May 17, 1949. D. K. CRAMPTON ET AL 2,470,689

PROCESS FOR TIN-COATING THE INTERIORS OF COPPER TUBES

Filed Feb. 16, 1943 4 Sheets-Sheet 1

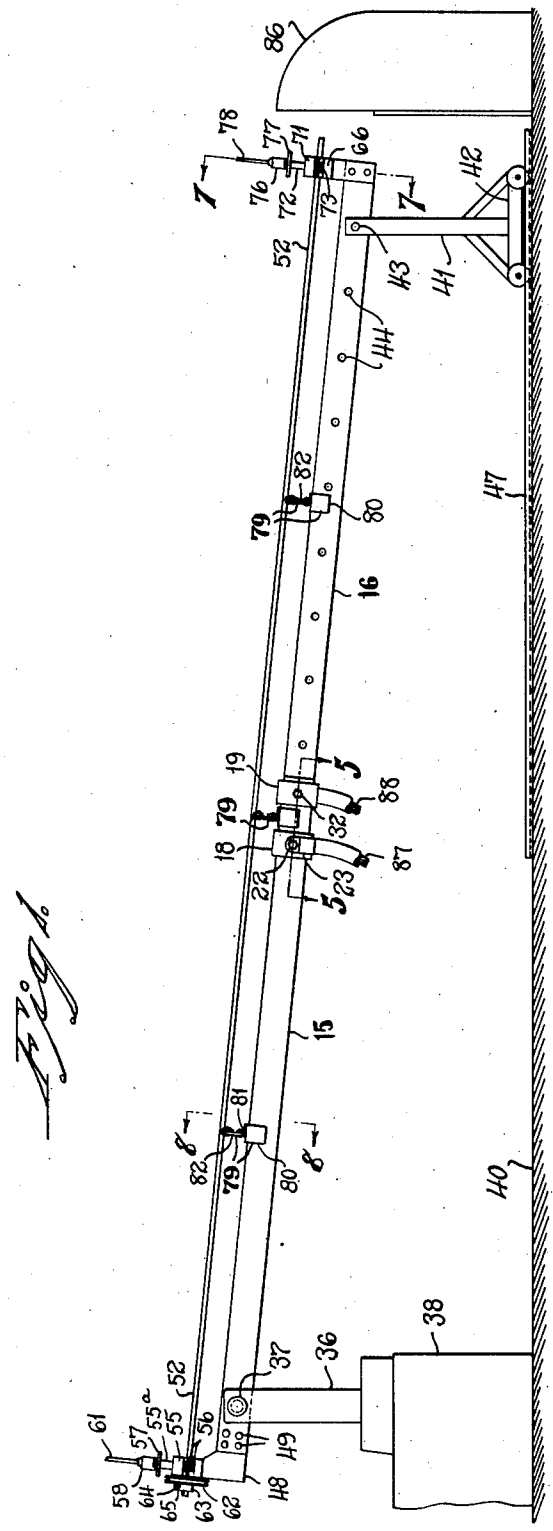


Fig. 1.

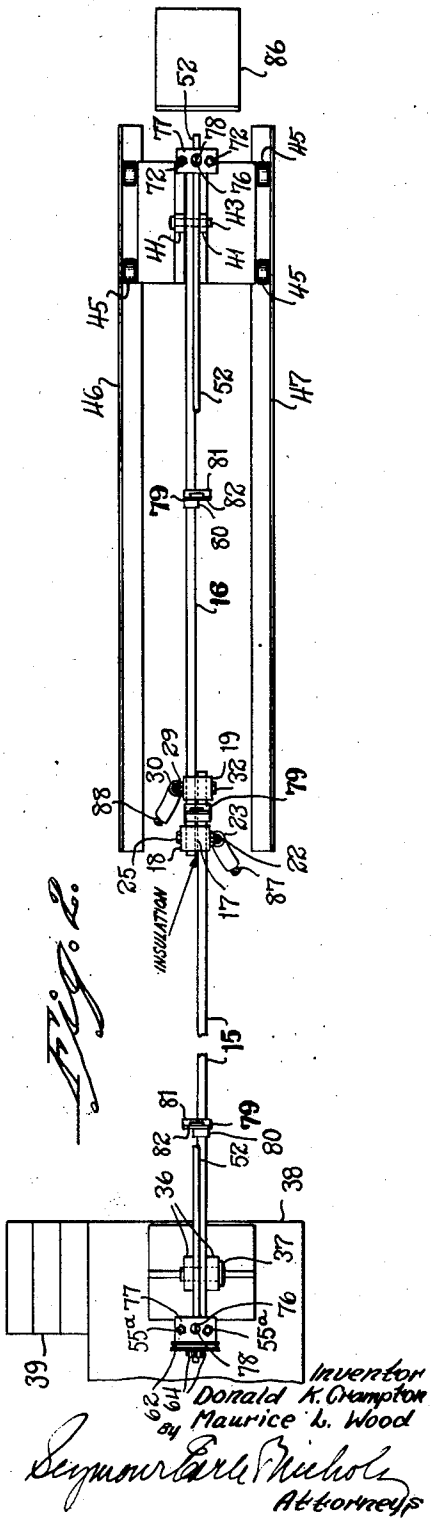


Fig. 2.

