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(54) **Continuous molten copper cladding of ferrous alloys.**

(57) An apparatus for the continuous molten copper cladding of ferrous alloys includes a melt furnace for a molten copper bath, the melt furnace having a bottom supporting a substantially annular dry orifice through which ferrous rod is to be drawn up into and through the melt into a cladding mechanism, the cladding mechanism to be at least partially submersible in the molten copper bath and comprising a substantially cylindrical, vertically orientable nozzle exhibiting a guiding surface at one end, an annular entry guide attached to and positioned by the guiding surface of the nozzle, a substantially cylindrical chill mold having an interiormost surface into which nozzle is threaded, and a fireproof lining surrounding and contacted to an exterior surface of the nozzle.

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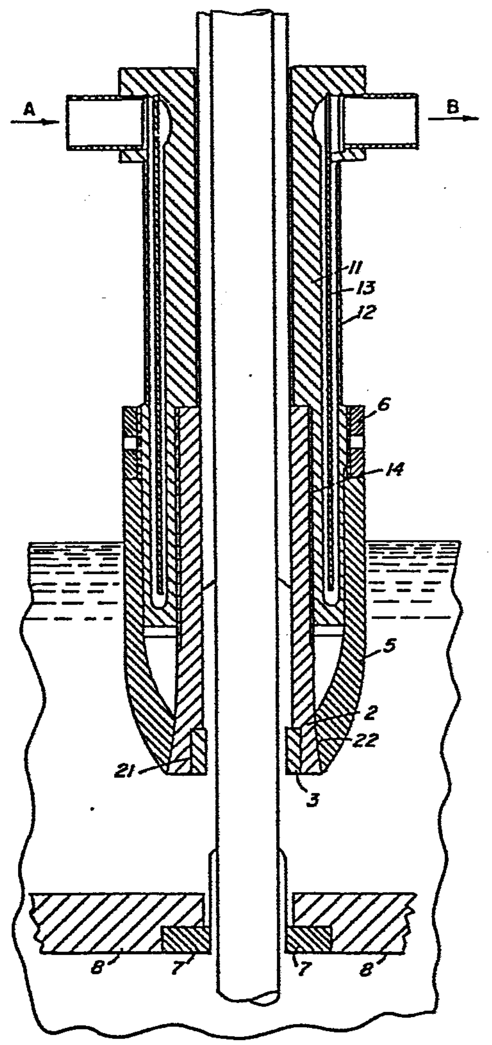

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CONTINUOUS MOLTEN COPPER CLADDING OF FERROUS ALLOYS

TECHNICAL FIELD

The invention relates to the manufacture of copper-clad redraw rod and, more particularly, to the continuous casting of a molten copper coating to a hot, active, ferrous alloy base rod under controlled conditions.

BACKGROUND OF THE INVENTION

Heretofore a variety of approaches have emerged in an attempt to effectively and efficiently produce a composite wire comrising an inner core of, for example, steel or a nickel-iron alloy, and an outer layer of copper. In particular, U.S. Patent 3,820,232 by the present inventor and entitled "Method for Forming Composite Wire" is directed to the cold bonding of a copper sheath to a metallic core rod of dissimilar material. According to the invention embodied therein the external surface of the core is cleaned, coated with a relatively thin coating of copper and inserted into the copper sheath. Prior to core insertion, the sheath itself must be internally cleaned. The disclosure suggests either a rod and solvent swabbing technique or a high pressure solvent system for pumping liquid solvent through the sheath. Thereafter both the core and surrounding sheath are drawn through a reducing die exhibiting a die angle of approximately 30 to 40 degrees. In this process, while the core diameter remains substantially unaltered, the cross-sectional area of the sheath can be expected to experience a reduction of approximately 20 to 50 percent, depending on, inter alia, the original thickness of the sheath and the die angle employed.

Although the cold bonded sheath and rod process described above provides a high quality composite wire with only a modest capital requirement, it is available to provide wire of only limited sizes, generally 2 millimeter diaemter or less. Furthermore, the cold bonding process is significantly dependent on existence of quality copper tubes.

