Nov. 15, 1966 R. J. WADE 3,284,892

WIRE PROCESSING

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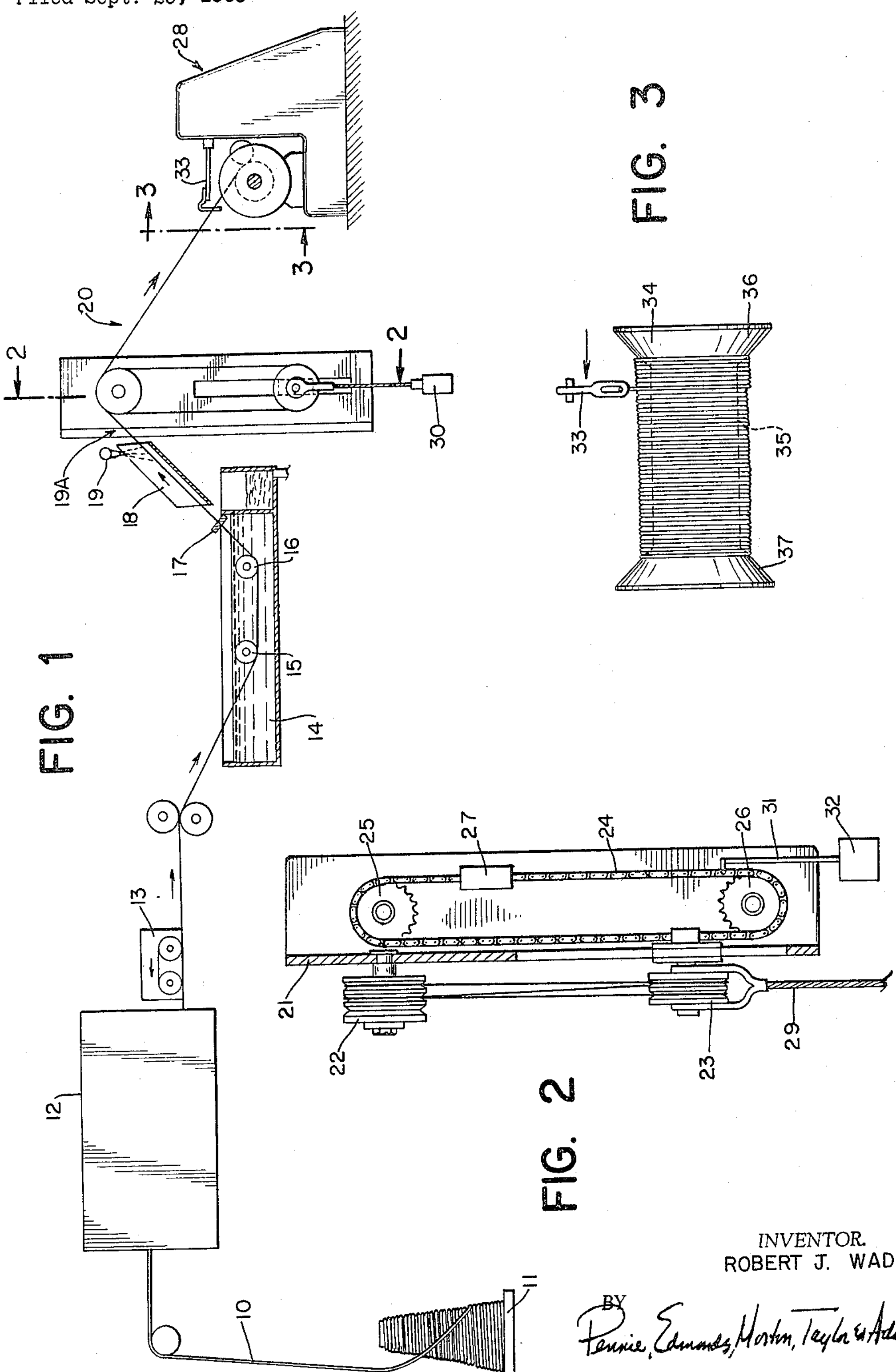