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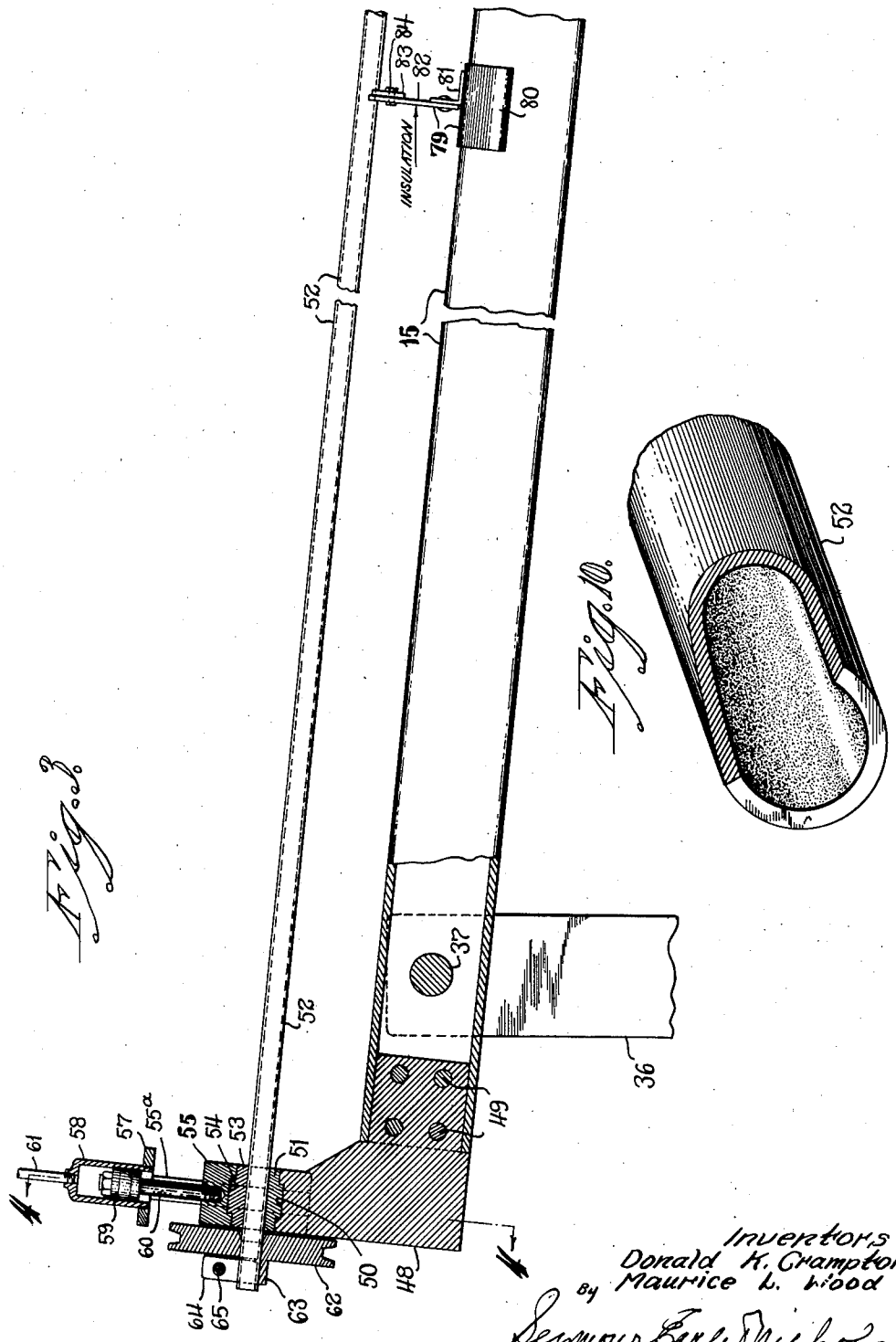


Fig. 10.

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PROCESS FOR TIN-COATING THE INTERIORS OF COPPER TUBES

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Fig. 4.

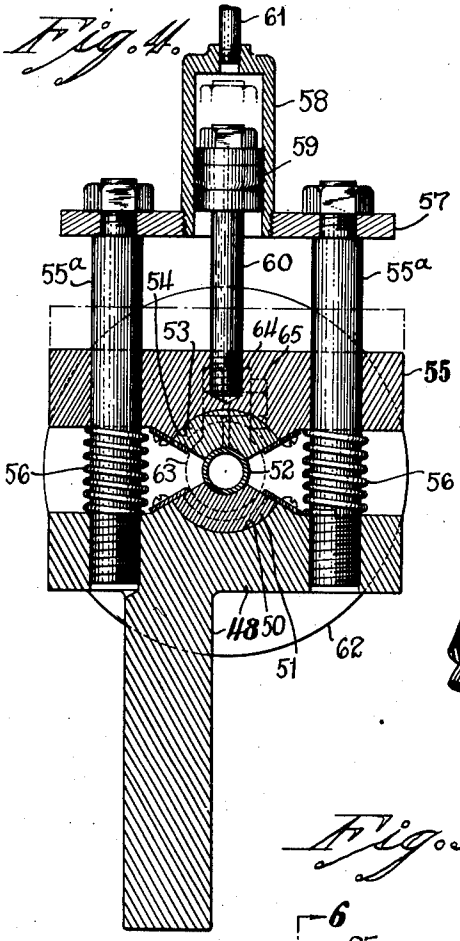


Fig. 6.