Copper-clad composite wire may also be produced by extrusion of the constituent rod and copper tube. A cold, hydrostatic, extrusion process for forming copper-clad aluminum is described in publication pamphlet AG 14-110 E (January 1972) of the ASEA corporation, Vasteras, Sweden. According to the hydrostatic extrusion process, a composite billet consisting of a round aluminum bar and a surrounding copper tube is fed into a pressure chamber toward the direction of a reducing die. The pressure chamber requires hydraulic fluid, normally castor oil, in order to provide an enveloping pressure so as to force the billet through the die. Pressure in the chamber is developed by a ram driven into the chamber, thereby compressing the oil. When the fluid has become sufficiently compressed, in the direction of the die, the billet begins to extrude through the die. Extrusion continues as long as the ram moves in the chamber in the direction of the die.

The process desribed above is alleged to extrude material at a high rate of reduction and into desired geometrical shapes. Because the castor oil also serves as a lubricant, the billet and die also need be configured so that the castor oil cannot escape between the billet and the die. A primary disadvantage of the hydrostatic extrusion process presently described is that there are no known refinements allowing the process to be used for the formation of copper-clad ferrous composites.

A "dip-forming" method of manufacturing copper-clad dumet (a nickel-iron alloy) is described in THE IRON AGE, December 22, 1966, pp. 46,47. The conceptual basis of that process is that, under appropriate circumstances, molten metal will form a sheath around a metal rod passing through the melt at a proper speed. According to this process, a properly cleaned nickel-iron rod is caused to pass through a refractory metal bushing where it enters a graphite crucible holding a molten copper bath. As the small diameter rod passes through the bath, molten copper freezes around the rod. The thickness of the copper sheath is determined by the temperature and depth of the bath as well as the speed with which the rod passes through the bath. After the rod is coated, it is cooled by a water-spray in an inert atmosphere.

U.S. Patent No. 3,714,701, entitled "Manufacture of Clad Metals" by Dion et al. represents yet another approach to the production of cladding a metal core rod with a sheath of dissimilar metal. As described therein, two thin, flat strips of cladding material are preformed into confronting semicylindrical shapes and positioned into convergence around a core rod. The strips and rods, which must remain substantially contaminant-free, are maintained at equal temperatures as the assembly is solid-phase roll bonded. The result is asserted to be a clad rod suitable for subsequent drawing into wire, requiring neither subsequent sintering, metal removal, or similar finishing operations.

Other approaches to the production of copper-clad composite wire, in addition to those alluded to above, comprise, inter alia, brazed tube and rod assemblies, hot rolling of cast composite ingots, and electro deposition, both single rod and continuous process.

In spite of the above, what continued to be sought, prior to the subject invention, was a process for producing copper-clad redraw rod of superior quality, the process to be characterized by modest capital investment and material cost requirements, to allow the use of large core rod coil weight, and to provide, at elevated levels of productivity a quality product exhibiting, especially, a formidable bond between core and sheath.

DISCLOSURE OF THE INVENTION

The above and other objects advantages and capabilities are achieved in one aspect of the invention by a method of forming a composite conductor, the conductor characterized by a ferrous core and a copper cladding. The method comprises the steps of preheating the core in a hydrogen atmosphere to a temperature approximately 50 to 100 degrees Farenheit below the melting point of copper, drawing the preheated core in an upwardly vertical direction through a dry orifice and a molten copper bath at a rate that permits wetting of the core and adhesion of a copper layer to the core, and cooling the composite ferrous core and copper cladding so that solidification of the cladding occurs at a point below the surface of the molten copper bath.

In another aspect of the invention, an apparatus for forming the composite conductor includes an annular dry orifice through which a ferrous rod is drawn up and through a molten bath into a core positioned by a nozzle threaded into an interior surface of a chill mold. The chill mold is provided a fireproof lining so that it may be inserted a requisite depth into molten copper bath.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is an apparatus, including a chill mold, nozzle, annular core and fireproof lining, according to which the subject invention is to be practiced.

DESCRIPTION OF A PREFERRED EMBODIMENT

For a better understanding of the subject invention, together with the objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims in conjunction with the above-described drawing.

