April 17, 1951 D. S. SEABURY ET AL 2,549,249

METHOD OF DRAWING FILLED TANTALUM TUBES

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FIG. 1

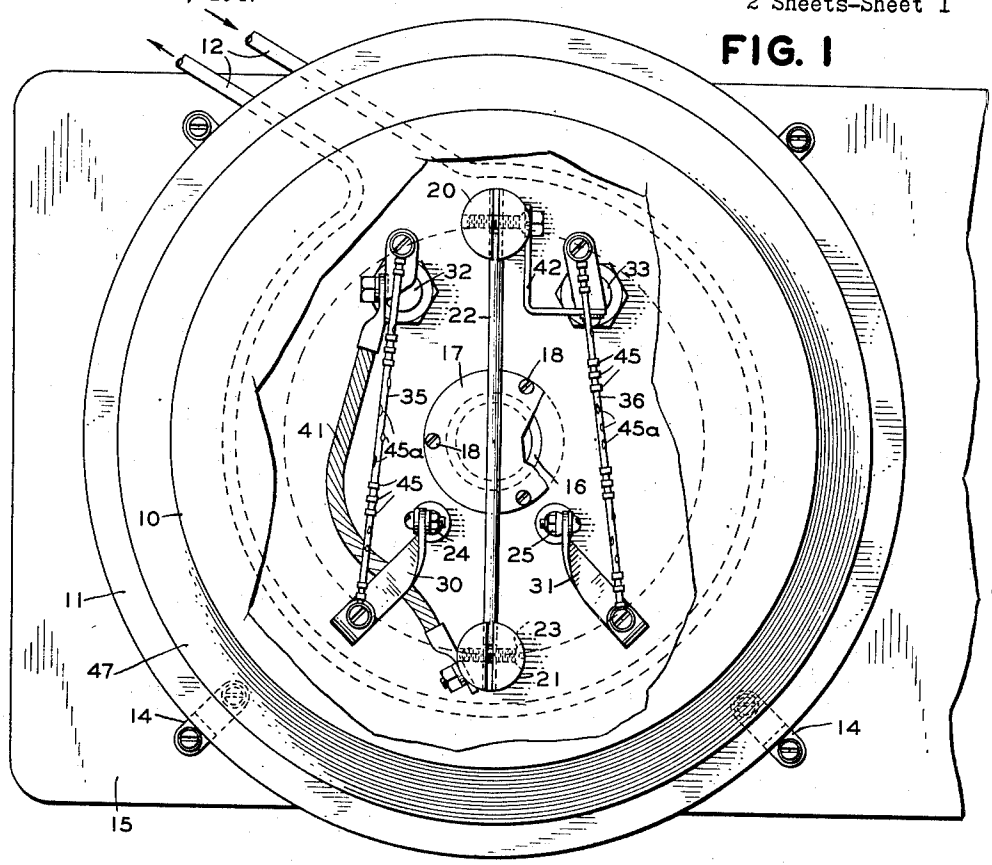
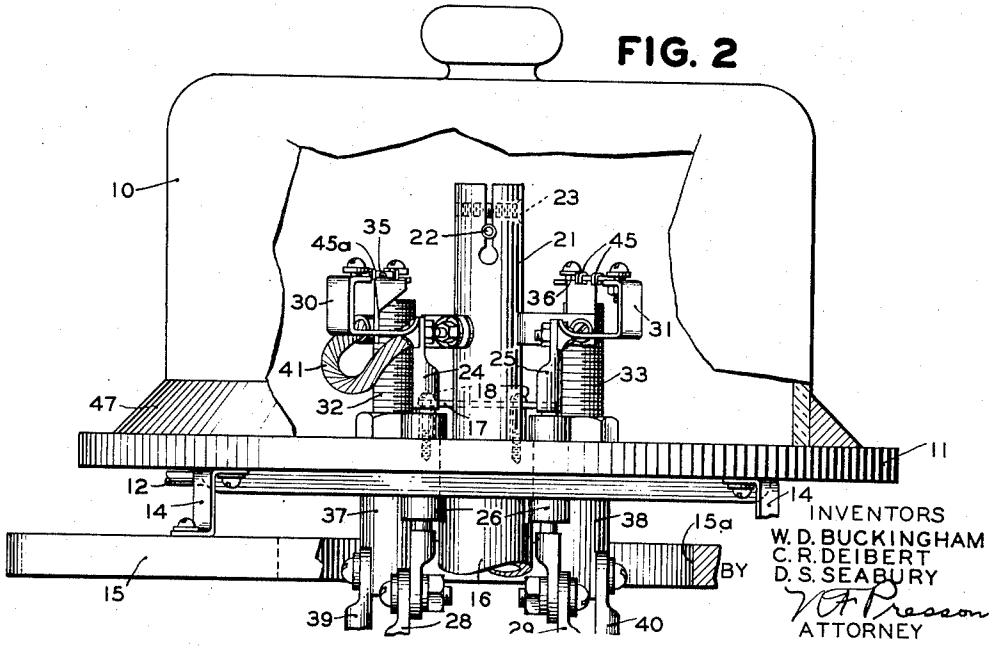