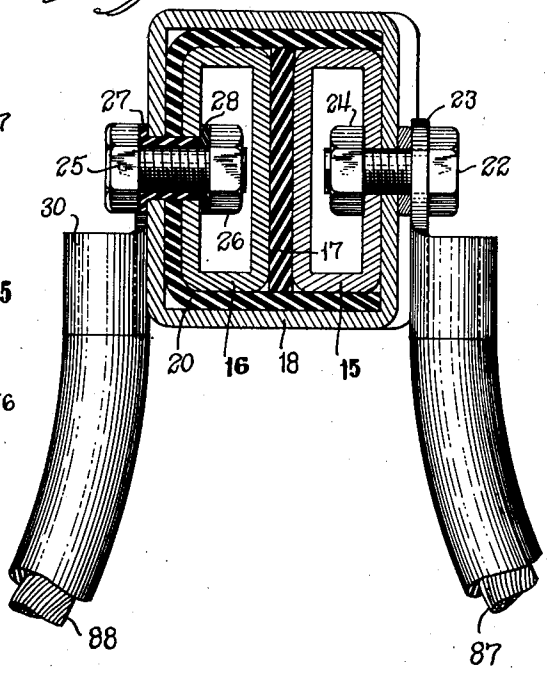
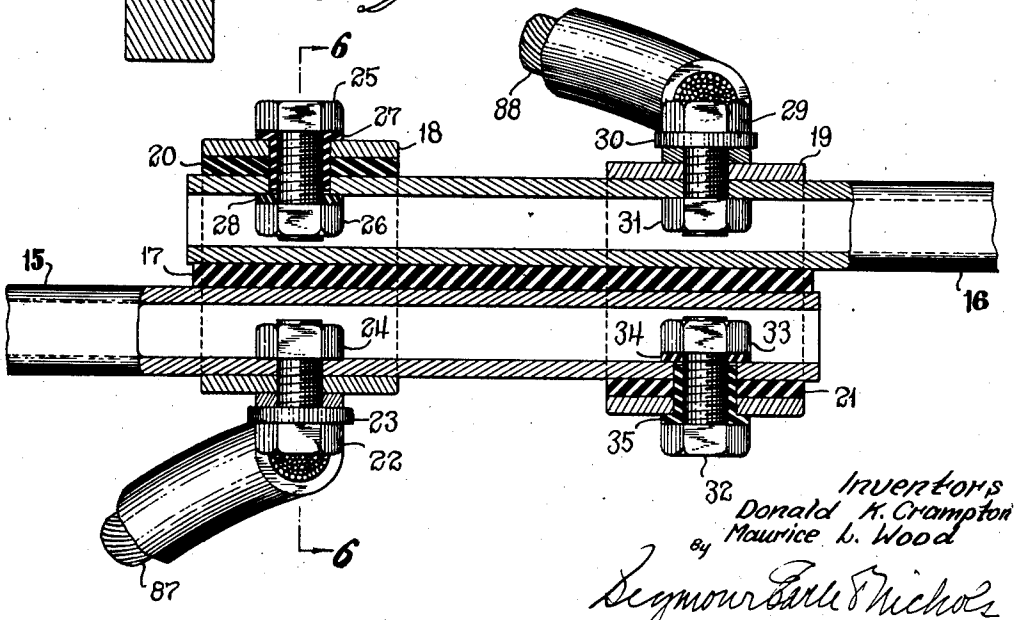


Fig. 5.



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Fig. 1.

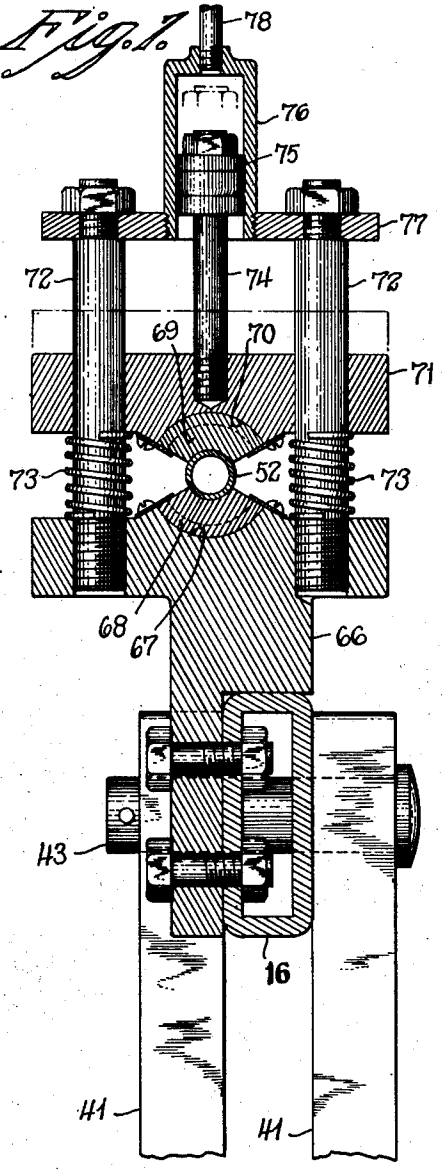


Fig. 8.