Referring now to the drawing, what is shown there is an apparatus according to the subject invention for the continuous molten copper cladding of a ferrous-rod. The apparatus depicted herein bears substantial similarily to ones disclosed and described in U.S. Patent 3,746,077, "Apparatus for Upwards Casting" to Lohikoski et al and U.S. Patent 3,872,913 "Continuous Method and Apparatus for Upwards Casting" to Lohikoski. (See also, "Upward Continuous Casting Technique in the Production of Nonferrous Wires", WIRE JOURNAL, March 1980, pp 102-104)

Involved therein are a technique and an enabling apparatus for the continuous upwards casting of variously profiled metal products. The products are formed by partially submerging a graphite die in a molten metal. The upper part of the die is provided with a water-cooled jacket so that as the melt cools and solidifies, it is pulled upward through the die. In U.S. Patent 3,746,077 the nozzle of the graphite die is submerged in the melt to a depth sufficient to effect solidification of the melt below the surface of the molten bath. The solidified melt is then further cooled as it is pulled upwardsthrough the apparatus. With particularity, the apparatus disclosed in U.S. Patent 3,746,077 includes a water cooled jacket, or chill mold, comprising an inner pipe, and intermediate pipe and an outer pipe through which cooling water is caused to flow. A nozzle is threaded into an interior of surface of the inner pipe and provides a guide surface at its lower end for a substantially annular core. The nozzle, the core and an accuminated mandrel, positioned within the nozzle, define a passageway through which molten metal is caused to flow in an upward direction. The chill mold itself is surrounded with a fireproof lining attached at the lower end of the nozzle so that chill may be immersed so deeply into the melt that the solidifying front is formed below the surface of the melt.

As the solidified pipe is drawn upward by a drawing apparatus, the extension of the inner pipe above the surface of the melt serves as an after-cooler of the pipe. Because the dimensions of the pipe are largely determined by the inner diameter of the core at the solidification front, it is possible to control relevant pipe dimensions, principally pipe thickness, by appropriately controlling the point at which the solidification front occurs.

Redirecting attention to the drawing included herein, there is depicted an apparatus similar in form to the apparatus described in U.S. Patent 3,746,077. The apparatus includes a chill mold 1 including an inner pipe 11, an outer pipe 12 and an intermediate pipe 13. Cooling water is caused to run into the chill mold through pipe A and out pipe B. A nozzle 2 is threaded into an interior surfaces of pipe 11 in order to promote efficient heat transfer between the chill mold and the nozzle. It is anticipated that the nozzle may be fabricative from solid graphite or from a sintered alloy of metal and metal oxide. An annular core 3 is attached to nozzle and is positioned with the assistance a guiding surface 21 defined by the nozzle. The lower end of the chill mold is protected by a fireproof lining 5 contacted tightly to the nozzle at exterior surface 22 largely through the operation of a nut 6 or similar fastening means.

The process for a manufacturing a composite conductor comprising a ferrous core and copper cladding proceeds as follows. The core is preheated in a reducing atmsophere, e.g. five percent hydrogen, ninety-five percent nitrogen, to a temperature slightly below the melting point of copper. In practice core may be heated to a temperature of approximately 1900° Farenheit. A reducing atmosphere is utilized in order to activate, i.e., flux, the preheated core.

The core is drawn up through a dry orifice 7, annular in configuration, supported by the bottom of the melt furnace 8 and through the molten copper bath 9. It should be noted that prevention of copper spillage through orifice 7 depends on the maintenance of the rod temperature to just below the melting point of copper.

The rod is drawn up through the molten bath at rates chosen to optimize the "wet" expose time of the rod, also dependent on the extent of immersion of the rod in the bath. The rod is then drawn up into the annular entry guide 3 and through the nozzle and chill mold so that a copper cladding forms around the rod. The weight of the cladding is primarily determined by the core rod size and the graphite die size. In summary, what the subject invention, as disclosed herein, comprises is a process and enabling apparatus for forming a composite conductor (read: wire) having a ferrous core, be it steel or iron-nickel alloy, and a copper cladding. It is to be understood that specific details of the process and apparatus are to be tailored according to the particular end product desired.

Accordingly, while there has been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

INDUSTRIAL APPLICABILITY

The subject invention is useful in the effective and efficient manufacture of copper-clad composite wire.

