

[54] **METHOD FOR FORMING COMPOSITE WIRE**

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[22] Filed: **Nov. 13, 1972**

[21] Appl. No.: **305,846**

[52] U.S. Cl. .... **29/474.4, 29/479, 29/527.2**

[51] Int. Cl. .... **B23k 31/02**

[58] Field of Search ..... **29/474.3, 488, 527.2, 478, 29/479, 474.4; 72/47**

[56] **References Cited**

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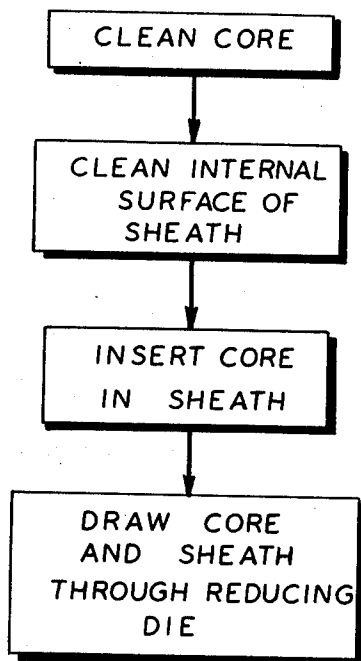
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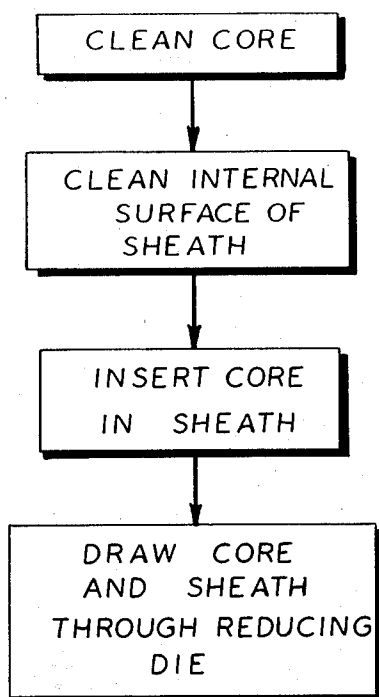
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### [57] ABSTRACT

There is disclosed a method for producing a composite wire having an outer sheath of copper and an inner core of a metallic material dissimilar to copper wherein the external surface of the core is cleaned, coated with a relative thin coating of copper and inserted into the copper sheath. The sheath itself is cleaned internally prior to the insertion whereupon both core and sheath are drawn through a reducing die which substantially reduces the cross-sectional area of the sheath.

**10 Claims, 1 Drawing Figure**





## METHOD FOR FORMING COMPOSITE WIRE

### BACKGROUND OF THE INVENTION

This invention relates to wire manufacturing and more specifically to a method for producing a wire having a solid inner core and an external sheath wherein both core and sheath are bonded together by drawing through a reducing die.

Even more specifically, this invention relates to the above-described method wherein the external sheath is comprised of copper and the inner core is of a metallic material dissimilar to copper.

Previously known methods for producing composite wire have varied from that as described in U.S. Pat. No. 2,063,470 (H. A. Staples) wherein copper in the form of a strip is formed about the core, to the method as described in U.S. Pat. Nos. 3,220,106 (K. B. Clark) and 3,220,107 (K. B. Clark) wherein at least two strips are sealed about the wire core. The end result in each of the above and similar methods was that the final product had at least one seam formed therein. As can be appreciated, a seam formed on any wire adds a possibly detrimental characteristic to the product in that under stress from heat or bending this seam may open substantially or deform otherwise. Such deformation in turn would permit impurities to enter the seam and adversely affect the conductivity and other properties of the wire.

Still another process for producing composite wire is disclosed in U.S. Pat. No. 2,317,350 (O. E. Adler et al.) wherein the core rod is subjected to several copper baths in which a relatively thin coating of copper is applied to the core at each bath. Prior to each bath, the core must also complete several cleaning operations. While the end product is a seamless and satisfactory conductive wire, the procedure is time consuming, complicated, and consequently expensive by manufacturing terms. Furthermore, the process as described is highly unsatisfactory for wires of any substantial diameter (the wire in U.S. Pat. No. 2,317,350 having a diameter of only 0.045 inches) because it would require several additional coating steps in order to achieve the proportional coating as needed.

It is believed, therefore, that a method for producing a wire having a seamless copper sheath and an inner core of material dissimilar to copper which is relatively inexpensive to manufacture and can be produced in substantially less time than previously known methods would constitute an advancement in the art.

### OBJECTS AND SUMMARY OF THE INVENTION

It is therefore a primary object of this invention to provide a method for producing a composite wire which obviates the above cited disadvantages of prior art methods.

It is a further object of this invention to provide such a method wherein the sheath is copper and the core is a metallic material other than copper.

It is an even further object of this invention to provide a method for producing wires of this composition which have relatively large cross-sectional areas.

In accordance with one aspect of this invention, there is provided a method for producing a composite wire having an external copper sheath and an inner core of metallic material dissimilar to copper. The method comprises an initial step of cleaning the core and then applying a relatively thin coating of copper thereto.