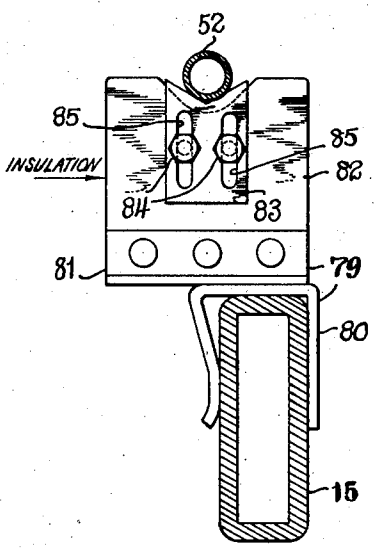
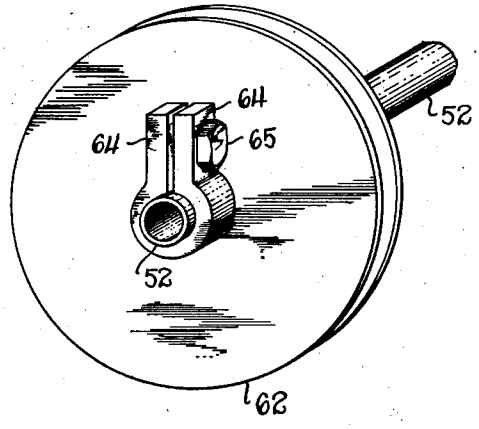


Fig. 9.



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UNITED STATES PATENT OFFICE

2,470,689

PROCESS FOR TIN-COATING THE INTERIORS OF COPPER TUBES

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Application February 16, 1943, Serial No. 476,046

2 Claims. (Cl. 117—97)

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The present invention relates to improvements in processes for coating the interiors of tubes, and relates more particularly to improvements in processes whereby coating of tin or tin alloys may be applied to the interiors of tubes formed of copper or copper alloys.

One of the objects of the present invention is to provide a superior process whereby tubes of copper-base materials may be provided interiorly with a continuous and effective coating of tin-base materials in a rapid and economical manner.

Another object of the present invention is to provide a superior process whereby relatively-thick coatings of the character referred to may be applied and solidified on the interior surfaces of copper-base tubes with a minimum of dross loss and without deleteriously affecting the tubes.

A further object of the present invention is to provide a superior process whereby hard-drawn tubes of copper-base materials may have their interiors provided with a continuous and effective coating of tin-base materials without causing such hard-drawn tubes to become appreciably annealed and thereby deprived of their desired hardness and rigidity.

A still further object of the present invention is to provide a superior process of the character referred to whereby the coating of tin-base material may be applied to the interior surfaces of copper-base tubes without also coating the exterior surfaces of such tubes and without causing the appreciable discoloration thereof.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features in the said disclosure which are novel over the prior art.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

Fig. 1 is a broken view in side elevation of one form of apparatus suitable for carrying out the process of the present invention;

Fig. 2 is a broken top or plan view thereof;

Fig. 3 is a broken detail view mainly in vertical central-longitudinal section and partly in side elevation of the left-hand portion of the apparatus shown in Figs. 1 and 2;

Fig. 4 is a transverse sectional view taken on the line 4—4 of Fig. 3;

Fig. 5 is a broken detail sectional view taken on the line 5—5 of Fig. 1;

Fig. 6 is a transverse sectional view taken on the line 6—6 of Fig. 5;

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Fig. 7 is a broken transverse sectional view taken on the line 7—7 of Fig. 1;

Fig. 8 is a similar view taken on the line 8—8 of Fig. 1;

Fig. 9 is a broken perspective view of the tube-driving pulley, together with a portion of a tube; and

Fig. 10 is a perspective view partly in section schematically showing a coated tube produced in accordance with the present invention.

The particular apparatus chosen for purposes of illustrating one mode of carrying out the present invention comprises two tubular bus-bar sections 15 and 16 extending in parallelism with each other, though slightly laterally displaced with respect to each other so that the inner portion of each overlaps the adjacent inner end of the other bus-bar member. The said bus-bar members are, in the instance shown, of rectangular form in cross section and are preferably formed of copper or other high electro-conductive material.

Interposed between the respective overlapping inner portions of the bus-bar members 15 and 16, is an insulating-plate 17 which serves to physically hold the inner portions of the said bus-bar members apart and to insulate the same one from the other. Embracing the overlapping inner portions of the bus-bar members 15 and 16, as well as embracing the insulating-plate 17, are two tubular clamping-members 18 and 19. The said clamping-members 18 and 19 are each of rectangular form in cross section, as is shown particularly well with respect to the clamping-member 18 in Fig. 6.

The tubular clamping-member 18 is in electrical engagement with the bus-bar member 15 but is insulated from the complemental bus-bar member 16 by a substantially U-shaped insulating-plate 20, as is particularly well shown in Figs. 5 and 6. Conversely, the tubular clamping-member 19 is in electrical contact with the bus-bar member 16 but is insulated from the complemental bus-bar member 15 by an insulating-plate 21 corresponding to the insulating-plate 20 before described.

