METHOD OF MANUFACTURING WIRE

Original Filed Oct. 19, 1937

Fig. 1.

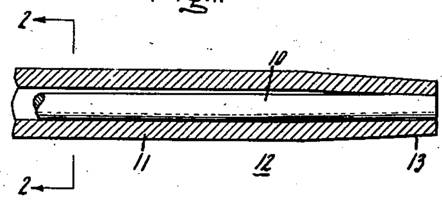


Fig. 2.

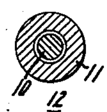


Fig. 3.

Fig. 4.

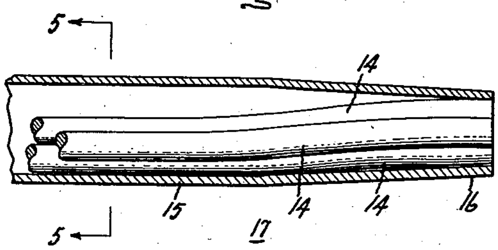


Fig. 5.

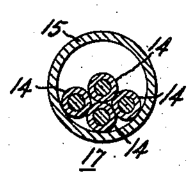


Fig. 6.

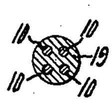


Fig. 7.

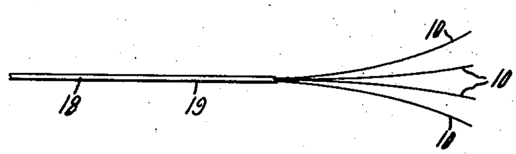
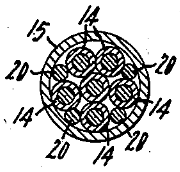


Fig. 8.



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UNITED STATES PATENT OFFICE

2,215,477

METHOD OF MANUFACTURING WIRE

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Application October 19, 1937, Serial No. 169,838
Renewed December 23, 1939

5 Claims. (Cl. 205—21)

My invention relates to the manufacture of fine drawn wire, and more particularly to the manufacture of extremely fine wires of pure aluminum or other similar metals, or alloys thereof, such as are used for the combustible material in photoflash lamps.

To warrant the use of pure aluminum wire for the combustible material in photoflash lamps, the size of the wire must be made small enough to permit ready ignition of such wire. Thus, to obtain ready ignition of pure aluminum wire, it must be drawn down to a size such that a meter length thereof will weigh between one to two milligrams. For a pure aluminum wire of circular cross-section, the diameter must be of the magnitude of one mil or thereabouts in order to fall within the aforementioned range of weight per meter.

Due to the brittleness of aluminum wire and its relatively low tensile strength when drawn to very small diameters, it has been found extremely difficult to manufacture such wire fine enough to permit its use in photoflash lamps, and methods heretofore employed have been impractical because of the great expense involved. However, by surrounding or embedding the aluminum wire within a jacket of soft and ductile metal, such as copper, so as to form therewith a composite unitary wire structure, the ductile metal jacket will lend or furnish support to the relatively brittle aluminum wire during the various drawing operations. Accordingly, the composite wire structure can be drawn down to the point where the embedded pure aluminum wire is of the required fineness without fracturing the same, whence the metal jacket or matrix may then be removed from the aluminum wire by passing the composite wire through a chemical bath which will dissolve the metal of the jacket but not the aluminum.

One object of my invention is to provide an improved and practical method for the manufacture of extremely fine wires of aluminum or other similar metals or alloys thereof, which method will be simple in procedure and relatively inexpensive.

Another object of my invention is to provide an improved method for the manufacture of wire of the type referred to above whereby large quantities of the same can be produced with a minimum number of drawing and various other allied operations.

Still another object of my invention is to provide a method for the drawing of fine wires of aluminum whereby the surface of such wires will be protected against oxidation by the atmosphere and from other deteriorating influences during the various drawing and annealing operations.

Further objects and advantages of my invention will appear from the following description thereof and from the accompanying drawing.

