base with a high-melting ductile metal, such as copper or silver, with which such alloys will readily unite or else film-coating said base by said Page process, and then casting the alloy against such filmed surface at a more convenient casting temperature. By this expedient, brass which is often two-thirds zinc, may be readily and easily united to steel though the boiling point of zinc is relatively low.

In another and copending application, Serial No. 368,770, filed April 17, 1907, I have claimed the described process and products thereof.

Though the ordinary brasses, that is, copper-zinc alloys, and bronzes (copper-tin or copper-tin-zinc alloys) may be so attached to ferrous metals and the produced clad metals used for many purposes, for certain other purposes they suffer from certain disadvantages and are lacking in certain advantages. Not all the brasses and bronzes will coextend, as by drawing or rolling, with steel at steel-working temperatures as indefinitely as will copper, silver or gold, many such alloys tending to crack or crumble after the extension has reached a certain stage. For articles which are to carry but thin or film-like coatings of simple brass or bronze, it is therefore frequently advisable to produce a preliminary coating of copper on the steel, carry the extension of the clad metal to, or nearly to, the stage desired and then produce the alloy in place, as more particularly described and claimed in my co-pending application Serial No. 438,680, filed June 15, 1908. There are however certain copper alloys of the nature of brass and bronze but distinguished therefrom by containing iron and other alloying metals which are more tenacious and possess better extending properties than ordinary brass or bronze; working well with steel at steel working temperatures and being capable of great coextension therewith when joined thereto in the stated manner. A small amount of iron in these alloys produces a great change in their properties in this regard. These alloys, which are generally called alloys of the "delta metal" or "sterro-metal" types, are, furthermore, highly desirable for a number of special purposes such as marine work since they unite high tensile strength, and in many cases, onsiderable hardness with good resistance against corrosion. Tobin bronze, for example, though containing but a tenth per cent. or so of iron, has a tensile strength of about 79,000 pounds while about as resistive to the action of sea-water as copper. A typical Tobin bronze will have about 59 per cent. copper, 38.40 per cent. zinc, 2.16 per cent. tin, 0.31 lead and 0.11 per cent. iron. A delta metal will carry about 60 per cent. copper or less, 34 to 44 per cent. zinc, 2 to 4 per cent. iron and 1 to 2 per cent. of tin. These ferrous copper alloys however for any special use must be of quite exact composition, such composition varying with the special use, and they cannot therefore be exposed to unduly high temperatures or kept heated for a long time, since the more oxidizable metals tend to burn out and change the composition. They must therefore commonly be made directly before use from exact quantities of the several ingredients. Slight va-

riations in the amount of iron change the character of these ferrous copper alloys materially. And for many purposes it is desirable to have such alloys reinforced by backings of the still stronger and stiffer ferrous metals—and the more so since such ferrous metals are commonly cheaper—provided the ferrous backing can be completely shielded and isolated by such alloy. In a ship plate, for instance, it is desirable to have the smooth, slightly frictional, non-corroding surface of Tobin bronze but it is not necessary, if a strong metal backing can be provided, that the thickness of the bronze layer be very great. On the other hand, it is desirable to have the strength and stiffness of steel if such steel can be thoroughly protected from corroding influences. In the present invention, such bodies of duplex or compound metal are provided. To this end, a steel or iron billet, ingot or other body is preliminarily produced carrying a welded-on coating of copper, silver, aluminum bronze or other metal capable of withstanding the very high supermolten temperatures. This coating may be produced according to the process described in my Patent 853,716, which, briefly stated, comprises producing a clean surface on the steel body and momentarily contacting it, as by dipping, with a mass of copper maintained in the supermolten condition. Upon withdrawal, the dipped billet will be found covered with a thin, cohering coating of copper having the described properties. The billet before and after dipping must be preserved against oxidation by suitable air-excluding means, as by the use of casings filled with producer gas or the use of protective coatings of flux. Against one or all surfaces of this filmed billet may now be cast the desired amount of the ferrous copper alloy. While such alloy at the common casting temperature will not cohere directly with and to steel, and moreover when contacted with steel in a molten condition is likely to take up more than the exact amount of iron desired in its composition, it will cohere readily to the copper of the filmed surface and cannot, of course, take up iron therefrom. After casting the alloy against such filmed surface, the compound metal article may be allowed to cool and may then be reheated and worked, or it may be directly worked while still retaining the heat due to the operation. The alloy may be, and preferably is, made directly before the operation by melting the copper, adding thereto the desired amount of the other ingredients and applying while still molten.