The internal surface of the copper sheath is cleaned whereupon the core is inserted therein. Both core and sheath are then drawn through a reducing die during which time the cross sectional area of the sheath is substantially reduced.

### BRIEF DESCRIPTION OF THE DRAWING

The drawing is a flow diagram illustrating the steps of the present invention.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For a better understanding of the present invention, together with further and other objects, advantages, and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the above description of some of the aspects of the invention.

The drawing illustrates the various steps, as will be described, which are utilized to achieve the method in accordance with a preferred embodiment of the present invention.

The preferred core to be used with the present invention is of an iron alloy composition. Preferably, this composition consists essentially of 42 percent by weight nickel and the remainder iron, although it is understood that the present method is not restricted to cores solely of these proportions or materials and any metallic core dissimilar to copper can be used. Steel has also been determined to be a suitable material for the core. A suitable supplier of rods of the above described nickel-iron composition is the W. B. Driver Co. of Newark, N.J., a subsidiary of the assignee of the present invention. Preparation of this rod in order to assure a surface of acceptable quality finish involves a multi-step process. Initially, the ingots are heated and roll cogged to slab form. The entire surface is then ground to remove scale and surface defects following which a visual inspection is held. The slabs are then reheated and reduced to billet form and then reground. Inspection of the ground billet involves utilization of fluorescent magnetic particles which highlight any seams, cracks, or similar flaws. Any such defects are then removed by surface grinding. The billets are then reheated and hot rolled to the prescribed diameter. The coiled hot mill rod is descaled and pickled to remove any scale formed from the hot rolling operation. The above described method for preparing the core rod produces a rod having a highly satisfactory finish.

The next step in preparing the core rod is the application of a relatively thin coating of copper to the surface thereof. To do so, Applicant utilizes a copper flash system in which large coils of core rod weighing several hundred pounds are moved through a seven dip cycle involving five tanks. In the first tank, the coils of core rod are soaked for 1 hour in a suitable caustic at 150° to 170°F. They are then rinsed with water in a second tank for a period of approximately fifteen minutes following which they are immersed in a third tank of dilute sulfuric acid (approximately 10 percent by weight). The period for this immersion is only about 20 seconds after which they are re-immersed in the second tank (water rinse) for a period of 2 minutes. The core coils then are subjected to a solution of copper sulfate within a fourth tank for a period of about 15 seconds. This solution comprises approximately 10 percent by weight sulfuric acid and copper sulfate salt in solution

at about twenty ounces per gallon. Following the copper sulfate bath, the coils are once again returned to the second tank, this time for a twenty minute rinse in moving cold water. Following a three minute rinse in a fifth tank of hot water, the coils are allowed to dry.

Each of the tanks used in the previously described copper coating step have a capacity of approximately 600 gallons, thereby making this process more applicable to production of large quantities. Cleaning of the internal surface of the copper tube can be accomplished by any of several possible methods. An earlier known practice was to swab the tube internally with a long rod and solvent. However, this method proves impractical for tubes of substantial length and a different process must be incorporated. Applicant has found that a high pressure solvent system which would pump liquid solvent through the tube and thereafter force cloth swabs or plugs through in order to dry the tube provides a very satisfactory method of achieving this purpose. To further assist in drying, clean air can also be forced through the tube in rapid fashion. A suitable solvent used by Applicant is trichlorethylene.

The next step in assembling the composite wire is insertion of the nickel-iron core into the elongated copper tube. The tube is straightened using any of several well known tube or wire straightening methods. The straightened tubes, some measuring in excess of 100 feet in length, are assembled in a side-by-side relationship on a suitable work area. At one end of this area is a wire straightening apparatus which simultaneously straightens the core rod and thereafter feeds it into one of the tubes. Practically any one of the power driven apparatus known in the art of wire straightening is sufficient to accomplish this step and further description is therefore believed unwarranted.

Once the core has been straightened and inserted within the tube, the new composite is subjected to a standard swaging step which substantially deforms at least a 5 inch portion of one end of the tube sufficiently in order that it will readily enter the reducing die. This step could also be accomplished by hand, but Applicant prefers the above mentioned apparatus in order to assure a uniform swage to the end.

The swaged end is next inserted into a carbide die through which the tube and core are to be drawn. Carbide reducing dies, as standard in the industry, have an included die angle for each leveling surface of approximately 15°. The die as used by Applicant, however, has an included die angle of approximately 30° and is preferred for the drawing operation. Included die angles ranging upwards of approximately 40° have also been successfully used. To draw the composite through the die, a set of drawing jaws having a linkage member attached thereto are affixed to the previously described swaged end. The composite wire is then drawn by a power driven capstan, approximately 30 inches in diameter, which pulls the linkage member and wire tangentially thereon until the operation is completed. Completion of the operation consists of disengaging the linkage and drawing jaws from the swaged end and withdrawing the coiled completed product from the capstan. Applicant prefers that the drawn wire (or finished product) consists essentially of from 21 to 25 percent by weight copper. This is primarily because of the main intended purpose for the product - that being to provide a lead-in electrical connection for glass encased electrical devices. One particular example of

