METALLURGY

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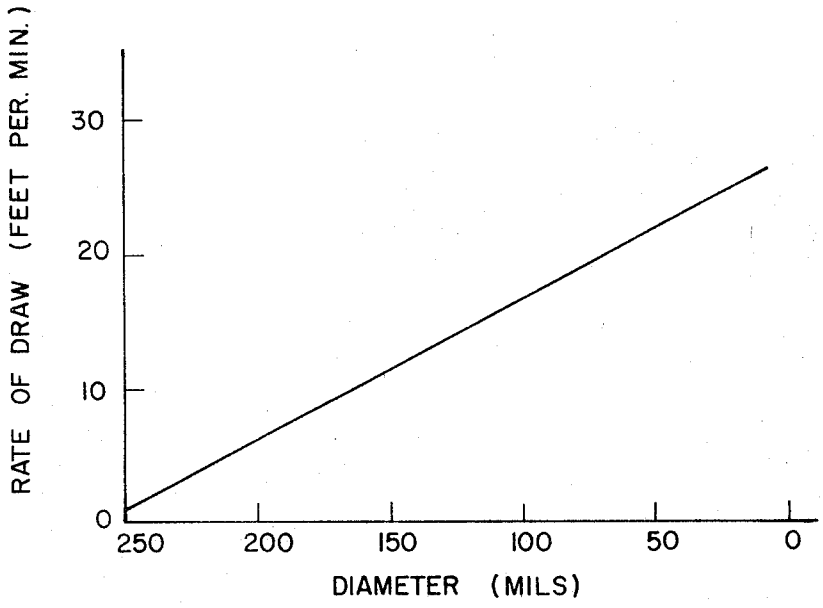


Fig.-2

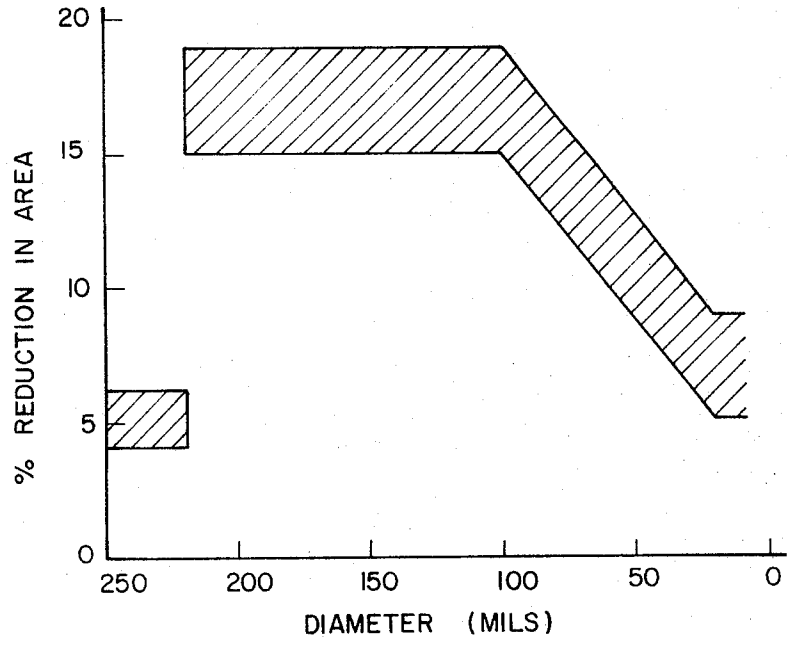


Fig.-1

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This invention relates to alloys and more particularly to superconducting alloy wires.

Accordingly, a principal object of the present invention is to provide a method for producing superconducting wires of alloys comprising, by weight, from about 20 to 50% zirconium and the balance niobium.

Another object of the invention is to provide a method for cold drawing rods or wires of the above alloys into fine, ductile wires possessing very desirable superconducting properties.

Other objects of the invention will be obvious and will in part appear hereinafter.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the drawings wherein:

FIGURE 1 graphically illustrates the present invention in connection with the cold drawing of alloy wire having an initial diameter of about 250 mils; and

FIGURE 2 graphically illustrates typical rates at which the alloy wire can be cold drawn.