In a clad metal body according to the present invention, the steel core or base may be of any of the usual grades or varieties of steel or iron, or any of the various "alloy steels," such as nickel steel, cobalt steel, manganese steel, chrome steel, vanadium steel, etc., etc.; the linking metal may be copper or a high melting alloy thereof; and the coating may be any of the binary or ternary alloys of copper and iron, such as sterro or delta metal, Tobin bronze, manganese bronze, etc., or ferrous alloys of silver, gold, aluminum etc. The linking metal and the alloy having been attached as liquids possess the poreless characteristics of liquids and set liquids, and the coating of the steel is therefore poreless, dense and impervious to corrosive agencies, the steel being thoroughly shielded against corrosion thereby. In the coextension of the joined metals, the coating is still further compacted and hardened, as described.

For many purposes, the original billet, bar or plate of steel or other ferrous metal may be filmed with the linking metal, the full amount of the alloy coating cast against the filmed surface and the compound body produced then directly worked down to the finished form by drawing, rolling, spinning, or hammering. Or, if desired, the original large billet, etc., may be film-coated and worked to smaller dimensions prior to attaching the alloy-coating, such coating attached and the compound body then reduced to the final dimensions.

In the clad metal body produced, before or after working, the line of union between the joined metals cannot be discovered by cleaving tools, such as a cold chisel, nor can such metals be parted by heating and quenching or by torsion to rupture.

Some of the alloys of copper, silver, gold, aluminum, etc., with iron, containing small amounts of iron, particularly the binary alloys, may be directly attached to steel by heating to a supermolten temperature, since they will withstand such a temperature, provided the contacting be but momentary since otherwise more iron will dissolve, disturbing the exactitude of their composition, but ordinarily it is better to attach even such alloys through the intermediacy of a linking coat of copper previously welded to the iron, thereby precluding the possibility of solution of more iron in such alloy. Such alloys, also, are best made just prior to the coating operation by dissolving the correct amount of iron (best nearly carbon-free) in the molten copper or copperlike metal. Instead of producing such unions by the "supermolten" method, they may be produced by the methods of my said applications Sr. Nos. 343,033, 438,396 and 358,007.

A method of producing weld-unions set forth in an application for Letters Patent Serial No. 443,298, filed July 13, 1908, comprising the casting of the metals to be united on opposite sides of a metallic separator under conditions precluding oxidation or with provision of means for removing oxid which may have formed, as for example, by use of molten wiping material and so causing both

metals to unite to said separator, is a substantial equivalent for the methods hereinbefore referred to.

What I claim is:—

1. A clad metal article comprising a base of ferrous metal carrying a welded-on, dense, impervious, continuous layer of an alloy comprising iron and copper or copper-like metal; said metal base and said layer being united by a firm, permanent cohering union resisting cleaving tools, temperature changes and mechanical stresses; and said alloy being of regulated composition.

2. A clad metal article comprising a base of ferrous metal carrying a welded-on, dense, impervious, continuous layer of an alloy comprising copper and iron and united thereto through the intermediacy of a high-melting, ductile non-ferrous metal welded to the metals on either side; said metal base and said layer being united by a firm, permanent, cohering union resisting cleaving tools, temperature changes and mechanical stresses.

3. A clad metal article comprising a base of ferrous metal carrying a welded-on dense, impervious, continuous layer for an alloy comprising copper and iron through the intermediacy of copper welded to the metals on either side; said metal base and said layer being united by a firm, permanent, cohering union resisting cleaving tools, temperature changes and mechanical stresses.

4. A clad metal article comprising a base of ferrous metal carrying a welded-on, dense, impervious, continuous layer of a ternary alloy comprising copper, iron and another and low-melting metal through the intermediacy of a high-melting ductile non-ferrous metal welded to the metals on either side; said metal base and said layer being united by a firm, permanent, cohering union resisting cleaving tools, temperature changes and mechanical stresses.

5. A clad metal article comprising a base of ferrous metal carrying a welded-on, dense, impervious, continuous layer of a ternary alloy comprising copper, iron and another and low-melting metal through the intermediacy of copper welded to the metals on either side; said metal base and said layer being united by a firm, permanent, cohering union resisting cleaving tools, temperature changes and mechanical stresses.

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

JOHN F. MONNOT.

Witnesses:
H. M. MARBLE,
FRANK E. RAFFMAN.