

UNITED STATES PATENT OFFICE.

JOHN F. MONNOT, OF NEW YORK, N. Y., ASSIGNOR TO DUPLEX METALS COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

COPPER-CLAD IRON AND STEEL.

No. 893,932.

Specification of Letters Patent.

Patented July 21, 1908.

Original application filed October 6, 1905, Serial No. 281,680. Divided and this application filed February 18, 1907. Serial No. 358,006.

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 Copper-Clad Iron and Steel; 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 consists in compound bodies of ferrous metals and copper permanently and indissolubly welded together, the said copper generally being in the form of a thin layer or stratum of dense, non-porous, impermeable characteristics, welded to and carried by the ferrous metal and relying upon it for support; all as more fully hereinafter set forth and as claimed.

High-melting malleable non-ferrous metals and non-ferrous alloys of the copper and noble metals groups, or such high melting metals as have little or no affinity for carbon (for example, do not readily form carbids), do not readily unite together with the unlike ferrous metals, (or the metals forming carbids), in a union analogous to a weld-union; and despite the many attempts heretofore made in the art, such a union has not been considered practicable by those skilled in the art. As a rule it is considered that only like metals will weld together, and ferrous metals and the stated non-ferrous metals are too unlike, it has been believed, for a true weld-union. This I have discovered is erroneous, and by the use of proper methods, unions which are, or are closely analogous to, welds, may be readily produced between bodies of ferrous metals on the one hand and such unlike metals as copper, silver, gold, aluminum, the various cupriferous alloys such as commercial gold and silver, brasses, bronzes, and the like. These non-ferrous metals are all malleable and of comparatively high melting point, viz., above 900° F., and therefore when united with steel the compound body formed may be worked at near the ordinary steel working temperatures, thereby rendering it possible to unite the steel and non-ferrous metal in the form of a billet and co-extend them in any manner desired, as by drawing, rolling and the like, to form fin-

ished articles. This operation offers many advantages in point of cost and simplicity, and further produces hardened, compacted, dense, non-porous and impermeable coatings of the coating metals. The two unlike metals being perfectly welded, such co-extension is feasible to any degree desired without separation and in the finished article the coating metal may be in as thin a film as is desired. With a weld union subsisting between the two metals, the coating metal can rely on the ferrous metal for support and it is not necessary as heretofore in this art with less perfectly united metals, to have the coating metal as a layer of sufficient thickness to sustain itself by its own strength.

The metal of the extended coating is in a somewhat different condition from the same metal extended as a single body, being proportionately much harder and denser than such metal. In ordinary cold-drawn or cold-rolled copper, for example, only a relatively thin exterior layer is hardened, the interior portion of the metal being as soft, or nearly as soft, as before. This is because, in extending a single metal, practically all the hardening action of the rolls or dies is confined to exterior layers; interior layers, removed from the action of the tool, acting, so to speak, as a cushion, so that the hardening does not extend inwards very far and so that such interior layers are practically speaking, not hardened at all; but in the case of the co-extended clad metals herein described, the interior ferrous metal, being relatively hard as compared with the metals employed as coatings, and the coatings being relatively thin, in coextension the softer metal undergoes compression between the harder and stiffer core metal and the rolls or dies with an effect much the same as if it had been compressed from the inside as well as from the outside, so that, when the coating is not too thick, the rolling or drawing hardens the layer of coating metal nearly uniformly throughout. The layer is in mass what the ordinary hard-drawn metal is in its superficial layers. Moreover, in clad metals of the character here described the coating is considerably strengthened and hardened by its molecular union or coherence with the base metal, the latter acting as a stiff and strong backing supporting it at all points; and particularly so when the coextension has been carried so

far as to make the coating filmiform. The thin coating of even such a soft metal as copper being welded at its base to the supporting steel and being too thin to permit lateral yielding, and being furthermore compacted and hardened by said drawing or rolling, behaves as if of relatively stiff, strong metal.