The outer wall of the bus-bar member 15 is rigidly clamped in electrical engagement to the adjacent side wall of the tubular clamping-member 18 by means of a clamping-bolt 22 extending laterally through both thereof, as well as through the perforated upper end of a conventional terminal-lug 23. Threaded onto the inner end of the clamping-bolt 22 at a point within the bus-bar member 15 is a nut 24, as shown in Figs. 5 and 6.

The tubular clamping-member 18 is also rigidly connected to, though insulated from, the outer wall of the bus-bar member 16 by means of a clamping-bolt 25 and a complemental nut 26. The clamping-bolt 25 extends inwardly through the adjacent wall of the clamping-member 18, thence through the insulating-plate 20 and finally through the outer wall of the bus-bar member 16, and the nut 26 is applied to the inner end of the said clamping-bolt at a point within the said bus-bar member 16. The clamping-bolt 25 is insulated from both the clamping-member 18 and the bus-bar member 16 by means of an insulating-bushing 27, while the nut 26 is insulated from the bus-bar member 16 by means of an insulating-washer 28, as shown in Figs. 5 and 6.

The bus-bar member 16 is both mechanically and electrically connected to the tubular clamping-member 19 by means of a clamping-bolt 29 which extends inwardly through the perforated upper portion of a terminal-lug 30, thence through the adjacent side wall of the clamping-member 19 and finally through the outer wall of the bus-bar member 16. On the inner end of the clamping-bolt 29 at a point within the bus-bar member 16, is a nut 31, as shown in Fig. 5.

In a manner similar to the connection of the clamping-member 18 to the bus-bar member 16, the clamping-member 19 is mechanically connected to but insulated from the bus-bar member 15. The connection is accomplished by means of a clamping-bolt 32 extending inwardly through the clamping-member 19, thence through the insulating-plate 21 and finally through the outer wall of the bus-bar member 15. The inner end of the clamping-bolt 32 has tightly threaded thereon a nut 33 which is insulated from the bus-bar member 15 by means of an insulating-washer 34. In turn, the clamping-bolt 32 is insulated from both the clamping-member 19 and the bus-bar member 15 by means of an insulating-bushing 35, as is shown in Fig. 5.

As thus secured together, the bus-bar members 15 and 16 together constitute a single rigid structure in which the respective members are insulated one from the other at their respective inner portions.

At its left end (as viewed in the drawings), the bus-bar member 15 is supported by the bifurcated upper end of a post 36 to which it is releasably coupled by a transverse pin 37. The post 36 may rest upon the upper surface of a platform 38 adjacent the left end of the apparatus. For convenience, steps 39 lead upwardly to the platform 38 from the floor 40 or other supporting surface, which latter is preferably of wood or other suitable material which will be effective as insulation at low potentials.

The right end of the unit comprising the bus-bar members 15 and 16, as well as the parts carried thereby, is supported by means of complemental vertical posts 41—41 which extend vertically upwardly from a carriage 42. The right end of the bus-bar member 16 is coupled to the respective upper ends of the posts 41—41 by means of a transverse pin 43 extending laterally through any desired one of a plurality of apertures 44 formed in a bus-bar member 16 at longitudinally-spaced intervals along the length thereof, as is shown in Fig. 1. To provide for bringing the upper ends of its posts 41—41 into registration with any desired one of the apertures 44—44 in the bus-bar member 16, the carriage 42 upon which the said posts are mounted, is provided with four (more or less) wheels 45. The wheels

45 are disposed one at each of the respective four corners of the carriage 42, as is shown in Fig. 2. Two of the parallel wheels on one side of the carriage 42 ride on a track 46, while the opposite pair of wheels ride on a track 47 extending parallel with the track 46.

At its left end, the bus-bar member 15 has rigidly attached thereto a head-fixture 48 having a portion extending upwardly beyond the upper surface of the bus-bar member 15 and also having a portion extending into the open left end of the said member and secured thereto by a plurality of rivets 49. As will be seen especially well by reference to Fig. 4, the upper portion of the head-fixture 48 is provided in its upper face with an arcuate recess 50 extending transversely of the head-fixture and opening upwardly. In the recess 50 is mounted a lower contact-shoe 51 which is preferably formed of graphite to provide both conductivity and lubrication. The upper face of the contact-shoe 51 is curved in a direction transverse of the structure to conform to a portion of the periphery of a tube 52, the interior of which it is desired to coat.

Arranged over the lower contact-shoe 51 and in oppositon thereto is an upper contact-shoe 53 having its lower face conforming to and contacting the tube 52, as is particularly well shown in Fig. 4. The upper contact-shoe 53 is mounted in a downwardly-opening transverse arcuate recess 54 formed in the under face of a vertically-movable carrier-plate 55. The said upper contact-shoe 53, like its complemental contact-shoe 51, is preferably formed of graphite or other suitable electro-conductive and self-lubricating material.

The carrier-plate 55 above referred to is adapted to reciprocate vertically on two vertical and laterally-spaced-apart guide-studs 55*a*—55*a* passing through the carrier-plate 55 with a smooth sliding fit and having their respective lower ends threaded into the head-fixture 48 before referred to, all as is particularly well shown in Fig. 4. Encircling each of the studs 55*a*—55*a* at a point intermediate the under face of the carrier-plate 55 and the upper face of the head-fixture 48 is one of two helical retiring-springs 56—56 exerting a constant effort to lift the carrier-plate 55 upwardly into a retired position.

