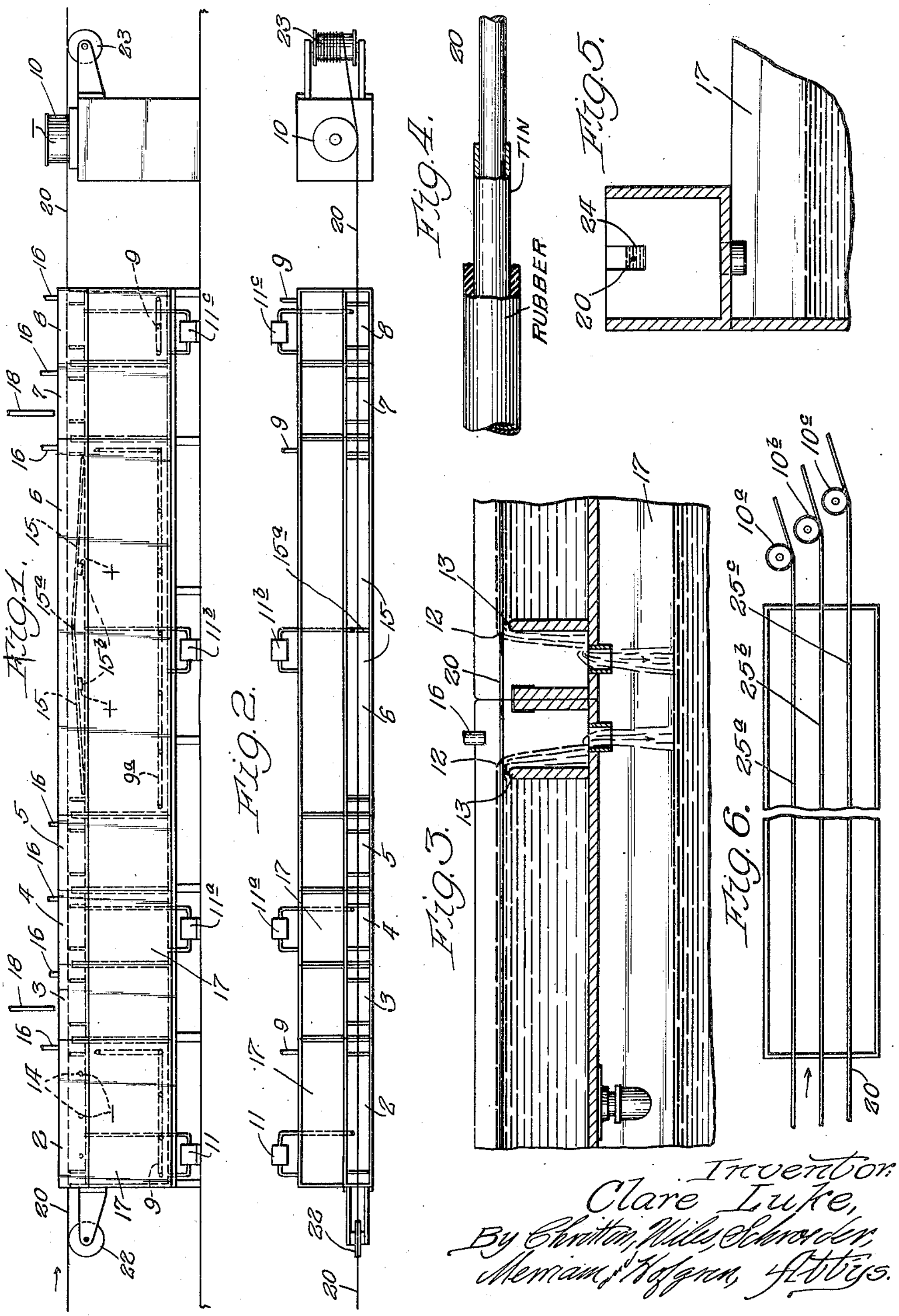
Feb. 21, 1950 C. LUKE 2,497,894

METHOD OF ELECTROPLATING FINE WIRE OF LOW ELASTIC LIMIT

Filed Oct. 14, 1944 2 Sheets-Sheet 1



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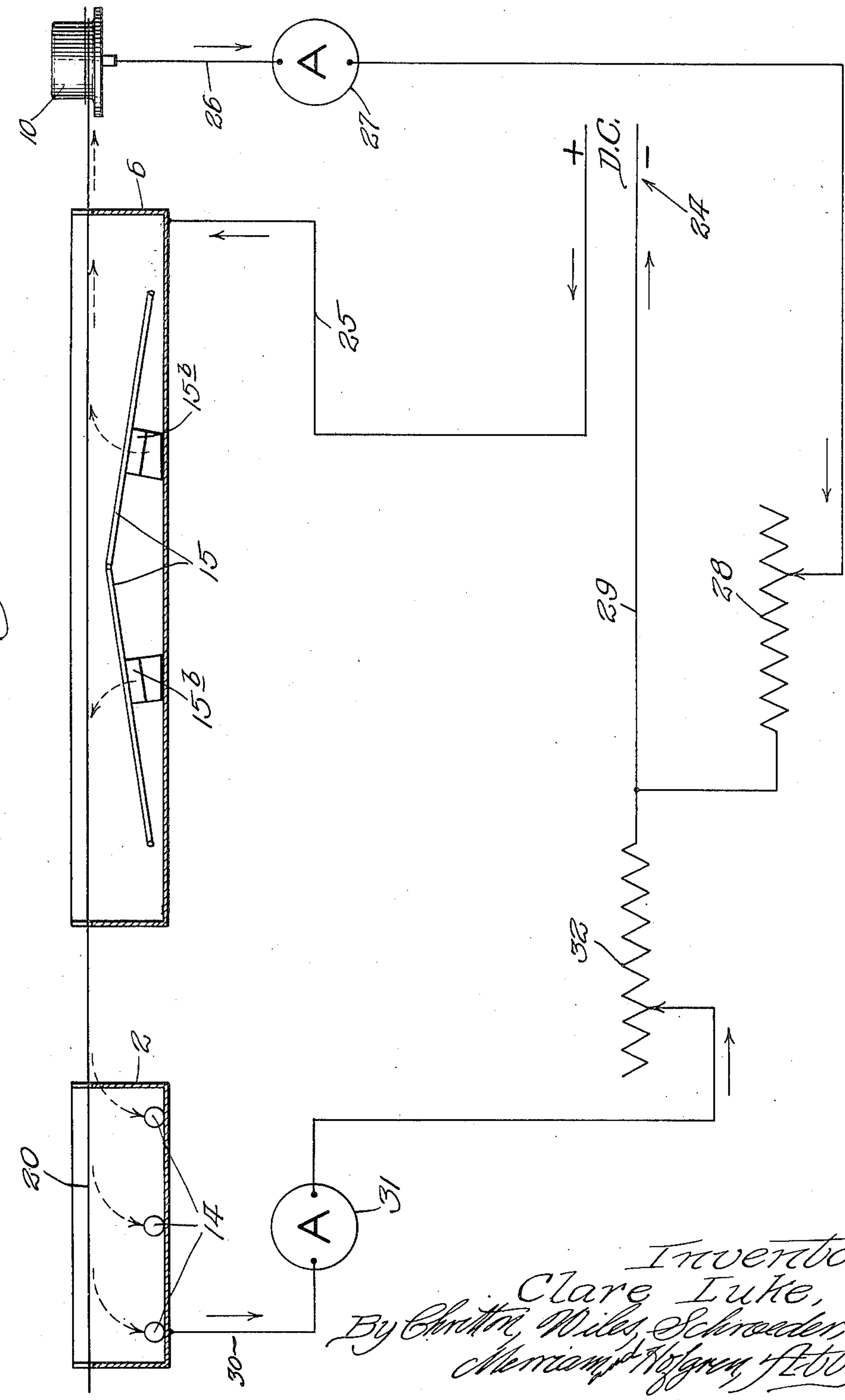

Fig. 7

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METHOD OF ELECTROPLATING FINE WIRE OF LOW ELASTIC LIMIT

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6 Claims. (Cl. 204—28)

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This invention relates to a method of handling wire of fine diameter and low elastic limit.