In the prior art ferrous metals have not been coated with a welded-on stratum of non-ferrous metal having these characteristics, and indeed most coated ferrous metals have been produced electrolytically. Electrolytic coatings, however, as of copper for instance, are not impermeable, pores or lines of separation always existing between the precipitated crystals, nor are they so united with the base as to stand coextension with it. For this reason electroplating is usually done in the finished article, each such article being separately treated. The cost of this is obvious. Many attempts have been made to produce cast-on coatings of copper and the like or steel, but these have been uniformly unsuccessful in attaining the desired type of union. Copper and like metals will not unite in a coherent union with ferrous and like metals at the ordinary casting temperature of the former; they will at most merely adhere with a union easily broken. Such coatings are, so to speak, merely stuck on, and they will stand no strain or stress, and though the joined metal in some cases can be co-extended to a limited degree, such coextension is not practicable beyond the point where the thickness of the coating metal is sufficient to sustain itself by its own strength, nor, core and sheath not being welded together so as to compel uniform coextension, do such coated metals extend together in such manner as to preserve their original ratio. Copper and steel, for instance, in a wire will be of different relative thicknesses in different places in such wire. I have, however, discovered that this lack of affinity between the ferrous metals on the one hand and the high melting non-ferrous metals on the other, which exists at the melting or ordinary casting temperature of the latter, vanishes when the non-ferrous metal is heated to a degree relatively high above its melting point. At temperatures several hundred degrees above their melting points and above the ordinary casting temperatures, the character of these metals undergoes a change and they now display a marked affinity, chemical or physical, for the ferrous metals and substantially pure, substantially homogeneous bodies of these metals may be readily united thereto. For lack of another name I have called this the "supermolten" condition. In the case of copper which melts at about 1920° F. the supermolten temperature is around and above 2550° F. That of silver is in the same neighborhood; that of aluminum somewhat lower, and that of gold

somewhat higher. In another application Sr. No. 281,680, of which this is a division, I claimed broadly a process of uniting these unlike metals founded on this phenomenon; said process being now broadly claimed in application Sr. No. 333,570 (Patent No. 853,716, May 14, 1907) and in the present application I claim certain products thereof.

Briefly stated, this process consists in momentarily contacting a cleaned steel ingot with a mass of supermolten copper or similar metal, thereby forming on its surface a firmly cohering film of such metal; this film cohering with a tenacity which renders it impossible to strip it with a cold chisel or similar cutting tool or to loosen it by expansion and contraction due to heat as by heating and quenching. To the copper-filmed surface so formed further copper may be united at the ordinary casting temperature, or sufficient copper may be taken directly from the bath of supermolten metal producing the film to make a coating of the thickness desired. In the case of such cupriferous alloys as brass and the various bronzes which will not stand heating to the supermolten temperature, the coating may nevertheless be formed in a similar way by the use of an expedient. The steel may be filmed with copper in the manner described and then brass or bronze at a convenient temperature may be cast against the so filmed surface. Copper being like in nature to the cupriferous alloys stated, union takes place between them without difficulty. Silver, gold and aluminum are applied in exactly the same manner as copper.

A compound billet with a ferrous metal core formed from any of these metals in the manner described will be found to have a union of the joined metals so intimate and perfect as to defy rupture by any change in temperature short of a fusing heat. A copper steel billet of this character may be heated red hot and dropped in a barrel of water without the slightest disturbance of union and the same is true of the other joined metals described. This is a test which no prior article in this art has ever withstood. It is only because the union between the metals is in the nature of, or analogous to, a true weld that my joined metals are enabled to withstand this extreme test. Metals merely stuck together, as in the prior art, will at once separate when subjected to the test. Furthermore, in such a billet on attempting to cut apart the joined metals with a cold chisel the tool absolutely refuses to follow the line of union, going off into the soft metal. Upon flexure to rupture of a thin piece of the joined metals, the break will take place either in the copper or the steel but not along their line of union. The bounding film-like layers between the abutting surfaces of the two metals appear to be

exceptionally strong, lending some support to the theory that there may be an extremely tenuous joining layer of a strong and tenacious alloy between the two metals, though to the eye the masses of copper and steel, having their ordinary appearance, seem to join directly. In prior articles made in this art a cold chisel readily finds the line of demarcation between the joined metals. A steel billet clad with three per cent of copper may be easily extended to the thinnest wire even to wire of hairlike thinness without separation of the two metals and with substantial preservation of the original ratio between them. In attempting to make wire of the articles of the prior art, co-extension was only possible so long as the copper remained in sufficient thickness to form a tube strong enough to sustain itself; it could not rely upon the steel core for support as does the welded-on three per cent. copper film of fine wire such as 39 gage wire, made from drawn-down bodies of the metal of the present invention. What is true of copper on steel is also true of the other non-ferrous metals stated when united to steel. These non-ferrous metals may also be united to metals of the iron-like group such as nickel, cobalt, etc., in the same manner.

Liquids and set liquids are devoid of pores and the non-ferrous metals being put on the ferrous base in a liquid condition, the coating is absolutely poreless. In the co-extension of the joined metals which is usually practiced, this coating is further compacted and hardened, such compacting and hardening taking place in the interior as well as in the exterior layers of the coating, as previously explained, and the underlying steel base is hermetically sealed from outside influences and cannot corrode or change. A copper-surfaced steel body therefore has at once the strength, stiffness and resilience of steel and the desirable surface of copper, combining the advantages of both metals.