In the drawing, Fig. 1 is an enlarged fragmentary view showing the initial step in the manufacture of wire according to the method of my invention, in which a relatively large rod of aluminum or other metal is inserted within, and rigidly secured to one end of, a tube of copper or other ductile metal; Fig. 2 is a transverse sectional view taken on the line 2—2 of Fig. 1; Fig. 3 is a transverse sectional view of the assembly shown in Fig. 1 after having been successively drawn through a series of reducing dies to thereby form a composite wire element; Fig. 4 is an enlarged fragmentary view showing an intermediate step in my method of manufacturing wire wherein a plurality of the wire elements shown in Fig. 3 are inserted within, and rigidly secured to one end of, a tube of copper or other ductile metal; Fig. 5 is a transverse sectional view taken on the line 5—5 of Fig. 4; Fig. 6 is a transverse sectional view of the assembly shown in Fig. 4 after having been successively drawn through a series of reducing dies; Fig. 7 is a fragmentary view of the assembly shown in Fig. 4 when drawn down to its final size with a portion of the ductile metal matrix removed to reveal the several aluminum wires embedded therein; and Fig. 8 is a view similar to Fig. 5 of a modification of my invention.

Referring to the drawing, the procedure followed in carrying out my invention may be described generally as comprising three steps, the first of which consists in assembling a suitable length of a rod 10 of pure aluminum or other metal of which the fine drawn wire is to consist, and of relatively large cross-sectional area, within a tube 11 of a relatively ductile metal, preferably copper, thereby forming the assembly 12. The ends of the aluminum rod 10 and copper tube 11 having been aligned, they are securely fastened together, preferably by pointing the assembly end, as shown at 13 in Fig. 1. This pointing operation may be conveniently performed by inserting the end of the assembly 12 in a suitable swaging or pointing machine. The assembly 12 is then drawn, pointed end first, through a series of reducing dies to a predetermined diameter, thereby forming a copper-sheathed aluminum wire 14 constituting one of the composite wire elements employed in the second step of the method comprising my invention.

The second step of my improved process consists in assembling a plurality of the composite wire elements 14, as produced by the first step, within a tube 15 of the same ductile material as that of the tube 11. The tube 15 should be of sufficient internal diameter to permit easy insertion of the composite wire elements 14 therein. The ends of the wire elements 14 and the tube 15 are then aligned and securely fastened together, as shown at 16 in Fig. 4, in the same manner as described above in connection with the first step, thus producing the multiple assembly 17. This multiple assembly 17 is then successively drawn, as before, through a series of reducing dies down to the point where the embedded aluminum wires are of the required fineness or cross-sectional areas. The composite multiple assembly 17 is thus drawn down to an extremely fine wire 18, as shown in Fig. 7, the ductile copper matrix 19 serving to support the fine aluminum wires 10 during the drawing operations and thereby preventing breakage of the same. It will be understood that once the assembly 17 has been drawn down to the point where a solid cross-sectional mass is formed (Fig. 6), the further drawing of such composite assembly will result in the reduction in cross-section of the embedded aluminum wires substantially in proportion to the reduction in cross-section of the whole assembly.

To separate the several aluminum wires or strands 10 from the surrounding copper jacket or matrix 19, it is merely necessary to immerse the composite wire 18 in a suitable chemical bath, such as dilute nitric acid, which will dissolve the copper but not the aluminum. The water remaining on the bare aluminum wires, as a consequence of the washing operation, must be quickly removed by mechanical means in order to prevent the redeposition of copper, or other metals present in the wash water, onto the bare aluminum wires. The mechanical removal of the remaining wash water may be accomplished by subjecting a loosely arranged mass of the bare aluminum wire to a violent agitation, such as is produced by a centrifuge or centrifugal drier. Alternatively, the bare aluminum wire may be passed between felt pads which will wipe or scrape the wash water from such wire.

During the various drawing operations referred to above, the embedded aluminum wires 10 tend to harden up. For this reason it is advisable to heat treat the composite wire structures at various stages of the drawing process to thereby anneal or soften the embedded aluminum wires and thus minimize the danger of breakage thereof.