FIG. 2



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FIG. 3

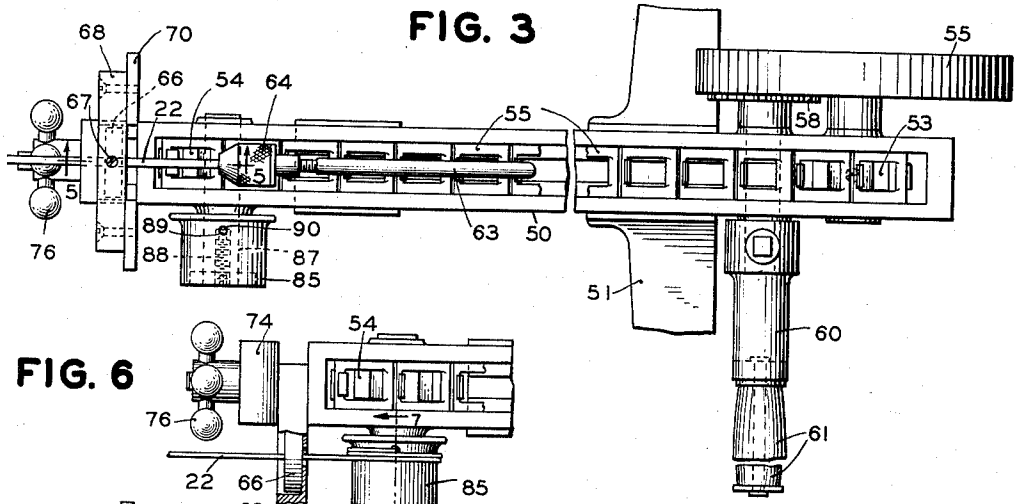


FIG. 6

FIG. 4

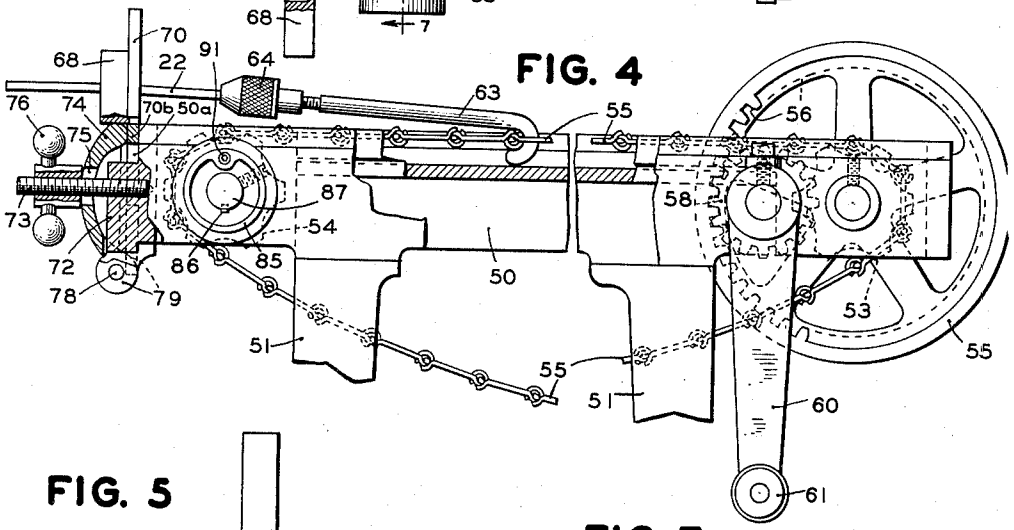


FIG. 5

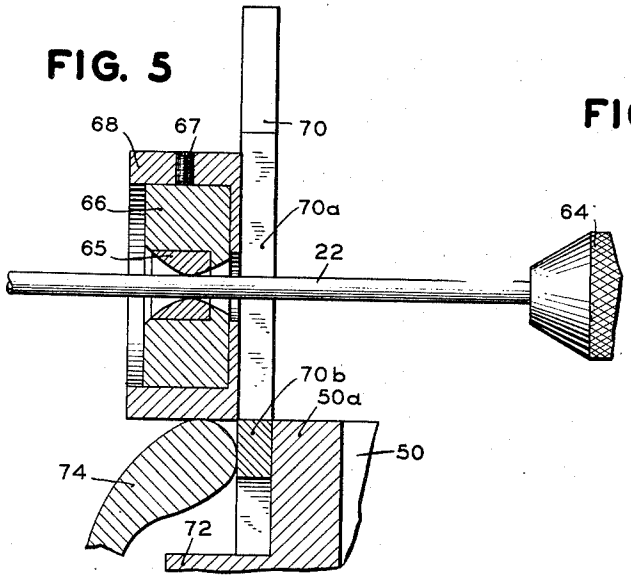
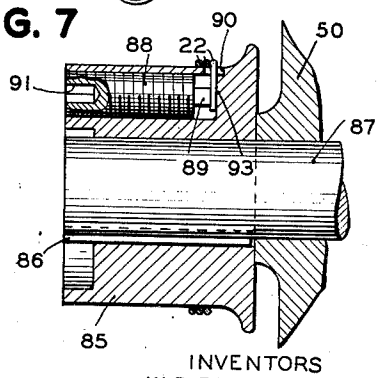


FIG. 7



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METHOD OF DRAWING FILLED TANTALUM TUBES

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Application January 22, 1947, Serial No. 723,616

3 Claims. (Cl. 29—155.42)

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This invention relates to drawing tubes through dies to reduce the diameter of the tubes and elongate the same, and more particularly to an improved method of and apparatus for drawing tubes of tantalum or other metal or alloys that present similar drawing difficulties.

Although not limited thereto, the invention is particularly applicable to the production of cathodes for use in concentrated arc discharge lamps, such as disclosed and claimed in a co-pending application of W. D. Buckingham and C. R. Deibert, Serial No. 668,092, filed May 8, 1946, now Patent No. 2,453,118, issued November 9, 1948. In one embodiment of the invention disclosed in the aforesaid application, the cathode structure comprises a short length of metal tubing of small diameter, within which is packed a core of active material, such as zirconium oxide, that forms on its exposed end surface an active layer or film which is the cathode proper of the concentrated arc discharge lamp. It has been found desirable to employ a tube of tantalum as the outer cathode pencil or holder. Tantalum tubing can be drawn down and hardens slowly during the drawing process, but when it was drawn through the dies to reduce the tubing to a small diameter suitable for the electrode structures of such lamps, it quickly fouled and injured the dies, and the heretofore known drawing operations proved to be too expensive and slow and also impracticable in other respects.

An object of the invention is to obviate the disadvantages of prior methods of drawing down tubes of tantalum and like materials, and to enable the same to be drawn to small diameters at an increased speed and without undue injury to the reducing dies employed.

Another object is to draw down a tube of tantalum or like material in manner suitable to form the holder or cathode pencil for the core of active material of an electrode structure.

These and other objects and advantages of the invention will be apparent from the following detailed description, taken in connection with the accompanying drawings, in which:

Figs. 1 and 2 are top and side views, respectively, of a bell jar within which the tantalum tubes are cleaned and coated in a vacuum prior to a drawing operation, a portion of the bell jar cover being broken away to show the interior thereof;

Figs. 3 and 4 are top and side views, respectively, of a draw bench for drawing down a tube of tantalum or like metal after the tube has been cleaned and coated by the apparatus of Figs. 1 and 2;

Fig. 5 is an enlarged sectional view taken along the line 5—5 of Fig. 3 showing details of one of the wire drawing dies and support means therefor;

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Fig. 6 is a fragmentary view, partly in section, showing details of supporting structure for one of the wire drawing dies employed; and

Fig. 7 is an enlarged sectional view, taken along the line 7—7 of Fig. 6, showing means for clamping the end of a tube during a drawing operation.

