J. F. MONNOT.

CLAD METAL AND PROCESS OF PRODUCING THE SAME.

APPLICATION FILED JULY 13, 1908.

929,687. Patented Aug. 3, 1909.

Fig. 1.

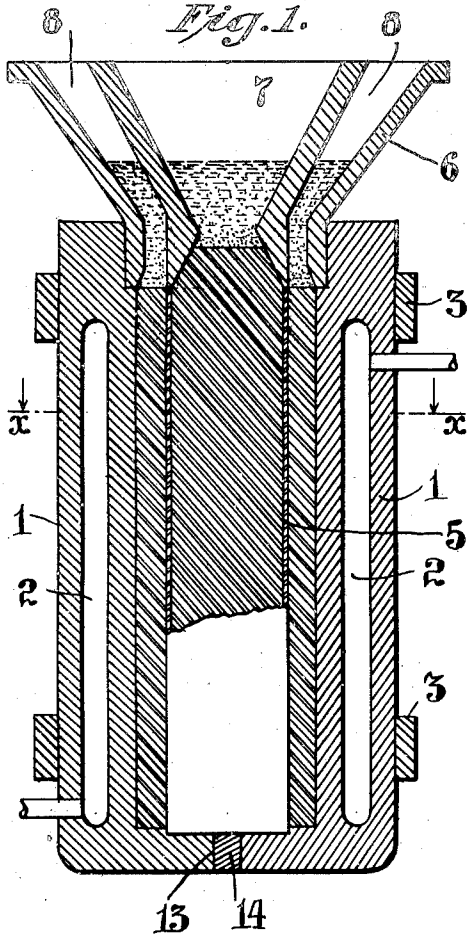


Fig. 2.

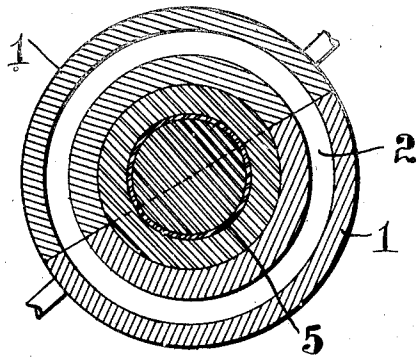


Fig. 4.

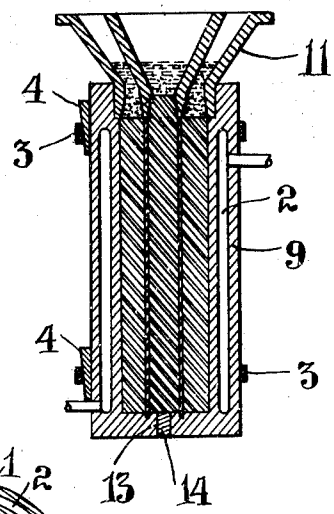


Fig. 3.

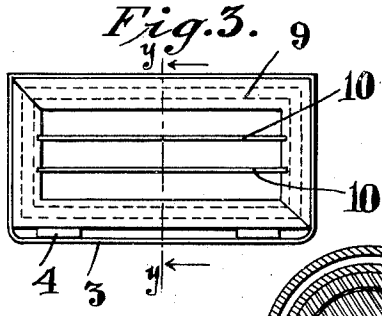
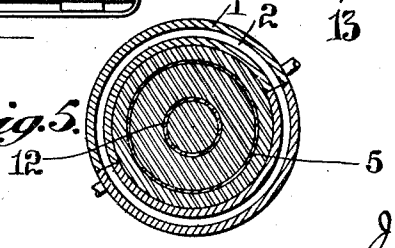


Fig. 5.



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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.

CLAD METAL AND PROCESS OF PRODUCING THE SAME.

No. 929,687. Specification of Letters Patent. Patented Aug. 3, 1909.

Application filed July 13, 1908. Serial No. 443,298.

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 Clad Metal and Process of Producing the 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 clad metals and processes of producing same, and comprises compound metal articles comprising a base of ferrous metal carrying a welded-on layer of an unlike metal permanently and indissolubly united thereto, and also a process of producing such clad metals, all as more fully hereinafter set forth and as claimed.