As a specific example of the procedure I have followed in successfully practicing my improved process, I first draw a pure aluminum rod, of approximately 125 mils diameter, through two dies down to a diameter of 102 mils or thereabouts. This 102 mil diameter aluminum rod 10 is then assembled within a copper tube 11 of approximately 267 mils outside diameter and 125 mils inside diameter. The aluminum wire and copper tube are securely fastened together at one end 13 by swaging or pointing, as previously described, and the entire assembly drawn through four dies down to a diameter of approximately 184 mils. At this point the composite wire structure is annealed by heat treating at 350° C. for approximately thirty minutes in a hydrogen atmosphere. The annealed wire is then drawn again through four dies down to a diameter of approximately 115 mils, thus completing the composite wire element 14 employed in the second step of my process.

Having produced a plurality of the composite wire elements 14 according to the above process, I then assemble four of such elements within a softened copper tube 15 of approximately 405 mils outside diameter and 345 mils inside diameter, thus forming the assembly 17 previously described. After the several composite wire elements 14 and copper tube 15 have been securely fastened together at one end 16, by swaging or pointing, the entire assembly is successively drawn through a series of ten dies to an outer diameter of approximately 184 mils. At this point the composite assembly is annealed, to soften the embedded aluminum wires, by heat treating said assembly at 350° C. for thirty minutes in a hydrogen atmosphere. The annealed assembly is then successively drawn through a series of four dies to a diameter of approximately 115 mils, when it is again annealed at 350° C. for thirty minutes in a hydrogen atmosphere. The 115 mil wire assembly is next drawn to a diameter of approximately 46 mils, through a series of seven dies, and then heat treated in the same manner as before. The 46 mil wire is in turn drawn through a series of ten dies to a diameter of approximately 26 mils, heat treated as before, and then drawn through a series of six dies to a diameter of approximately 16 mils and again heat treated as before. Finally, this 16 mil wire is successively drawn through a series of seven dies to a diameter of approximately 9 mils, at which diameter the embedded aluminum wires will approximate a diameter of 1.1 mils. The completed wire assembly 18 thus produced is then passed through a bath of dilute nitric acid which dissolves the copper but not the aluminum, thus removing the copper matrix 19 from the embedded aluminum wires 10 and producing four separate wires of pure aluminum. The bare aluminum wires are then washed and dried by subjecting a loosely arranged mass of such wire to a violent agitation, as previously described.

While the exact procedure described above is given as a specific example, it should be understood that various departures may be made therein without departing from the scope of my invention. Thus, the number and character of the various drawing and heat treating operations may be altered as the manufacturer desires. Also, the diameters of the aluminum rods 10, the copper tubes 11 and 15, and the assemblies 12 and 17 initially, or at different stages of the drawing and heat treating operations, may be varied as desired. Furthermore, instead of assembling four of the composite wire elements 14 within the copper tube 15, a greater or less number of such elements may be advantageously employed. Thus I have successfully practiced the invention by assembling seven copper-sheathed wire elements 14 within the copper tube 15, and it may even be possible to assemble as many as twenty of such wire elements within the said tube and successfully produce fine wire of aluminum by proper drawing and heat treating operations.

As a modification of my invention, as shown in Fig. 8, the multiple assembly 17 may be formed of a plurality of the copper-sheathed wire elements 14 previously described together with one or more bare aluminum wires 20 assembled within the copper tube 15. In such case it is important that the bare aluminum wires 20 be positioned within the interstices or spaces between adjacent wire elements 14, only one bare aluminum wire 20 being placed in each space in order to insure each wire 20 being maintained in spaced relation to the others by a layer of copper during the various drawing operations.

Alternatively, it may be advantageous to assemble a plurality of the composite multiple assemblies 17, before they have been drawn to their final size, within a copper tube and then proceeding with the various drawing and annealing operations necessary to reduce the embedded aluminum wires to the required size.