Heretofore, in the cold drawing of wires of alloys comprising, by weight, from about 20 to about 50% zirconium, and the balance niobium, and particularly those alloys containing between about 25 to 33% zirconium, considerable breakage was experienced. It has been found that the breakage of such alloy wires during cold drawing was in large part due to "coring" effects. "Coring" results when, for example, the wire drawn through the reduction dies is not adequately worked therethrough. In other words, as the wire passes through the die, the reduction thereof is such that the outer portion thereof is worked while the center or core portion receives little or no working. This effect is particularly pronounced with hard or unannealed metals. As a result of such differential working, cracks frequently are formed in the wire thus giving rise to many weak areas where breakage can occur. In the present invention, wires of the above alloys are cold drawn so as to be free from core cracks and hence from breakage due thereto. Thus, the present method provides for the production of fine, ductile alloy wires possessing very desirable continuous lengths and superconducting properties.

Briefly, the method for producing superconducting wire of an alloy comprising, by weight, from about 20 to 50% zirconium, and the balance niobium, comprises cold drawing a wire of the alloy through a plurality of dies to substantially reduce the diameter thereof, the area of the wire on being drawn through each of said dies being reduced between about 15 and 19%. The resulting thin wire is then cold drawn through another plurality of dies to a predetermined final diameter, the reduction taken in the area of the thin wire on being drawn through these dies being gradually decreased to between about 5 and 9%. In one embodiment of the invention, an alloy wire having an initial diameter of between about 150 and 350 mils is cold drawn through a plurality of dies to reduce the diameter thereof between about 40 and 75%, the area of the wire on being drawn through each die being reduced between about 15 and 19%. The resulting thin wire is then cold drawn through another plurality of dies to a predetermined final diameter, the reduction taken in the area of the thin wire on being drawn through these dies being gradually decreased to between about 5 and 9%.

The present invention is directed to a method for cold drawing a suitable rod or wire of certain alloys of niobium and zirconium into fine, ductile superconducting wire. The superconducting alloy compositions with which the present invention is concerned comprise, by weight, from about 20 to about 50% zirconium and the balance niobium. Wires of alloys containing between about 25 to 33% zirconium have been found to possess particularly useful superconducting properties. Preferably, the alloys contain a sum total of oxygen, nitrogen, carbon and hydrogen ranging between about 0.03 and about 0.05% with at least 50% of this sum total being oxygen.

Prior to any cold drawing of the alloy wire, the surface thereof is preferably first oxidized and then coated with a suitable drawing lubricant in order to help facilitate the cold drawing of the wire and to provide protection thereto during such drawing operation. The presence of the oxide layer and lubricant coating on the wire throughout the cold drawing operations is highly desirable and, accordingly, they are adhered or bonded to the base wire so as not to be readily stripped therefrom. In the present invention, the bonding of such coatings firmly to the base wire is achieved by initially drawing the coated wire through one or more water-cooled dies of a size such that the area of the wire on passing through each die is reduced only between about 4 to 6%. Generally, the desired bonding is obtained on drawing the coated wire through two or three dies of suitable size.

After this initial light reduction in the size of the wire for bonding purposes, the area and diameter of the wire are then substantially reduced. This reduction is preferably achieved by drawing the coated wire through a plurality of water-cooled dies of a size such that the area of the wire on passing through each die is reduced between about 15 and 19%. It has been found that such heavy reductions in the area of the wire on each die pass can be taken without undesirable breakage of the wire occurring. Moreover, such substantial area reductions on each die pass also result in the wire being thoroughly and completely worked so that "coring" and the undesirable effects thereof are eliminated. Furthermore, such thorough cold working of the alloy wire also results in improving the superconducting properties thereof.

When the alloy wire to be cold drawn has an initial diameter of between about 150 and 350 mils, preferably the heavy area reductions are continued until an overall or total reduction of between about 40 and 75% in the initial diameter of the wire is obtained. Generally, area reductions of between about 15 and 19% are taken on each die pass until a wire diameter of between about 70 and 115 mils is obtained.