At their respective upper ends, the guide-studs 55*a*—55*a* have rigidly secured thereto a mounting-plate 57, in the central portion of which is screwed the open lower end of an inverted cup-shaped cylinder 58. Reciprocating within the cylinder 58 just referred to is a piston 59 having a depending-stem 60 threaded into the central portion of the carrier-plate 55. As shown, the upper end of the cylinder 58 has connected to it a pressure-pipe 61 leading to any suitable source of compressed air or other fluid which will serve, when desired, to forcibly lower the carrier-plate 55 against the tension of the springs 56—56 to engage the upper contact-shoe 53 with the tube 52.

To provide for the rotation of the tube 52 which is to be interiorly coated, a circumferentially-grooved tube-driving pulley 62 is mounted at the left end of the said tube at a point outwardly with respect to the head-fixture 48 and associated parts. On its outer face, the pulley 62 is formed with an outwardly-extending web 63 formed integral therewith. Upstanding from and formed integral at their lower ends with the web 63, are a pair of complemental flexible clamp-

ing-arms 64—64 adapted to be drawn together into clamping engagement with the periphery of the outer end of the tube 52 by means of a clamping-screw 65. The tube-driving pulley 62 may be driven by means of a V-belt from any suitable source of power.

At its extreme right end the bus-bar member 16 has rigidly bolted thereto a head-fixture 66 complementing the head-fixture 48 before described, at the upper or left end of the assembly comprising the bus-bar members 15 and 16. Like the head-fixture 48 before described, the head-fixture 66 is provided in its upper face with an arcuate transverse and upwardly-opening recess 67 receiving a lower contact-shoe 68 having its upper surface transversely curved to conform to the curvature of the tube 52, as is shown particularly well in Fig. 7. Located above and arranged in opposition to the lower contact-shoe 68 is an upper contact-shoe 69 having its under face contoured to conform to the curvature of the tube 52 and preferably, as is also the contact-shoe 68, formed of graphite.

The upper contact-shoe 69 just above referred to is mounted in a transverse downwardly-opening arcuate recess 70 formed in the under face of a vertically-movable carrier-plate 71. The carrier-plate 71 has extending therethrough with a free sliding fit on each of the respective opposite sides of its contact-shoe 69, one of two vertically-extending guide-studs 72—72 which are threaded at their lower ends into the head-fixture 66. Encircling each of the guide-studs 72—72 at a point intermediate the under face of the carrier-plate 71 and the upper face of the head-fixture 66, is one of two helical retiring-springs 73—73. The said retiring-springs 73—73 exert a constant effort to raise the carrier-plate 71 upwardly to disengage the upper contact-shoe 69 from the tube 52.

Threaded at its lower end into the central portion of the carrier-plate 71, is the stem 74 of a vertically-reciprocating piston 75. The said piston 75 reciprocates in an inverted cup-shaped cylinder 76 threaded at its lower end into the central portion of a mounting-plate 77. The said mounting-plate 77 extends transversely between and is rigidly mounted upon the respective upper ends of the guide-studs 72—72 as is shown in Fig. 7. The cylinder 76 has connected to its upper end a pressure-pipe 78 leading to any convenient source of compressed air or the like.

Adjustably mounted along the length of the unit comprising the bus-bar members 15 and 16 respectively at spaced-apart intervals thereon, is a plurality of corresponding tube-supporting fixtures 79. Each tube-supporting fixture includes an inverted U-shaped clip 80 formed of spring material and fitting over the adjacent upper edge of one or the other of the bus-bar members 15 and 16, as is especially well shown in Fig. 8. Brazed or otherwise secured to the upper face of the clip 80 of each of the fixtures 79, is a transversely-extending bracket 81 to which is riveted a vertical plate 82 extending transversely of the bus-bar structure in a direction substantially perpendicular to the longitudinal axis of the tube 52 and formed of insulating material.

Bolted against one face of the plate 82 is a tube-supporting plate 83 which is preferably formed of wear-resistant material and which has its upper edge notched to support and laterally stabilize the adjacent portion of the tube 52. The tube-supporting plate 83 is, as shown in Fig. 8, secured to the plate 82 by means of bolts 84—84

which respectively extend through vertical clearance-slots 85—85 formed in the plate 83 to permit the latter to be vertically adjusted.

Located adjacent the right-hand or lower end of the tube 52 is a receptacle 86 having the upper portion of its face which is directed toward the adjacent end of the tube 52, open to receive excess tin or tin alloy in a manner as will hereinafter appear.

Operation

A clean copper-base tube is selected and while the respective left and right carrier-plates 55 and 71 are in their elevated positions as indicated by broken lines in Figs. 4 and 7 respectively, the said tube is positioned so that its respective opposite ends rest upon the lower contact-shoes 51 and 68. The tube 52 or its equivalent is of copper-base material, i. e., commercially-pure copper or an alloy predominantly of copper such, for instance, as brass, commercial bronze, cupro-nickel, etc.