Referring to Figs. 1 and 2 there is shown a bell jar 10 of glass which rests on a circular base plate 11 composed of cast iron or other suitable material, the base plate being secured, as by brackets 14, to a table or other support 15. Secured to and passing through the base plate 11 is a tube 16 which opens into the bell jar, and by means of which the bell jar may be evacuated, tube 16 comprising a line from a vacuum pump, not shown, which is capable of producing a high vacuum within the bell jar. A circular cover plate 17 is mounted as by machine screws 18, above the open end of a vacuum line 16, the plate being spaced from the opening to enable exhaustion of air and gasses from the interior of the bell jar, while preventing foreign material from entering the vacuum line. The vacuum line 16 passes through the base plate 11 with a sufficiently tight fit to prevent substantial loss of vacuum at this point.

Mounted on, but electrically insulated by bushings from, the base plate 11 and projecting upwardly within the bell jar are two posts 20, 21 of copper or other suitable metal, which posts have slotted ends for receiving and holding a tube 22 of tantalum or the like which is to be treated. Clamping screws 23, Fig. 2, are provided to hold firmly the ends of the rod 21. Two electrical terminals 24, 25 are supported by metal connecting studs 26 that are electrically insulated by bushings and pass through the base plate 11, thereby to make electrical connections through lugs 28 and 29 to an external source of heating current supply. Secured to terminals 24 and 25, respectively, are conducting brackets 30 and 31 which, in conjunction with two threaded terminal posts 32 and 33, serve to support two heating wires 35 and 36. The heating wires preferably, although not necessarily, are composed of tantalum, and in the embodiment disclosed each comprises a .030 inch diameter wire. The terminal posts 32 and 33 are mounted in studs 37, 38, Fig. 2, which pass through the base plate 11 and make electrical connections through lugs 39, 40 to the source of heating current supply, these elements being electrically insulated from the base plate 11. Terminal post 32 is electrically connected, by means of a stranded conductor 41, to the tube-supporting post 21, and terminal post 33 is electrically connected, through a strap 42, to the supporting post 20. The foregoing arrangement enables separate control of the heating circuits whereby the tantalum tube 22 and wires 35, 36 may be heated either inde-

pendently or conjointly during the treatment of the tantalum tube as hereinafter explained.

Initially, a tantalum rod is cut into short lengths and centrally drilled to produce a hollow rod or tubing. For small size concentrated arc lamp cathodes, such as for use in a 2-watt lamp, a ¼ inch tantalum rod is cut into lengths of 1¾ inches and these are centrally drilled to provide short pieces of tubing. The outer diameter of each piece is then reduced by a swaging machine, in a series of swaging steps, in known manner, mandrels of suitable sizes being inserted in the tube during the swaging operations. For example, four swaging steps with progressively smaller swaging dies conveniently may be employed to reduce the outside diameter of the tube from ¼ inch to approximately .154 inch, the inside diameter being approximately .081 inch. After the foregoing swaging operations, the length of the tube has been extended from 1¾ inches to approximately 6½ inches.

The cover 10 of the bell jar is removed and the swaged length of tubing 22 is inserted and clamped at its ends in the slotted portions of the supporting posts 20 and 21. On the tantalum heating wires 35 and 36 are hung small tin copper straps 45. The bell jar cover is replaced and its lower circular edge sealed at 47 with a vacuum sealing compound, various of which compounds are commercially obtainable; one of these designated in the trade as "Apiezon Q" often is used.