In various prior patents and patent applications I have set forth processes of uniting unlike metals, such as copper, silver, etc. to bodies of ferrous metal, involving the contacting of very highly heated molten copper, silver etc. with a perfectly clean surface of ferrous metal; and in applications Sr. Nos. 391,673 and 400,843 I have described processes involving the casting of the coating metal through a layer of molten "wiping material" and the contacting of the metal so cast with a clean surface of the ferrous base or with a film-coating previously formed on such surface by contact thereof with "supermolten" copper or like metal; the molten "wiping material" freeing the molten metal poured through it of entrained and occluded gases, oxid impurities, etc., and insuring tough, dense and homogeneous cast metal. In an application filed June 13, 1908, Sr.No. 438,396, I have described a process involving the casting of molten ferrous metal against the surface of a body of coating metal, the surface of such body being protected from oxidation by a layer of molten wiping material through which the ferrous metal is cast.

According to my present process, both the metal to form the coating, and the metal to form the core or base of the clad metal ingot or like object to be produced, are cast into the same mold through molten wiping material, the two metals being held apart by a suitable metal separator, with which both cast metals will unite inseparably, the metal of this separator being preferably, though not necessarily, substantially the same as one of the metals so cast; its surface being protected against oxidation, or cleaned of oxid prior to contact of the molten metal therewith, by a suitable layer of molten wiping material. The resulting clad metal ingot or other article will consist, therefore, of two layers of cast metal united to each other by being united to an intermediate substantial body of a metal which, even if identical in composition with one of the cast metals and weld-united thereto, will customarily be distinguishable from such cast metal upon microscopic examination, owing to differences of grain or structure, the result of prior working, which differences are readily discernible to skilled metallurgical microscopists. The two cast metals may be cast simultaneously or one after the other; and by preference the metal of lower melting point is cast last. Likewise in many cases means will be provided for cooling the mold rapidly once the metals have been cast; rapid cooling tending to improve the qualities of many metals, copper for instance. Heretofore this method of uniting unlike metals by casting them on opposite sides of a metallic separator has not been practicable, in the case of metals of high melting points or which oxidize readily and which are required to be capable of being worked after casting; for it has been impracticable heretofore to avoid excessive internal flaws, blow-holes, etc., in one or both of the metals so cast, or to avoid such oxidation of the surface of the separator as will prevent complete union of one or both metals thereto. But the invention of the process of casting the molten metal through a thick layer of wiping material, said wiping material either completely submerging the surface of solid metal to which the molten metal is to unite, or having marked oxid-dissolving power so that it progressively frees the surface of the solid metal of oxid just before contact of

the molten metal with such surface, has overcome this difficulty.

In the accompanying drawings I illustrate, more or less diagrammatically, the method of carrying out the said process, and apparatus such as may be employed in carrying out the process.

In said drawings—Figure 1 shows a central vertical section of a cylindrical mold, pouring tile, separator, and the cast metal bodies cast according to my said process; Fig. 2 shows a horizontal section on the line x—x of Fig. 1; Fig. 3 shows a top view of a mold for making rectangular ingots according to said process; Fig. 4 a central vertical section thereof on the line y—y of Fig. 3; and Fig. 5 shows a transverse section of a cylindrical mold indicating the use of a plurality of separators for casting the steel successively to avoid softness of the metal at the center.

Referring first to Figs. 1 and 2, 1 designates a circular two-part mold, provided with cooling means 2, which in the instance shown is a jacket through which cooling water, oil, etc. may be circulated; or compressed air or other suitable gas may be expanded in this jacket space for the purpose of absorbing heat. In the construction shown the mold is assumed to be of metal, iron molds being permissible in casting copper and like metals owing to the fact that, according to this process, the metal need not be at the "supermolten" temperature, or other very high temperature, when cast; it being common to cast copper ingots in iron molds. But in lieu of a metal mold, a mold of refractory material, for example, a mold of homogenized thermally conductive carbon, such as illustrated and described in my application Sr. No. 430,097, may be used Such iron molds, and also carbon molds such as referred to, have the advantages that they withstand high temperatures and sudden great changes of temperature well, and are not disintegrated by high temperatures or by the action of ingredients of the "wiping material" which may be used. If the copper or like metal were cast at "supermolten temperature" there might be some solvent action of the molten metal on the metal of an iron mold, though effective cooling of the mold by the means described would tend to prevent or greatly decrease such solvent action. At ordinary casting temperature copper has practically no action on iron. Suitable means, as for example bands 3 and wedges 4, are provided to prevent separation of the sections of the mold during the casting and until the cast metal has solidified. A sectional mold is employed, instead of the one-piece mold commonly used in casting ingots, simply because it is desirable in many cases that the ingot produced shall have no draft vertically; otherwise a one-piece mold would be used. 5 designates the separator, which in this case is a thin steel tube. At its lower end this separator seats in a recess in the bottom of the mold, as illustrated in Fig. 4. 6 is a suitable pouring tile or funnel, and may be of refractory material, such as fire clay, or carbon, or may be of metal. It is provided with a central space 7 for the introduction of the molten metal for the core and with side spaces 8 for the introduction of the molten coating metal.