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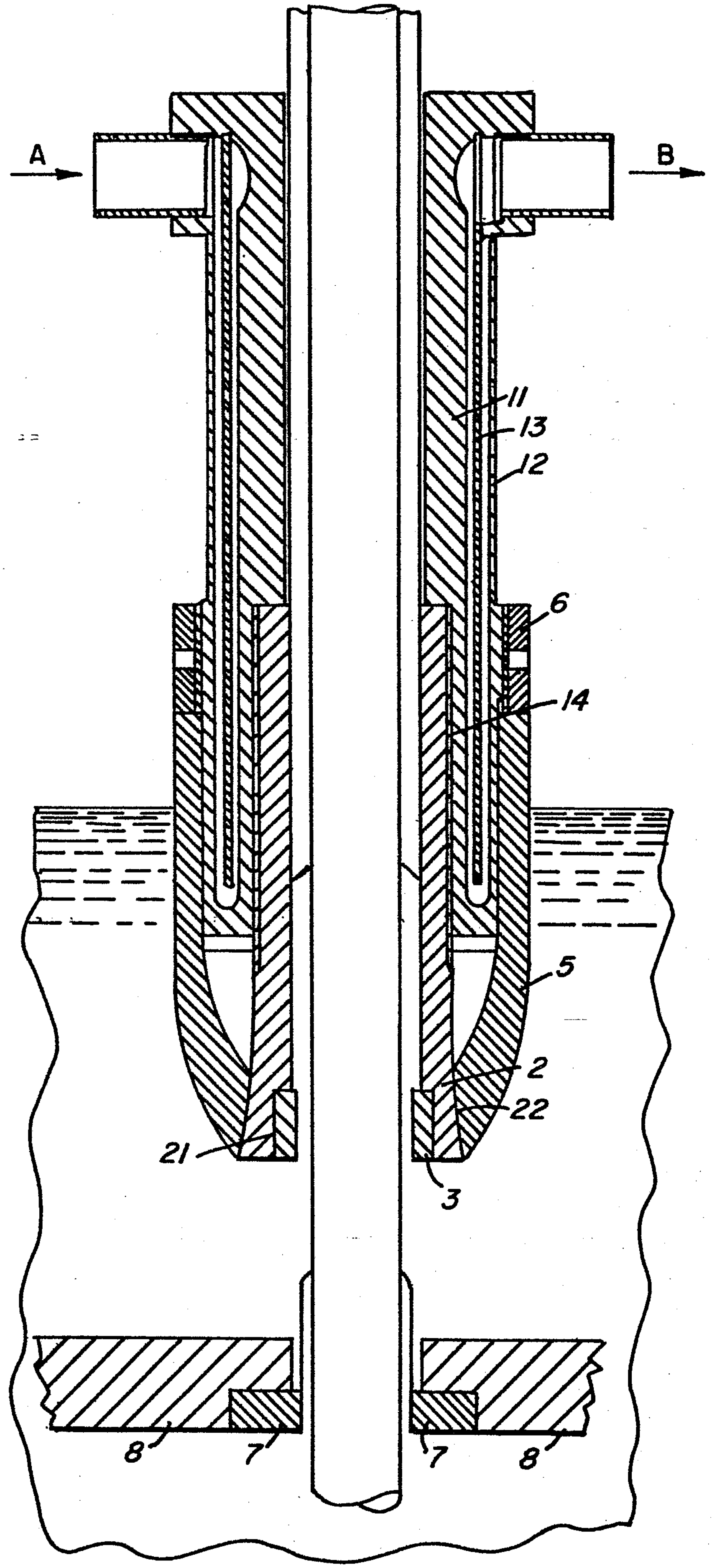
WHAT IS CLAIMED IS:

An apparatus for the continuous molten copper cladding of ferrous alloys including a melt furnace for a molten copper bath, the melt furnace having a bottom supporting a substantially annular dry orifice through which ferrous rod is to be drawn up into and through the melt and into a cladding mechanism, the cladding mechanism at least partially submersible in the molten copper bath and comprising a substantially cylindrical, vertically orientable nozzle exhibiting a guiding surface at one end, an annular entry guide attached to and positioned by the guiding surface of the nozzle, a substantially cylindrical, melt surface chill mold having an interiormost surface into which nozzle is threaded, and a fireproof lining surrounding and contacted to an exterior surface of the nozzle.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EUROPEAN SEARCH REPORT

0149063

Application number

EP 84114168.2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,X	US - A - 3 872 913 (T.J.J. LOHIKOSKI) * Fig.; claims *	1	C 23 C 2/00 C 23 C 2/04 C 23 C 2/38 B 22 D 11/10 B 22 D 11/12 B 23 K 20/00
D,X	US - A - 3 746 077 (T.J.J. LOHIKOSKI et al.) * Fig.; claims *	1	
A	EP - A1 - 0 038 975 (BETHLEHEM STEEL CORPORATION) * Fig. 1-3; claims 1-17 *	1	
A	EP - A1 - 0 038 036 (BETHLEHEM STEEL CORPORATION) * Fig. 1-3;claims 1-6 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

C 23 C
B 22 D
B 23 K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	22-03-1985	SLAMA

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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