The vacuum system represented by the tube 16 then is turned on and the bell jar is exhausted until a high degree of vacuum is obtained within. Heating current is then caused to flow in a series circuit through the tantalum tube 22 and the heating wires 35 and 36. This circuit within the bell jar, as seen from Fig. 1, is the terminal 24, bracket 30, heating wire 35, terminal post 32, conductor 41, supporting post 21, tantalum tube 22, supporting post 20, strap 42, post 33, heating wire 36, bracket 31 and terminal 25. The flow of heating current is continued until there is very little or no indication of gases being liberated from the tantalum tube. By this time the small copper strips on the heating wires 35 and 36 will have melted down and have formed small copper beads or balls, as indicated at 45*a* in Fig. 1. The tantalum tube again is degassed by applying the heating current to the terminal lugs 39 and 40, Fig. 2, and thence to the terminal posts 32 and 33, with no current flowing through the heating wires 35 and 36. When tube 22 is thoroughly degassed, the heating current is disconnected therefrom, and while the tantalum tube is still very warm, as cherry red, the heating circuit is connected first across terminals 24, 32 and subsequently across terminals 25, 33 so as to heat the wires 35 and 36 successively and hence the small copper balls 45*a* thereon. The copper balls are heated to nearly white heat and are thus evaporated off the wires 35, 36, a high vacuum being maintained within the bell jar during this entire period. The evaporated copper condenses on the outer surface of the cooler tantalum tube 22 and forms a thin copper coating thereon, the heating current being discontinued at this time. During these operations cooling water is passed through a tube 12 which is in contact with the base plate 11, so that the sealing compound 47 will not soften and cause a leak into the bell jar. The vacuum is then broken and the coated tube removed, care being taken not to touch the tube as it comes from the bell jar thereby to maintain the surface clean. The copper coating thus applied to the tantalum tube is too thin to prevent injury to the drawing dies subsequently employed, but the copper-coated tube readily may be electroplated in known manner until a coating of approximately .002 inch of copper has been built up thereon. This tubing is then filled and packed with zirconium oxide or other cathode material suitable for the purpose, and the ends of the tubing are closed in and sealed in any suitable manner, as by the use of a jig, so that the core of zirconium oxide will not be affected by the subsequent steps of treating and drawing the tubing. The copper-coated tantalum tube with its filling of cathode material may be drawn through the reducing dies without fouling or injuring the dies and the tubes may be drawn down expeditiously to a very small diameter and to a great length.

The draw bench shown in Figs. 3 and 4 comprises an iron framework generally designated at 50 which is supported by legs 51 at a convenient working height. Mounted in the framework is a driving sprocket 53 and a driven sprocket 54 having teeth which engage the links of an endless pulling chain 55. Sprocket 53 is secured to a driving wheel 55 which has an internal gear ring 56 that meshes with and is driven by a smaller spur gear 58. The latter gear may be rotated manually through the medium of a crank 60 and crank handle 61. The various links of the chain 55 may be engaged by a hook member 63 having secured thereto a jaw chuck 64 which receives and grips one end of the copper-plated tantalum tube 22 for drawing the tube through drawing dies such as the die 65, Fig. 5. These dies, which preferably are composed of a material such as a tungsten-carbon-cobalt alloy, commonly designated in the trade as Carboloy, or aluminum bronze, are mounted in a die block 66 and the die block is secured, as by a set screw 67, in a die holder 68 which is secured, as by screws, to a supporting plate member 70. The latter member is bifurcated at 70*a* to provide clearance for the tube 22. The plate 70 is clamped against an end 50*a* of the iron framework support 50 this end of the framework having a block 72 that receives and holds a threaded stud 73, Fig. 4, of the die-clamping assembly which includes a curved clamping plate member 74 having an opening 75 to provide clearance for the stud 73. The upper end of the clamping member 74 is held in clamping engagement against the central portion 70*b* of the plate 70 by a hand wheel 76 which is internally threaded to engage the stud 73. The lower portion of the clamp member 74 is hingedly mounted by ears 79 and a pin 78 which passes through the ears and through an ear which depends from the block member 72.

The tantalum tube is drawn down on the draw bench in a series of drawing steps through successively smaller dies. For example, in the first operation on the draw bench the 6½ inch copper-coated tube, one end of which is gripped by the jaw chuck 64, is drawn through a starting die and is elongated thereby to a length of 7 inches or more. The second drawing die, which is slightly smaller than the first, further elongates the tantalum tube approximately 1 inch, and the successively smaller dies employed each progressively increases the length and decreases the diameter of the tantalum tube. In drawing down electrode tubing for use in a small size lamp, and starting with a copper-coated

tube having an outside diameter of approximately .155 inch, the first drawing die used will be a .1443 inch die and the last die used will be .0142 inch. Prior to each die-drawing operation, the pulling end of the tube **22** is swaged down slightly to enable the end to be passed through the drawing die a sufficient distance so that it can be seized by the jaw chuck **64** or by the other drawing mechanism hereinafter described. Beeswax or other suitable lubricant also is applied to the drawing dies to reduce to some extent the friction during the drawing operations.