In carrying out the process, the mold having been assembled, and the separator 5 put in place, molten wiping material is introduced both inside and outside the separator; or a fusible solid wiping material may be placed in the mold instead, as the first of the molten metal introduced will melt this solid wiping material. Borax, or a mixture of borax and sodium or potassium silicate, is a suitable wiping material. The pouring funnel 6 is put in place either before or after the addition of the wiping material, as preferred. The molten metals for the core or base and for the coating are then poured in; and in passing through the molten wiping material the molten metals are wiped or washed and freed of entrained and occluded gases, oxid impurities, etc. and the metal, when solidified, is free from blow-holes, blebs, etc. The molten wiping material may be introduced in such quantity as to completely submerge the separator, in which case it is not necessary that the wiping material shall contain much oxid-dissolving constituent; or, and preferably, the wiping material is used merely in such quantity that it will form a deep layer through which the molten metal passes, the wiping material then containing a considerable proportion of oxid-dissolving constituent, such as borax, which progressively cleans the surface of the separator as it rises. In general the molten steel will be poured in in such quantity that it will completely fill the interior of the separator and will rise somewhat into the funnel 6, the metal within the funnel solidifying last, owing to there being less cooling action at the top, particularly if the funnel is of material of low heat conductivity—fire clay or carbon, for example; the molten steel in the upper portion of the separator and in the funnel serving to fill up any "pipes" and the like formed in the solidification of the metal below, so insuring a good quality of the cast metal. The wiping material, being of low thermal conductivity, acts to delay somewhat the solidification of this upper layer of molten metal and thereby aids in obviating piping. The fluid pressure due to this additional height of metal also helps to insure sound dense metal free from piping and the like.

In a broad sense, it is immaterial which of the two metals is poured first, or whether both are poured simultaneously; but in general it is best to pour the steel first, and then to pour the copper or other coating metal (the casting temperature of which is much lower than that of the steel); the coating metal then helping to cool the steel. Soon after the coating metal is poured, in either case, cooling fluid or its equivalent will be passed through the cooling jacket of the mold, thereby hastening the solidification of the coating metal, preventing it from being heated, by conduction from the molten or partly solidified steel, to such extent that the molten coating metal will attack the mold, causing the coating to shrink on to the separator and so causing the separator to contract with the cast steel within it and preventing shrinking of the cast steel away from the separator before a complete union between the separator and cast steel has been formed, and insuring a good quality of coating; for as previously stated, copper and many other metals are improved in quality by being caused to solidify quickly.

As explained in my Patent No. 853,716, and in other patents and pending applications, copper cast at ordinary casting temperature against the surface of a solid relatively cool steel object does not form a weld-union with the steel, but does form such a union with the steel if contacted therewith at a higher or "supermolten" temperature. In the invention of the present case it is probable that the coating metal in immediate proximity to the separator is raised to supermolten condition by conduction of heat from the molten steel; for which reason it is unnecessary and inadvisable to cast the coating metal at supermolten temperature. The chilling of the mold as described prevents the outer layers of the coating metal reaching the supermolten condition.

It will be observed that since the cast coating metal contracts at the same time as the cast steel core or base, and the steel separator contracts with both, there is no tendency for separation of the one metal from the other; and owing to the temperature to which the separator and the layers of coating metal adjacent thereto are raised by the steel, complete union of both cast metals to the separator is insured.

In general the surfaces of the separator will be thoroughly cleaned, by sandblasting or otherwise, before said separator is introduced into the mold; but the deep layers of wiping material on both sides of the separator are capable of dissolving a considerable amount of oxid on the surfaces of the separator.