Following the positioning of the tube as above described, air or other fluid pressure is supplied to the cylinders 58 and 76 through their respective pressure-pipes 61 and 78. The application of the pressure just referred to will serve to depress both of the carrier-plates 55 and 71 to thereby cause the upper or left end of the tube to be gripped (with capacity for rotation, however) between the lower contact-shoe 51 and the upper contact-shoe 53. At the same time, the lower or right end of the tube will be gripped (with freedom for rotation) between the lower contact-shoe 68 and its complemental upper contact-shoe 69. In this manner, the upper or left end of the tube 52 is electrically connected to the left bus-bar member 15, and the lower or right end of the tube is electrically connected to the right bus-bar member 16, which bus-bars, as previously noted, are insulated one from the other at the center of the bus-bar structure where the respective members overlap.

The tube-driving pulley 62 may now be slipped over the projecting upper end of the tube 52 and the clamping-arms 64—64 thereof tightened into gripping engagement with the tube by means of the clamping-screw 65.

The tube-driving pulley 62 may now be driven to correspondingly rotate the tube 52 from any convenient source of power and at a predetermined rate. A relatively-high heating current is now supplied to cables 87 and 88, respectively extending to the terminal-lugs 23 and 30. As previously noted, the terminal-lug 23 is electrically connected to the inner end of the left bus-bar 15, while the terminal-lug 30 is similarly connected to the inner end of the right bus-bar member 16.

A suitable flux may now be poured into the upper or left end of the tube 52 preferably while a relatively-high "heating current" is applied to the tube 52 through the cables 87 and 88 and while the said tube is being rotated. When the tube 52, or its equivalent, reaches the desired temperature, i. e., a temperature above the melting-point of the tin-base material to be applied to the interior of the tube, the current-supply to the cables 87 and 88 and hence to the respective opposite ends of the tube 52, is cut down in value to what may be aptly termed a "sustaining current," which has a heating-value substantially such as will maintain the previously-heated tube at the elevated temperature which it has reached by virtue of the initial and relatively-high "heating current."

Tin-base material in a molten condition (tin or tin alloys such, for instance, as tin-lead alloys or tin-lead-antimony alloys) may now be introduced into the left or upper end of the tube 52 while the sustaining current is "on." The said molten tin-base material will flow downwardly through the interior of the tube and coat the interior thereof, which interior has been fluxed, as previously described. The quantity of tin-base material poured into the upper end of the tube is preferably in an amount in excess of what by test has been determined to be required for the coating, so that excess tin-base material will drip from the lower or right-hand end of the tube.

When the tin-base material poured into the upper end of the tube 52 fully shows at the lower end thereof, a blast of carbon dioxide, or other suitable gas, is blown into the upper end of the tube 52 while the latter is still rotating and still under the influence of the sustaining current, so that excess tin-base material will be blown out of the lower end of the tube and into the receptacle 86.

The current-supply to the cables 87 and 88 and hence to the tube 52, may now be completely shut off, whereupon pressure to the respective cylinders 58 and 76 may be released, to thereby permit the upper contact-shoes 53 and 69 to be retired out of engagement with the upper and lower ends of the tube, respectively. The tube-driving pulley 62 may now be removed from the upper end of the tube and the said tube completely removed from the apparatus, with its now-solidified interior coating of tin-base material.

By a procedure such as above outlined, a tube of copper-base material may be readily supplied with an interior coating of tin-base material of very appreciable thickness and of a smooth continuous and non-defective character. The thickness of the coating may be varied within relatively-wide limits by varying the inclination of the tube, its speed of rotation, the temperature to which the tube is heated, and the time during which the elevated temperature is maintained following the introduction of the tin-base material. In addition to the foregoing factors, the temperature of the molten tin-base material, when the same is introduced into the tube, will also affect the thickness of the coating when other factors are equal.

The thickness of the coating on the interior of the tube may be varied from about 0.0005" to about 0.002", whereas, with prior practice, it has been economically practical to achieve a smooth coating of only about 0.0001" in thickness.

By heating the tube by means of its own resistance, rather than by flame or by induction, the said tube at substantially all points between the respective pairs of contact-shoes at its respective opposite ends, achieves a substantially-uniform temperature and thus contributes materially to the uniformity of the coating, in combination with the other essentials of the process as set forth in the appended claims. One of the very troublesome factors in the coating of tubes of copper-base material has been overcome by the present method, namely, that of having the tin-base material erode, scour, or dissolve portions of the copper-base material at points in the tube where the temperature is excessively high, as has occurred in connection with

the uses of prior processes. Ordinarily and after coating, the very small portions of the tube 52, or its equivalent, which are gripped between a pair of contact-shoes, as well as the portions of the tube extending outwardly therebeyond, should be severed from the finished tube, inasmuch as the heating and coating of these parts is ordinarily not as uniform as are the portions of the tube extending between the respective pairs of contact-shoes.

Angle of inclination of the tube

The optimum angle with reference to the horizontal has been found to vary somewhat with the length of the tubes being coated. Suitable angles of inclination are as follows for tubes of commercially-pure hard-drawn copper tubing:

Length of Tube	Angle Range	Preferred Angle
	Degrees	*Degrees*
15'	20 to 30	30
20'	25 to 35	35
25'	30 to 40	40

Speed of rotation of the tubes

The optimum speed of rotation of a given tube is not markedly critical and for purposes of description let it be assumed that the tube in question has an internal diameter of .75" with a wall-thickness of about .05". With such a tube it has been found that 100 R. P. M. gave very satisfactory results and insured the uniform distribution of the tin-base coating within the tube, as well as the drainage of the excess coating from the lower end thereof, though it may be noted that a speed of about 150 R. P. M. produces substantially the same satisfactory result.