After the diameter of the wire has been substantially reduced in the above manner, say to between about 70 and 115 mils, the thin wire is then drawn through another plurality of dies to a predetermined final diameter, for example 10 mils. In this case, the dies are of a size such that the reduction taken in the area of the wire on passing through the dies is overall gradually reduced to between about 5 to 9%. In other words, as the diameter of the wire is gradually reduced so also the reductions taken in the area. Preferably, area reductions of between about 5 and 9% are taken on each die pass on wire having a diameter of below about 50 mils.

The speed or rate of cold drawing the wire varies with the diameter of the wire. Thus, as the diameter of the wire is gradually decreased, the rate of draw is gradually increased. For example, wire on the order of about 210 mils can be cold drawn at a rate of about 5

feet per minute, while say wire on the order of about 70 mils can be cold drawn at a rate of about 20 feet per minute.

For superconducting uses, the wire is generally cold drawn to a diameter below about 15 mils. The thin wire resulting from the cold drawing operations, after the removal of oxide and lubricants therefrom, can be coated with a suitable thickness of copper, for example, about 1.0 mil on radius, by known electroplating techniques and then provided with a coating of a suitable electrical insulating material. Exemplary of the insulating materials utilized on superconducting wires are the organic plastic materials, such as, polyamides (nylon), fluorocarbon resins, e.g. tetrafluoroethylene resins and the like, epoxys, etc.

Referring now to the drawings wherein the present invention is illustrated by a typical cold drawing of an alloy wire having an initial diameter of about 250 mils. As shown, a 250 mil wire, having its surface oxidized and coated with a drawing lubricant, can be drawn through a plurality of water-cooled dies to a diameter of about 220 mils, the area of the wire on passing through each die being reduced between about 4 to 6%. The resulting wire can then be drawn through a series of water-cooled dies to a diameter on the order of about 100 mils, the area of the wire on passing through each die being reduced between about 15 and 19%. The overall reduction in the diameter of the starting 250 mil wire at this point is about 60%. The thin wire can then be drawn through another plurality of water-cooled dies to a diameter on the order of about 20 mils. In this instance, the reduction in the area of the wire on passing through these dies is gradually decreased to between about 5 and 9%. For example, wire having a diameter on the order of about 80 mils can be drawn through a suitable die to reduce the area thereof between about 12.5 and 16.5%, while the area of say a 60 mil wire can be reduced between about 10 and 14%. A 30 mil wire, for instance, can be drawn through a suitable die to reduce the area thereof between about 6 and 10%. The wire can finally be drawn through another plurality of water-cooled dies to the desired diameter of say 10 mils, the area of the wire on passing through each of these dies being reduced between about 5 and 9%.

The rate of cold drawing the wire varies with the diameter thereof. As illustrated, the rate or speed of drawing increases as the diameter of the wire decreases. For example, wire having a diameter on the order of about 250, 210, 160, 120, 70 and 20 mils can be drawn, respectively, at rates on the order of about 1, 5, 10, 15, 20 and 25 feet per minute.

The wire drawing dies which make up the die line preferably comprise carbide inserts with a 12° approach angle and back relief and a relatively short bearing surface. The wire is drawn through the various dies by means of drawing capstans and suitably wound thereon. Prior to being drawn through the dies, the wire is passed through a suitable drawing lubricant contained in the die box.

Since certain changes may be made in the above-described details without departing from the scope of the invention herein involved, it is intended that all matter contained in the description shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A method of cold drawing wire of an alloy comprising, by weight, from about 25 to 33% zirconium, the sum total of oxygen, nitrogen, carbon and hydrogen ranging between about 0.03 and 0.05%, at least 50% of said sum total being oxygen, and the balance niobium, said wire having a diameter of between about 150 and 350 mils, which comprises cold drawing said alloy wire through a plurality of dies to reduce the diameter thereof to between about 70 and 115 mils, the area of said wire on passing through each of said dies being reduced between about 15 and 19%, and thereafter cold drawing said alloy wire through another plurality of dies to reduce the diameter thereof below about 15 mils, the reduction taken in the area of said alloy wire on passing through these dies being gradually decreased to between about 5 and 9%.

2. The process of claim **1** wherein the wire is initially subjected to oxidizing conditions to provide an oxidized coating on the surface thereof and is then coated with a drawing lubricant prior to the drawing operation, the first several dies reducing the cross-sectional area of the coated wire by only about 4 to 6%.

No references cited.

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