Wire is customarily stored and transported on spools on which the wire is wound in a plurality of overlapping courses, each extending from one end of the spool to the other. In any treatment the wire must be taken off of one spool and placed upon another. In handling very fine wires, particularly of metal such as copper, the mere transfer from one spool to another is a matter of some difficulty and is likely to lead to considerable breakage. For example, an annealed copper wire having a diameter of 0.005 inch and having an elastic limit of 20,000 lbs. per sq. in., will stretch beyond its elastic limit if the tension upon it exceeds ¼ lb. Even with a similar wire of 0.020 inch diameter, the tension cannot exceed 4 lbs. The present invention provides a method by which wires of these small diameters and low elastic limit may successfully be handled and even passed through a series of baths without being stretched beyond their elastic limits.

This is accomplished by mounting the take-off spool in such manner as to feed wire at a predetermined level, passing the wire under tension below its deforming tension in a catenary path of extremely small depth to a take-up spool or drum. The wire may in its path be permitted to fall, to the extent of the depth of the catenary, into one or more baths which preferably include a cleaning bath, a pickling bath, a plating bath, and one or more washing baths. Plating is preferably by electrodeposition. It is of course impracticable to employ solid contacts within the catenary when dealing with wires of such small strength. Current is, therefore, passed through the wire by contacts which include one or more of the baths and one of the spools, preferably a power driven take-up spool or drum.

By means of the invention it has been possible for the first time to electroplate copper wire as small as 0.005 inch in spool length unbroken sections. This is of great value in the electric industry where the copper wires are to be coated with a rubbery insulation, particularly a sulfur containing elastomer insulation which is adversely affected by contact with copper.

The invention is illustrated in the drawings in which Fig. 1 is a side elevation of an apparatus suitable for practicing the invention; Fig. 2 is a plan view; Fig. 3 is an enlarged sectional side elevation showing in detail the method of suspension of the wire catenary in two of the baths; Fig. 4 is a diagrammatic enlarged view of the wire; Fig. 5 is a transverse end elevation of a modified form of overflow; Fig. 6 is a fragmentary plan view showing a modified system incorporating several wires; and Fig. 7 is a diagram of the electric circuit.

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The apparatus comprises a suitable mounting upon which a let-off spool (not shown) is carried. A series of tensioning and spacing members 22 of which only one is illustrated are provided adjacent the spool to maintain the wire 20 at substantially a predetermined vertical position. The wire 20 passes through a series of baths which will be later described to a power driven capstan 10 around which the wire is wrapped several times and from which it is passed to a take-up spool 23. It will be noted that between the spacing or tensioning devices 22 and the point of contact with the capstan 10 the wire is suspended in a catenary of very small depth. With 0.005 inch annealed copper wire the catenary should not be deeper than approximately ½ inch and is preferably about ¼ inch. For 0.020 wire the depth of the catenary may be somewhat greater.

The series of baths comprises an alkali cleaning bath 2 preferably containing an alkali cyanide solution; a cold water rinse 3, an acid pickle bath 4, a water wash 5, a plating bath 6, a cold water wash 7, and a hot water wash 8. Each of the baths is constantly supplied with fluid which overflows at the edges of the baths as shown in Figure 3. This overflow is, except in the case of the cold wash water, recycled by means of pumps 11. The surface tension of the liquid in each bath forms an inverted meniscus 12 at the overflow 13 and the wire passes into and out of each bath through such a meniscus. In some instances the depth of the meniscus may be increased by providing narrow slots in the end of the bath through which the overflow will run and within which the wires pass. Such a slotted overflow 24 is indicated in Figure 5.

As indicated in the wiring diagram, Fig. 7, in which direction of current flow is indicated by arrows, plating current from a direct current source 24 passes through a wire 25 to electric contacts 15 b in the plating bath 6; the current actually passing into the electrolyte through the anode 15. The current splits in the bath 6 as it passes into the wire 20, part of the current passing through the capstan 10 and the wire 26 to an ammeter 27 and a variable resistance 28, thence through the wire 29 as to the source of current. The remainder of the current passes through the wire 20 to the bath 2, through the electrolyte to the electrodes 14, from which it passes through a wire 30, an ammeter 31, a variable resistance 32, and through the wire 29 to the source of current. The ammeters 27 and 31 indicate the current levels in the baths 6 and 2, respectively, permitting the operator to maintain proper distribution of current to the two branches of the circuit by means of the variable resistors 28 and 32. In view of the current flow above described, it is clear that the electrode 15 in the bath 6 is positively charged, while the capstan 10 and the electrodes 14 are negatively charged.