Brass clad and bronze clad steel made according to said process are very advantageous for many purposes where the strength and cheapness of the ferrous metal and the appearance of the cupriferous alloy are required, as in the metal fixtures of trolley cars, bedsteads, telephone parts, scientific instruments and a myriad other uses. Such clad metals may have a minimum thickness of the relatively expensive coating metal and yet be of long life, the cupriferous alloy being hard and dense, and thoroughly supported by the underlying metal to which it is welded in a manner precluding exfoliation. Its compactness, homogeneity, continuity and freedom from pores, blowholes, etc. prevents moisture and gases penetrating to corrode the underlying steel and lift the coating in the manner familiar with electroplated ware. Such cupriferous alloys however must ordi-

narily be applied with an intermediate layer of a pure, heat-resisting metal such as copper or aluminum, preferably the former, though an aluminum-filmed steel surface is readily "wet" by cast-on brass or bronze and may be used to secure the desired weld-linking between the steel and the cupriferous alloys. Coin gold and silver, and baser alloys of the same metals of course contain copper and may be readily welded to a copper filmed surface if desired, though these cupriferous alloys will withstand heat sufficiently to permit a direct application in the supermolten state. Such cupriferous alloys as the brasses composed in various proportions of zinc and copper, and the bronzes, containing copper and tin in various proportions, as well as the ternary alloys of copper, zinc and tin, however, do not well withstand the supermolten temperature, the zinc or tin burning out. Aluminum bronze though less sensitive to the supermolten heat may also be advantageously applied with an intermediate linking film of copper or aluminum, as this permits working with the alloy at lower temperatures.

In another and co-pending application, Ser. No. 368,770, filed April 17, 1907, I have described and claimed methods of uniting cupriferous and other alloys to ferrous metals by means of a linking layer of a high-melting metal as well as metal bodies comprising metals so linked.

One important product which may be made by the methods described in my above mentioned applications and which embodies the invention of this case, consists of very pure iron or steel, containing practically no carbon or other metalloids, but coated with copper, aluminum, silver, gold, bronzes, or other coating metals. Such pure iron or steel may be produced by the Tropenas process, for example, by carrying the operation to the point of substantially complete elimination of the metalloids, and before the steel commences to burn, removing it from the converter. Such steel is very soft and ductile and malleable and has high electrical conductivity, but is extremely apt to take up oxygen and other impurities. By the methods of handling and heating which may be employed in carrying out the process in my said applications, I can handle ingots or cores of such pure metal without oxidation or other contamination thereof, such pure metal being sealed in against contamination and once the coating of copper or other metal is applied to such an ingot or core, the coating protects the pure core metal from oxidation etc. Because of the extreme ductility of this pure steel, the clad ingots made from it may be extended to the most extreme thinness, thus making practicable the use of such material for foil, tinsel, gold leaf, silver leaf, etc. In rolling out ingots or

billets of such joined metals into compound plate and cutting, stamping up or the like to form finished articles, the cutting of course exposes the underlying, sealed-in ferrous metal but such edge portions may be sealed in like the body of the article by a simple expedient. It is found that by cutting such a plate with cutters having a rather rounded edge in lieu of the usual sharply triangular one, the steel and the copper cut differently, the copper flowing a little before the tool and inclosing the edge. A sufficient union between the meeting edges of copper so brought into contact may be secured by the use of the usual burnishing and spinning tools. I have filed an application describing and claiming this method of covering the cut edges, such application being Sr. No. 303,916.

The relative ratio of the joined metals may be as desired, three per cent. being usually sufficient for copper clad steel for most purposes where the coextension is not carried too far. With brass clad and bronze clad steel this thickness is also usually sufficient.

By the term "non-ferrous metal," as used herein, I mean metal which is so unlike iron or steel in chemical and physical properties as not to be ordinarily considered an iron-like metal, and which does not readily unite with or weld to iron by ordinary methods; also alloys containing no iron, or at most but very small amounts and not exceeding 1 per cent. or so.

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.

In this application I claim only the product comprising ferrous metal and copper united as above described; copper being understood, as above explained, to be metal of

commercial grades, ranging from the pure metal through so-called "electrolytic" metal to metal not containing more than 1 per cent. or so of iron and like proportions of other impurities. In application filed Apr. 13, 1907, Sr. No. 367,985, I have claimed a product comprising silver united to ferrous metal as described; in application filed Apr. 13, 1907, Sr. No. 367,986, I have claimed a product comprising gold united to ferrous metal as described, with or without an intermediate metal; in application filed Apr. 23, 1907, Sr. No. 369,995, I have claimed a product comprising silver united to ferrous metal by an intermediate metal; in application filed Apr. 23, 1907, Sr. No. 369,997, I have claimed a product comprising a light-metal-group metal (aluminum for example) united to a ferrous metal with or without an intermediate metal; and in various other applications I have claimed other products comprising weld-united unlike metals.

What I claim is:—

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

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

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

JOHN F. MONNOT.

Witnesses:

ROGER H. LYON,
H. M. MARBLE.