Much the same method may be used in producing rectangular ingots. Figs. 3 and 4 illustrate the formation of such ingots, coated on both sides. In these figures, 9 designates a suitable rectangular mold, and 10, 10 separator plates therein, and 11 a suitable pouring funnel or tile. In performing the process, molten steel or other suitable metal is poured, through molten wiping material, into the space between these separator plates, and molten coating metal into the spaces between these separator plates and the sides of the mold. The operations which take place are substantially the same as in the formation of round ingots as previously described.

It will be understood that the process above described is applicable for the making of a variety of ingots of different forms, either round, square, rectangular, hollow, or of other shapes; that in the case of a hollow object to be coated, the coating metal may be introduced on the inside instead of the outside; etc. The necessary modifications in the form and construction of molds, separators, etc. will readily suggest themselves to those skilled in the art. Likewise it will be understood that either in the apparatus shown in Figs. 1 and 2, or in the apparatus shown in Figs. 3 and 4, the copper or like metal of lower melting point may be cast on the inside of the separator or separators and the steel or other metal of higher melting point may be cast on the outside of the separator or separators.

In the union of high carbon steel and copper, some difficulty has been experienced owing to the tendency of the oxygen of the slight amount of copper oxid necessarily present in good copper to insure a good quality of metal, to combine with the carbon of the steel. This difficulty is overcome according to the present process because the separator itself may be of mild or low carbon steel, while the steel cast therein may be of high carbon steel. Low carbon steel unites readily to high carbon steel cast against it and copper containing a slight amount of copper oxid unites readily to low carbon steel.

I find it convenient in pouring the molten metals as herein described, to pour most but not quite all of the steel first, then to pour the copper and finally to pour the remainder of the steel; the steel last poured serving to fill any spaces left as a result of shrinkage etc., and to fill in any pipes that may have formed.

When casting very large steel cores or bases, in order to prevent the metal in the center from being less dense than at the outside, I may not only employ a separator to separate the steel from the copper, but may also employ a separator to separate the steel into two or more parts. This is illustrated in Fig. 5, in which 12 designates a second

separator. In such case molten steel is poured first into the space between separators 5 and 12, then the copper is poured and then steel is poured into the space within separator 12.

Preferably the ingots produced as above described, are rolled directly after being taken from the mold and without reheating, or at most only after being subjected to more or less soaking heat. This has the advantage that during rolling the steel core or base will be at a higher temperature than the copper coating, both because of the steel having had a higher temperature initially and because of the greater heat conductivity of copper. It is thus possible to roll the ingot with the steel core or base at a temperature close to or above the melting point of copper—a temperature at which the steel could not be rolled otherwise, and a temperature at which the steel is much softer than if the limit of the temperature were set by the temperature to which copper can be heated for rolling.

Before introducing the molten metals into the mold, I preferably heat the mold and separator or separators. To this end the mold may have in its bottom an opening 13 through which the flame from a suitable burner may be projected into the mold; this opening being closed by a suitable plug 14 of clay or the like before the molten metal is introduced.

In another application Serial No. 443,299, filed July 13, 1908 which I am about to file, I have described a process of forming compound bodies of like metals comprising the casting of molten metal through a deep layer of wiping material into contact with the surface of a solid body of like metal and the progressive cleansing of such surface by the action of the wiping material as it is displaced and rises, and in such application claim broadly the progressive cleansing of a surface against which molten metal is cast by the action of material displaced by the molten metal. Therefore I do not claim such invention broadly herein.

When the ingot mold employed is very thick, in proportion to the thickness of the bodies of molten metals, and is of thermally-conductive material, it will in general have in itself sufficient heat-storage and heat-abstracting capacity to render the use of special cooling means unnecessary; or instead of employing a cooling jacket the mold may in many cases be cooled sufficiently by flowing water or other cooling fluid against its outer surface.

In some cases the separator may be of a non-ferrous metal. For example, in the case of a copper steel article, the separator may be of copper. This may be especially desirable when electrical conductivity wire and the like is to be produced, the copper separator, although probably melted by the steel, preventing the wandering of portions of the steel into the main portion of the copper. Where the separator is of metal of lower melting point than the steel, in general the cooling of the ingot mold will have to be particularly efficient.

What I claim is:—

1. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of unlike metals into contact with opposite surfaces of a separator of material capable of weld-uniting with both the metals so cast, and progressively cleaning one or both said surfaces by the action thereon of a deeper layer of cleansing material progressively displaced by the molten metals so cast.

2. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of unlike metals into contact with opposite surfaces of a separator of material capable of weld-uniting with both the metals so cast, and progressively cleaning one or both said surfaces by the action thereon of a deep layer of molten flux containing oxid-dissolving material.

3. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of unlike metals into contact with opposite surfaces of a separator of material capable of weld-uniting with both of the metals so cast, one or both of the metals so cast being cast through a deep layer of wiping material in contact with the corresponding surface of said separator and comprising material having a cleansing action on said separator.

4. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of unlike metals into contact with opposite surfaces of a separator of material capable of weld-uniting with both of the metals so cast, one or both of the metals so cast being cast through a deep layer of molten inorganic wiping material in contact with the corresponding surface of said separator and comprising oxid-dissolving material.

5. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of unlike metals into contact with opposite surfaces of a separator of material capable of weld-uniting with both said metals so cast, one or both of said metals being cast through a deep layer of wiping material, and progressively cleaning one or both said surfaces of said separator by the action thereon of cleansing material progressively displaced by one or both of the molten metals so cast.

6. A process of producing clad metal ob-

jects comprising unlike metals weld-united, which comprises casting molten bodies of unlike metals into contact with opposite surfaces of a separator of material capable of weld-uniting with both said metals so cast, one or both of said metals being cast through a deep layer of wiping material, and progressively cleaning one or both said surfaces of said separator by the action of a deep layer of molten flux containing oxid-dissolving material.

7. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of ferrous and non-ferrous metals into contact with opposite surfaces of a ferrous metal separator, and progressively cleaning one or both said surfaces by the action thereon of a deep layer of cleansing material progressively displaced by the molten metals so cast.

8. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of ferrous and non-ferrous metals into contact with opposite surfaces of a ferrous metal separator, and progressively cleaning one or both said surfaces by the action thereon of a deep layer of molten flux containing oxid-dissolving material.

9. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of ferrous and non-ferrous metals into contact with opposite surfaces of a ferrous metal separator, one or both of the metals so cast being cast through a deep layer of wiping material in contact with the corresponding surface of said separator, said wiping material comprising material having a cleansing action on said separator.

10. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of ferrous and non-ferrous metals into contact with opposite surfaces of a ferrous metal separator, one or both of the metals so cast being cast through a deep layer of molten inorganic wiping material in contact with the corresponding surface of said separator, said wiping material comprising oxid-dissolving material.

11. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of ferrous and non-ferrous metals into contact with opposite surfaces of a ferrous metal separator, and progressively cleaning one or both said surfaces of said separator by the action thereon of fusible mineral cleansing material progressively displaced by one or both of the molten metals so cast.

12. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of ferrous and non-ferrous metals into contact with opposite surfaces of a ferrous metal separator, and progressively cleaning one or both said surfaces of said separator by the action of a deep layer of molten flux containing oxid-dissolving material.

13. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of steel and copper into contact with opposite surfaces of a steel separator, and progressively cleaning one or both said surfaces by the action thereon of a deep layer of cleansing material progressively displaced by the molten metals so cast.

14. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of steel and copper into contact with opposite surfaces of a steel separator, and progressively cleaning one or both said surfaces by the action thereon of a deep layer of molten flux containing oxid-dissolving material.

15. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of steel and copper into contact with opposite surfaces of a steel separator, one or both of the metals so cast being cast through a deep layer of wiping material in contact with the corresponding surface of said separator and comprising material having a cleansing action on said separator.

16. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of steel and copper into contact with opposite surfaces of a steel separator, one or both of the metals so cast being cast through a deep layer of molten inorganic wiping material in contact with the corresponding surface of said separator, and comprising oxid-dissolving material.

17. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of steel and copper into contact with opposite surfaces of a steel separator, and progressively cleaning one or both said surfaces of said separator by the action thereon of fusible mineral cleansing material progressively displaced by one or both of the molten metals so cast.

18. A process of producing clad metal objects comprising unlike metals weld-united, which comprises casting molten bodies of steel and copper into contact with opposite surfaces of a steel separator, and progressively cleaning one or both said surfaces of said separator by the action of a deep layer of molten flux containing oxid-dissolving material.

19. A process of producing clad metal ob-

jects comprising unlike metals of different melting points weld-united, which comprises casting molten bodies of said unlike metals on opposite sides of a separator of material capable of weld-uniting with both metals so cast and abstracting heat from the metal of lower melting point, and thereby maintaining the temperature of a portion thereof below the temperature of the other metal.