The wire may be withdrawn from the let-off spool at a speed of 400 ft. to 500 ft. per minute. A suitable total tension is less than ¼ lb. The cleaning bath is designed to remove saponifiable impurities and suitably is an alkali cyanide, for example one containing 2 oz. of sodium cyanide per gallon. It is preferably heated to a temperature of the order of 140° F., as, for example, by steam coils 9. Overflow liquid is recycled by the pump 11 beneath the surface of the bath, it being introduced near the bottom. An air jet 16 having a small opening immediately above the wire and directed vertically downward removes cleaning liquid carried from the bath by the wire. An enlarged jet is shown in Figure 3. The amount of liquid carried from a bath by a small wire is extremely great and losses because of this would be sufficient to render the process unduly expensive, if the liquid were permitted to be lost. In conventional plating baths the liquid is removed by wipes of cloth or other material, but in the present system such methods cannot be employed because of the tension necessarily imposed. The air blast satisfactorily removes the liquid from small wires and the wires feel dry to the touch after passing through the air. Similar air jets are provided after each bath. In each case the jet is within the area bounded by the sump below the bath. Each bath, except the cold water washes, is provided with a sump 17, which need not be further described.

The wire passes from the first air jet 16 to the cold water rinse, thence under another air jet 16 into the acid pickle 4. This acid is preferably hydrochloric which is ordinary commercial hydrochloric diluted with from 1 to 4 parts of water. Overflow acid is recirculated by the pump 11*a*. The edges of this tank, as is the case with all of the other tanks, should have substantially the same level so that the overflows in all cases are within the catenary formed by the wire 25. The wire, after cleansing and neutralization in this bath, passes under another air jet 16 and into the water wash 5, into another jet 16 and into the plating bath 6.

For tin plating a fluoride tin bath of conventional composition may be employed. A suitable amperage is 500 per square foot but this may be varied to as low as 20 or as high as 1800. The amount of plating required for use in electric wiring is not great, generally being about 0.00002 inch. At 500 ft. per minute, and 500 amperes per square foot, the wire will acquire this coating in 9 feet of travel. The preferred bath has about this length.

As shown in the drawing, the electrode 15, which may be the bottom of the bath or may be a tray secured above the bottom of the bath, is sloped downwardly from the center in each direction. The amount of this slope is such as to equalize the voltage drop through the solution. It must of course be varied with variations in the size of the wire and, for that reason, is preferably hinged at 15*a* to permit adjustment.

The plating fluid is heated in the sump by steam coils 9*a* preferably to a temperature in the neighborhood of 140° F. The liquid is circulated by a pump 11*b* and reintroduced at the bottom of the tank 6.

The wire passes from the plating bath under another air jet 16 through the overflow of the cold water wash 7, under another air jet 16 through the overflow of the hot water wash 8, under another air jet 16 and to the capstan 10. The hot water wash is maintained at a temperature around 190° F. by steam coils 9 in the sump. Overflow is circulated to the bottom of the tank by the pump 11*c*. This hot water bath serves to assist the final air jet 16 by heating the wire to a point where any remnant or trace of water is evaporated.

The capstan 10 is of conventional tapered shape and is so spaced that its take-up level is substantially the same as the level produced by the tensioning and spacing devices 22. The capstan is driven by a motor at a predetermined speed and the wire then passes to the spool 23 which is driven in conventional manner by a slipping belt under constant tension so that there is no slack in the wire or any superimposed tension beyond the desired amount.

It will be observed that the wire 25 is suspended in a catenary of small depth, which catenary is constantly changing as the wire advances and which maintains its shape. The catenary passes through the overflow of each of the baths, all of its contact with the liquids being confined to a layer of liquid having the depth of the catenary. As already stated, it is preferred to use a catenary having a depth of approximately ¼ inch even over a space of approximately 30 feet.

Make-up water is supplied to the cold water tanks in any suitable fashion, as from overhead pipes 18.

The product produced by the herein described method is characterized by the fact that all of the plated metal occupies the same position with respect to underlying metal and to the center of the wire which it occupied at the time it was deposited. If it were attempted to electroplate a wire of the type here described by ordinary methods, the wire would stretch as much as 40–50% of its length so that deposited metal would be displaced longitudinally and vertically with respect to its initially occupied position.