such devices are diodes wherein the lead-in wire is sealed within the glass casing. It has been determined that composite wires, having a 42 percent nickel-iron composition for the core and the copper sheath being from 21 to 25 percent by weight of the entire product, seal best within the aforementioned glass. An increase above the previously mentioned limit of 25 percent by weight copper adversely affects the expansion properties of the composite wire. The end result is that the glass in most cases will expand during heat buildup and consequently the expansion mis-match between the glass and the wire will cause cracks or breaks thereby destroying the device. As described, for cores of 42 percent nickel-iron compositions it is preferred to maintain the copper within 21 to 25 percent by weight of the composite wire. As a cost factor, it also may be desirable to maintain these same percentages of copper when bonding the copper to cores of other material such as steel, although this percentage ratio is not intended to restrict the overall concept as disclosed herein. At least three series of tests were run, each involving several draws of composite core and tube. Each series utilized tubes of different diameter and wall thickness combinations while maintaining a constant diameter for the cores.

#### EXAMPLE I

Several composites were drawn from copper tubes having original outside diameters of approximately 0.750 inches being mated with 42 Ni-Fe core rods of substantially 0.500 inch diameter. The original wall thickness for the tubing was about 0.035 inches. After one draw through the reducing die having an included die angle of substantially 30°, the end product had an average outside diameter within the range of about 0.5610 inches to 0.5615 inches. Additionally, the percentage (by weight) of copper of the composite ranged from about 21.0 percent to 24.0 percent, well within the desired ranges as originally established. It is remembered that the final core diameters for each of the composites are substantially the same as those of the original core before draw. Accordingly, and as described, only the copper sheath was reduced in overall cross-sectional area. In the above example, this sheath had a reduction in area of about 22.3 percent.

#### EXAMPLE II

In this series of tests, the average outside diameter for the tubes of copper was again 0.750 inches and the core rod diameter once again 0.500 inches. This time, however, the tube's wall thickness was increased to approximately 0.049 inches. The result was that the end product again fell within the desired ranges of copper by weight percentages or about 23 percent. The included die angle for this series of draws was approximately 30° and resulted in an average reduction of sheath area of approximately 52 percent.

#### EXAMPLE III

Larger outside diameters for the copper sheaths were used in this testing series. Sheaths ranging approximately 0.875 inches in outside diameter and having an average wall thickness of about 0.060 inches were mated with 42 Ni-Fe core rods of 0.500 inch diameter. When drawn through a die having a die angle of about 40°, the average final copper sheath thickness reduction was approximately 50 percent, or reduced to 0.030

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thickness. Again, the original core outside diameters were not reduced. The resulting composite had an average copper by weight percentage of about 23 percent.

Additional series of tests were conducted with final product composites having outside diameters as small as 0.016 inches. Again, the desired results of approximately 23 percent by weight copper were obtained. Additionally, mechanical and electrical properties were tested, as in tests of Examples I-III, with the end results falling well within the desired ranges. Typical values for finished wire are:

Tensile strength — 69,000 p.s.i.

Yield strength — 43,000 p.s.i.

Elongation — 25 percent

The finished composites also possess good, consistent weldability characteristics primarily because the copper cladding remains essentially free of degrading alloying elements and is of substantially the same chemistry throughout the length of the wire.

Thus, there has been illustrated and described a method for producing composite wire having an inner metallic core of a material other than copper and an outer sheath of copper. This product is seamless, can be produced in relatively less time than products by comparative methods, and is relatively inexpensive to manufacture.

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.

What is claimed is:

1. A method for producing a metallic composite wire having an outer sheath consisting essentially of copper and an inner core consisting essentially of a metallic material dissimilar to copper wherein said sheath is provided in elongated form and said core is inserted therein, said method comprising:

substantially cleaning the external surface of said

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core and applying a substantially thin copper coating thereto prior to insertion of said core within said sheath,

substantially cleaning the internal surface of said elongated sheath prior to insertion of said core; inserting said core within said elongated sheath whereby said core will be loosely positioned within said sheath;

drawing said loosely positioned core and said sheath through a reducing die whereby only the cross-sectioned area of said sheath is substantially reduced to provide a drawn composite wire having an established percentage by weight of copper.

2. The method according to claim 1 wherein said inner core material is an iron alloy composition.

3. The method according to claim 2 wherein said iron alloy consists essentially of about 42 percent by weight nickel and the remainder iron.

4. The method according to claim 2 wherein said iron alloy material is steel.

5. The method according to claim 1 wherein said established percentage of copper is within the range of from about 21 percent to about 25 percent.

6. The method according to claim 1 wherein said elongated sheath comprises a seamless tube.

7. The method according to claim 6 wherein said elongated seamless tube is approximately one hundred feet in length.

8. The method according to claim 1 wherein said method for cleaning the internal surface of said sheath comprises forcing a cleaning solvent therethrough and thereafter substantially drying said internal surface.

9. The method according to claim 1 wherein a common end portion of said copper sheath and said core inserted within said sheath are subjected to a swaging step prior to drawing of said core and sheath through said reducing die.

10. The method according to claim 1 wherein said reducing die has an included die angle within the range of about 30° to 40°.

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