20. A process of producing clad metal objects comprising unlike metals of different melting points weld-united, which comprises casting molten bodies of said unlike metals on opposite sides of a separator of material capable of weld-uniting with both metals so cast, the metal of lower melting point being also cast against a heat-abstracting body, and by the action of said heat-abstracting body maintaining the temperature of the portion of the molten metal adjacent thereto materially below the temperature of the other metal.

21. A process of producing clad metal objects comprising unlike metals of different melting points weld-united, which comprises casting molten bodies of said unlike metals on opposite sides of a separator of material capable of weld-uniting with both metals so cast, the metal of lower melting point being also cast against the surface of a jacketed mold, and passing cooling medium into the jacket of said mold and thereby maintaining the temperature of the portion of the molten metal adjacent to said mold materially below the temperature of the other metal.

22. A process of producing clad metal objects comprising ferrous metal and non-ferrous metal of lower melting point than said ferrous metal, which comprises casting molten bodies of said ferrous and non-ferrous metals on opposite sides of a separator of material capable of weld-uniting to both, and abstracting heat from the non-ferrous metal and thereby maintaining the temperature of a portion thereof below the temperature of the ferrous metal.

23. A process of producing clad metal objects comprising ferrous metal and non-ferrous metal of lower melting point than said ferrous metal, which comprises casting molten bodies of said ferrous and non-ferrous metals on opposite sides of a separator of material capable of weld-uniting to both, the non-ferrous metal being also cast against a heat-abstracting body, and by the action of said heat-abstracting body maintaining the temperature of the portion of the molten metal adjacent thereto materially below the temperature of the ferrous metal.

24. A process of producing clad metal objects comprising ferrous metal and non-ferrous metal of lower melting point than said ferrous metal, which comprises casting molten bodies of said ferrous and non-ferrous metals on opposite sides of a separator of material capable of weld-uniting to both, the non-ferrous metal being also cast against the surface of a jacketed mold, and passing cooling medium into the jacket of said mold and thereby maintaining the temperature of the portion of the molten metal adjacent to said mold materially below the temperature of the ferrous metal.

25. A process of producing clad metal objects comprising steel and copper, which comprises casting molten bodies of said steel and copper on opposite sides of a separator of material capable of weld-uniting to both, and abstracting heat from the copper and thereby maintaining the temperature of a portion thereof below the temperature of the steel.

26. A process of producing clad metal objects comprising steel and copper, which comprises casting molten bodies of said steel and copper on opposite sides of a separator of material capable of weld-uniting to both, the copper being also cast against a heat-abstracting body, and by the action of said heat-abstracting body maintaining the temperature of the portion of the molten metal adjacent thereto materially below the temperature of the steel.

27. A process of producing clad metal objects comprising steel and copper, which comprises casting molten bodies of said steel and copper on opposite sides of a separator of material capable of weld-uniting to both, the copper being also cast against the surface of a jacketed mold, and passing cooling medium into the jacket of said mold and thereby maintaining the temperature of the portion of the molten metal adjacent to said mold materially below the temperature of the steel.

28. A process of producing clad metal objects comprising unlike metals of different melting points weld-united, which comprises casting the metals of higher and lower melting points on the inside and outside respectively, of a tubular separator of material capable of weld-uniting to both, the metal of lower melting point being cast last and by its chilling action and its contraction causing the separator to contract with the metal within it.

29. A process of producing clad metal objects comprising unlike metals of different melting points weld-united, which comprises casting the metals of higher and lower melting points on the inside and outside, respectively, of a tubular separator of material capable of weld-uniting to both, said separator contained within a mold adapted to abstract heat from the metal of lower melt-

ing point cast between the sides of said mold and said separator, and casting the metal of lower melting point last and by its chilling action and its contraction causing the separator to contract with the metal within it, the heat-abstracting action of the separator limiting the temperature of the metal adjacent to it.

30. A compound metal object comprising layers of ferrous and non-ferrous metal, the latter a metal of high melting point, weld-united by an intermediate layer of a metal like one of said metals and to which both are weld-united.

31. A compound metal object comprising layers of ferrous and non-ferrous metals, weld-united by an intermediate layer of ferrous metal to which both are weld-united.

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

JOHN F. MONNOT.

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