A system may be employed with more than one wire, in which case a capstan may be employed for each wire. Such an instance is shown by Figure 6, in which wires 25*a*, 25*b* and 25*c* are respectively driven by capstans 10*a*, 10*b* and 10*c*. It will be seen that the distance between each capstan and the plating bath 6 will be different. This is compensated for by including a separate voltage regulator with each wire so that they may be separately adjusted.

The invention is primarily applicable to wires having a cross-sectional area not substantially more than 0.0004 square inch, and elastic limits of not substantially more than 20,000 lbs. per square inch.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom.

What I claim as new, and desire to secure by Letters Patent, is:

1. The method which comprises withdrawing a metal wire having a cross-sectional area not substantially greater than 0.0004 square inch and

an elastic limit of not substantially more than 20,000 lbs. per square inch from a let-off spool while maintaining the wire at a predetermined vertical position, passing the wire in catenary suspension of a depth not substantially exceeding one inch below said vertical position and at a speed of at least several hundred feet per minute to a rotating power driven take-up through the overflow meniscuses of at least one aqueous liquid bath, which is a metal plating bath, said wire being suspended between only two points and being free from contact with any solid body therebetween, supplying current to said wire during such passage through connections including only said bath and said take-up, while maintaining upon the wire a tension less than that required to stretch it beyond its elastic limit, and removing substantially all liquid from the wire at the exit of each bath.

2. The method of electroplating annealed copper wire having a cross-sectional area not substantially greater than 0.000025 square inch which comprises passing the wire at a speed of about 400–500 feet per minute from a first support through the overflow meniscuses of a series of aqueous baths, at least one of said baths being a plating bath and the others being cleaning baths, to a rotating power driven take-up, maintaining the wire out of contact with any solid body in a free suspension having a depth of not over one-half inch and under a tension of not more than one-fourth pound during such passage, and supplying electric current to said wire during such passage by means of connections including only said baths and said take-up.

3. The method which comprises withdrawing annealed copper wire having a cross-sectional area not substantially greater than 0.000025 square inch from a let-off spool while maintaining the wire at substantially a predetermined vertical position, passing the wire at a speed of about 400–500 feet per minute to a rotating power driven take-up through the overflow meniscuses of a series of overflowing baths while maintaining upon the wire a tension not exceeding one-fourth pound, at least one of said baths being a plating bath and the others being cleaning baths, supplying electric current to said wire during said passage by means of connections including only said baths and said take-up, and maintaining said wire free from contact with any solid object other than the let-off spool and the take-up.

4. The method of electroplating wire of low elastic limit having a cross-sectional area not substantially greater than 0.0004 square inch which comprises advancing the wire at a speed of at least several hundred feet per minute in a suspension of depth not substantially exceeding one inch from a first support through the overflow meniscus of at least one aqueous liquid bath which is a metal plating bath to a second support which is a rotating power driven take-up while maintaining the wire at a predetermined vertical

position and free from contact with any solid body other than said first suport and said take-up, introducing electroplating current to said wire from said bath and removing said current from said wire through one of said supports and maintaining a tension upon the wire insufficient to stretch it beyond its elastic limit.

5. The method of electroplating wire of extremely small cross-sectional area and low elastic limit which comprises passing the wire progressively, at a speed of at least several hundred feet per minute while maintained in a substantially catenary suspension of a depth not substantially exceeding one inch and free from contact with any solid object, through a series of baths, at least one of said baths being an aqueous plating electrolyte and the remainder of said baths being cleaning baths, and said baths having overflow portions with the meniscuses thereof within the catenary, to a driven take-up, supplying electric current to said wire during such passage by means of connections including only said baths and said take-up, collecting the overflow from each bath in a sump and returning it to the bath, removing liquid carried by the wire from each bath by means of a blast of air directed upon the wire to its appropriate sump, and collecting the wire upon the take-up.

6. The method of treating a wire of extremely small cross-sectional area and low elastic limit which comprises passing the wire at a speed of at least several hundred feet per minute in a substantially unimpeded catenary path of a depth not substantially exceeding one inch progressively through the overflow meniscuses of overflowing liquid baths, at least one of said baths being a plating bath and the others being cleaning baths, to a take-up, supplying electric current to said wire during said passage by means of connections including only said baths and said take-up, and maintaining said wire free from contact with any solid object while passing in said path.

CLARE LUKE.

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