While it is possible to draw down a single copper-sheathed aluminum wire to produce a single extremely fine wire of aluminum, it is necessary, in order to reduce the diameter of the embedded aluminum wire to one mil or thereabouts, to draw the whole composite wire assembly down to a proportionately small diameter, such as, for instance, three mils or therabouts. However, by assembling a plurality of copper-sheathed aluminum wires within a copper tube in accordance with the second step of my improved method, to thereby form a composite multiple wire structure comprising multiple wires 10 of aluminum embedded in a matrix 19 of copper, the multiple wire structure so formed need not be drawn down to as small a diameter as is necessary in the case of a single copper-sheathed aluminum wire, in order to reduce the embedded aluminum wires 10 to the required cross-sectional size. Thus, the multiple wire structure produced by the second step of the specific example previously described above need only be drawn down to a diameter of 9 mils to produce aluminum wires of a size falling within the range of one to two milligrams per meter. It is therefore evident that the number of drawing and heat treating operations are considerably reduced by my improved method. This advantage may be better understood in view of the fact that the draft of the drawing dies must of necessity be made proportionately smaller the smaller the diameter of the die, so that a greater number of dies are required to produce a given reduction in cross-section at such smaller diameters. From this it is seen that the larger the initial multiple assembly 17, i. e., the greater the number of wire elements 14 assembled within the copper tube 15, the fewer the number of drawing and annealing operations required to produce aluminum wires of a given size, with attendant decrease in cost of manufacture.

By my improved multiple wire process I am able to produce a much greater quantity of fine aluminum wire for a given amount of drawing than by the single wire process. Thus, where four aluminum wires are employed in the second step of my process, four times as much wire will be produced as when a single aluminum wire is drawn. Furthermore, the copper matrix 19 surrounding the several aluminum wires 10 serves to protect the surfaces of such wire against oxidation by the atmosphere during the various drawing and annealing operations. Likewise, the said copper matrix protects the embedded aluminum wire from the deteriorating effects of the lubricants employed in the drawing operations, and prevents pitting of such wires.

The extremely fine pure aluminum wire may be employed in photoflash lamps of the type disclosed and claimed in application Serial No. 131,614, filed March 18, 1937, by the inventor herein and Robert E. Worstell. In the said application, a sealed bulb contains the aluminum wire together with a suitable foil, such as aluminum foil. However, the bulb may be filled with the aluminum wire alone if desired.

While I have described my process in connection with the manufacture of fine wires of pure aluminum, it should be understood that it may be advantageously applied to the manufacture of fine wire of other metals or alloys of a relatively brittle nature, such, for example, as cerium, or magnesium, or alloys thereof, suitable dissolving agents being employed for the copper or other sheath metal which will not adversely affect the core metal.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of manufacturing wires of a relatively brittle metal which consists of assembling a rod of said metal within a tube of a relatively ductile metal to form therewith a composite single assembly, successively drawing said assembly through a series of dies to thereby form a composite wire element, assembling a plurality of said wire elements within a tube of metal of the same character as that of the first-named tube to form therewith a composite multiple assembly, successively drawing said multiple assembly through a series of dies to reduce the same to a predetermined diameter, and then removing the ductile metal from the embedded wires of brittle metal.

2. The method of manufacturing fine wires of aluminum which consists of assembling a rod of aluminum within a tube of copper to form therewith a composite single assembly, successively drawing said assembly through a series of dies to thereby form a composite wire element, assembling a plurality of said wire elements within a second copper tube to form therewith a composite multiple assembly, successively drawing said multiple assembly through a series of dies to reduce the same to a predetermined diameter, and then passing said multiple assembly through a chemical bath to dissolve the copper metal and separate the several embedded aluminum wires therefrom.

3. The method of manufacturing wires of a relatively brittle metal which consists of assembling a rod of said metal within a tube of a relatively ductile metal to form therewith a composite single assembly, pointing an end of said assembly to securely fasten the ends of said rod and tube together, successively drawing said assembly through a series of dies to thereby form a composite wire element, assembling a plurality of said wire elements with a tube of metal of the same character as that of the first-named tube to form therewith a composite multiple assembly, pointing an end of said multiple assembly to securely fasten the end of said second-mentioned tube to the ends of said composite wire elements, successively drawing said multiple assembly through a series of dies to reduce the same to a predetermined diameter, and then removing the ductile metal from the embedded wires of brittle metal.

4. A wire for photoflash lamps consisting of substantially pure aluminum and having a diameter of less than about two mils.

5. A wire for photoflash lamps consisting of substantially pure aluminum and having a diameter of the order of one mil.

MARVIN PIPKIN.