Fluxing

Many suitable fluxes are available for use in connection with the present process and as above noted, it is preferred, for purposes of economy and time, that the fluxing operation be done while the tube is subjected to the initial heat current.

One particularly effective fluxing compound may be composed of 10% by weight of ammonium chloride, 25% by weight of zinc chloride, 5% by weight of amyl phosphoric acid, and the balance of water.

It is preferred that prior to employing a suitable fluxing compound that the tube have its interior thoroughly cleaned in readiness for the reception of the flux.

Temperature of tubes during process

The temperatures to which the tubes are heated should be such as to be at or above the melting-point of the tin-base material but not sufficiently high to anneal the tube nor to materially oxidize or discolor the outside thereof.

When employing a commercially-pure tin coating, it has been found that if the molten tin is maintained at about 600° F. when poured into the interior of the tube, and if the temperature of the tube itself is maintained within the ranges of about 500° F. to about 575° F., excellent results are achieved without occasioning the scouring or erosion of the interior of the tubes. It may be here noted that in pouring the molten tin-base material into the tube, such pouring should be done under circumstances (well known in the art) which will serve to preclude the entry of dross into the tube.

Resistance heating of the tubes

The most satisfactory and economical results have been achieved by first applying to the given tube a relatively-high current which, as before noted, may be aptly termed the "heating current," followed by the application of a substantially-lower current-density which may be described as the "sustaining current."

By way of example, it has been found that in coating a 21'-long tube of phosphor copper having an internal diameter of about 0.75'' and a wall-thickness of about 0.05'', the initial heating current should amount to about 2500 amperes applied at from about 6 to 10 volts. This initial high amperage will very rapidly drop to about 2000 amperes, due to the rise in temperature and hence the increase in resistance of the tube. This initial heating current, under the conditions just described, should be maintained for about 15 to 20 seconds.

Following the application of the heating current to the tube, it has been found under the conditions above outlined that only about 170 amperes are required as a "sustaining current" to permit the full coating of the interior of the tube, and to maintain the same at a temperature above the melting-point of tin, despite heat losses due to radiation, convection, etc.

The blowing-out of the tube

The gas employed for ejecting excess tin-base material from the interior of the tube and smoothing the remaining coating, is preferably in the form of a non-oxidizing gas or vapor such, for instance, as carbon dioxide, steam, or nitrogen, though, in most instances, an air blast will serve the purpose without causing material oxidation of the coating.

Time cycle

It has been found that in most instances and with a properly-trained crew that tubes may be heated and coated at the rate of about one each 30 to 40 seconds without any sacrifice of quality of the coating and without appreciably oxidizing or discoloring the uncoated exterior of the tubes.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

We claim:

1. The process of coating the interior of a substantially straight copper-base metal tube, with tin-base metal, comprising: heating a substantially straight copper-base metal tube to a substantially-uniform temperature substantially throughout its length between its opposite end portions, which temperature is at least as high as the melting-point of the tin-base metal with which the interior of the tube is to be coated but not in excess of about 600° F., by means of the inherent resistance of the tube to the passage of electric current longitudinally through the tube, by applying electric current to the said opposite end portions of said tube and passing said electric current longitudinally through said tube; rotating the said heated tube about its longitudinal axis with said axis in a position inclined to the horizontal with one end of said tube higher than the other end with both of said ends open; and then introducing said tin-base metal in molten condition into the said open higher end of said rotating inclined heated tube into molten alloying coating contact with the interior surface of said tube, any excess of said molten tin-base metal draining out through said open lower end.

2. The process of coating the interior of a substantially straight copper-base metal tube, with tin-base metal, comprising: heating a substantially straight copper-base metal tube to a substantially-uniform temperature substantially throughout its length between its opposite end portions, which temperature is at least as high as the melting-point of the tin-base metal with which the interior of the tube is to be coated but not in excess of about 600° F., by means of the inherent resistance of the tube to the passage of electric current longitudinally through the tube, by applying electric current to the said opposite end portions of said tube and passing said electric current longitudinally through said tube; rotating the said heated tube about its longitudinal axis with said axis in a position inclined to the horizontal with one end of said tube higher than the other end and with both of said ends open; and then introducing said tin-base metal in molten condition into the said open higher end of said rotating inclined heated tube into molten alloying coating contact with the interior surface of said tube, any excess of said molten tin-base metal draining out through said open lower end; the electric current employed to heat said tube including an initial heating-current and a subsequent sustaining current; the said initial heating-current being more than twice as great as said subsequent sustaining current, and being sufficient and employed to heat the said tube rapidly to temperature substantially at least as high as the melting-point of the said tin-base metal; and the said subsequent sustaining current which is less than half as great as said initial heating-current being sufficient and employed to maintain the said tube substantially at said temperature at least as high as the melting-point of said tin-base metal during the coating process subsequent to the said initial heating operation.

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