When the tube **22** has been drawn out to a considerable length, for example, 15 feet, it is too long to be handled by the jaw chuck **64** and hook member **63**. The die **68**, without the plate **70**, is then lowered and clamped in the position shown in Fig. 6, and the drawing is effected by a pulley **85** which is keyed at **86**, Fig. 7, to a shaft **87** driven by the sprocket **54**. Within the pulley is a screw-threaded bore and pin **88**, the pin having an inner end **89** that clamps the pulling end of the tube **22** which has been passed through a hole **90** in the pulley. The outer end of the clamping pin has either a square or hexagonal hole **91** therein for receiving a tool for rotating the pin until it tightly clamps the end of the tube against an internal shoulder **93** of the pulley, and thus enables the pulley to exert the high pulling force required to draw down the tubing to a small diameter. In drawing down the tubing to produce a diameter of .0142 inch, approximately 40 drawing operations are employed whereby the original 6½ inch tube is drawn out to form about 45 feet of electrode tubing. Such a length of tubing will provide cathodes for approximately 1000 2-watt lamps. After the drawing operations are completed the tubing is cleaned of any remaining copper in a nitric acid bath.

Not only do the drawing operations above described enable the tube of material, such as tantalum, to be drawn down expeditiously without undue injury to the drawing dies, but the drawing operations compress and tightly pack the zirconium oxide core within the tubing which results in substantially improved operating characteristics of the lamp in which the electrode is used.

As above set forth, the methods of drawing down tantalum tubing or the like is especially useful in the production of cathodes for concentrated arc lamps, but it will be obvious to those versed in the art that the method advantageously may be employed wherever it is desired to draw down tubes of tantalum or like refractory material to produce tubing of smaller diameter and greater length, and the invention therefore is not limited except as indicated by the scope of the appended claims.

What is claimed is:

1. A method of drawing a tube of tantalum or other refractory metal adapted for use in an electrode structure in a concentrated arc discharge lamp, which comprises passing heating current through the tube in a high vacuum to remove occluded gases and impurities therefrom, passing heating current through a conductor in said vacuum in such manner as to heat a quantity of copper until the copper evaporates and condenses on the outside of the tube

to form a coating thereon, filling said tube with a core of an electrode-forming material, sealing the ends of the cored tube, electroplating the coated tube with a further coating of copper, drawing the coated tube through successively smaller drawing dies to reduce the diameter and increase the length of the tube, and subsequently removing the copper coating that remains on said tube after the drawing operations.

2. A method of drawing a tube of tantalum or other refractory metal adapted for use as an electrode structure in an electrical discharge device, which comprises electrically heating a length of such tubing in a rarefied atmosphere to remove occluded gases and impurities therefrom, electrically heating in said rarefied atmosphere a ductile metal that has the property of adhering to the metal of the tube and is considerably softer than the metal of the tube in such manner that the softer metal evaporates and condenses on the outer surface of the tube to form a coating thereon, electroplating the coated surface of the tube with a further coating of a ductile metal that has the property of adhering thereto and is considerably softer than the metal of the tube, filling said tube with a core of electrode-forming material, thereafter drawing the coated and filled tube through successively smaller drawing dies to reduce the diameter and increase the length of said tube, and subsequently removing the coating of softer metal that remains on said tube after the drawing operations.

3. A method of drawing a tube of tantalum or other refractory metal adapted for use as an electrode structure in an electrical discharge device, which comprises electrically heating a length of such tubing in a rarefied atmosphere to remove occluded gases and impurities therefrom, electrically heating in said rarefied atmosphere a quantity of copper in such manner that the copper evaporates and condenses on the outer surface of the tube to form a coating thereon, electroplating the coated surface of the tube with a further coating of copper, filling said tube with a core of electrode-forming material, thereafter drawing the coated and filled tube through successively smaller drawing dies to reduce the diameter and increase the length of said tube, and subsequently removing the coating of copper that remains on said tube after the drawing operations.

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