FIG. 1

FIG. 2

FIG. 3

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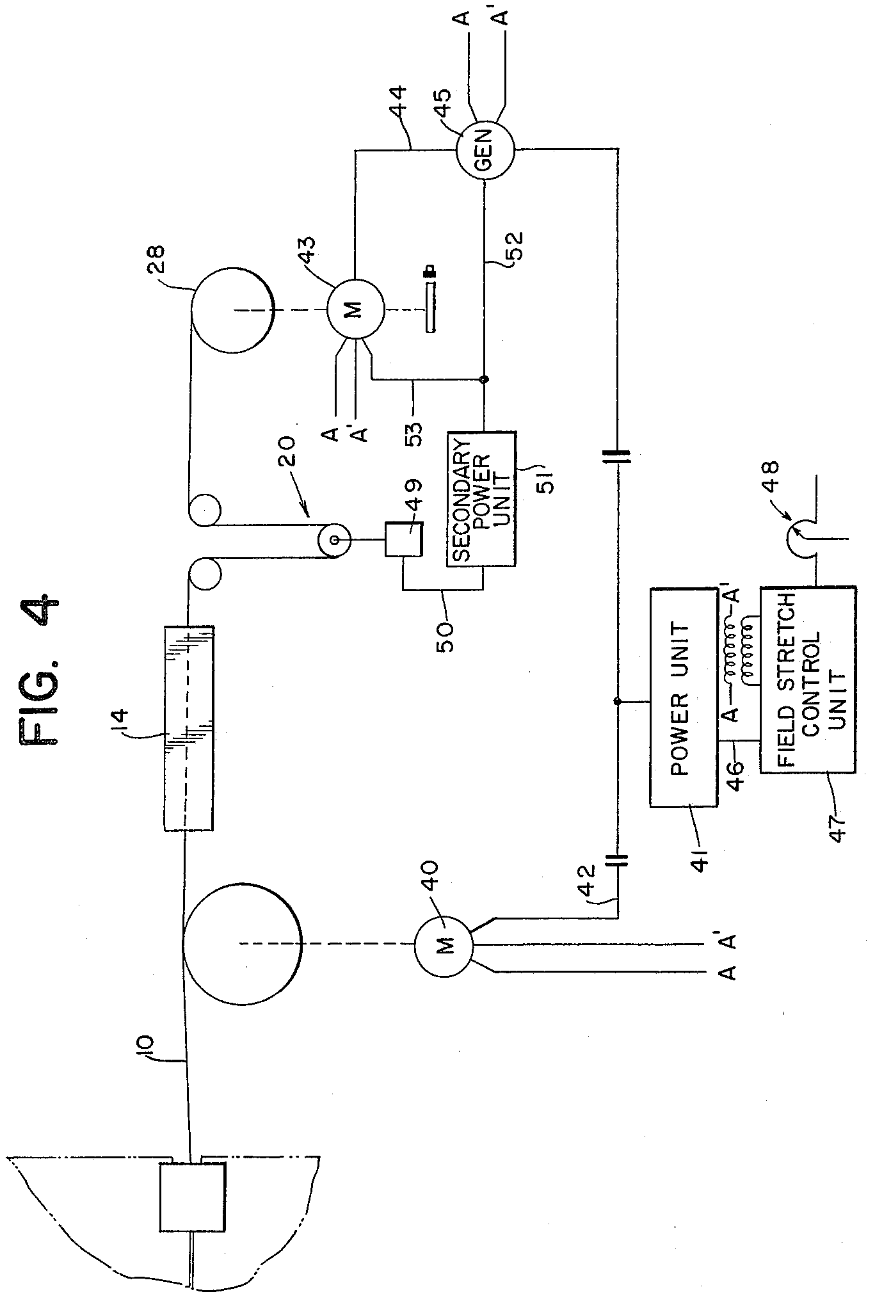
FIG. 4



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WIRE PROCESSING

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This invention relates to a method of continuously processing wire in which the wire is reduced in diameter, plated with a metal coating, and spooled at a fixed tension. It also relates to a system for performing the process of the invention and to the spooled wire product resulting from the practice of the method.

Generally, wire manufacturers have followed a procedure of separately drawing wire to its final size, annealing the drawn wire and plating it with a metal coating such as tin. After these separate operations were completed and often between each of the operations mentioned, the wire was spooled and either transferred to the subsequent operation or finally spooled to its finished packaged form. It was generally though impossible to perform all these operations continuously, particularly where the size of the wire is so small that it would easily break if the linear speed and tension on the wire were varied during one of the operations of the process. It is applicant's intention to provide a method for continuously processing wire in which sufficient control is maintained over the wire during each of its operations so as substantially to preclude snapping of the wire during its processing.

Broadly stated the method of processing wire according to the invention comprises feeding wire through a series of dies to draw the wire to a small diameter, applying a thin metallic coating to the wire, and annealing the wire. Throughout the operation, the invention provides a method of controlling the tension on the wire to maintain a substantially fixed tension on the moving wire, and subsequently spooling the wire at the fixed tension to form a wire spool having each of the turns of the winding wound at substantailly the same tension.

The invention also provides a system for processing wire as the wire is fed along a continuous path of travel comprising wire drawing means for reducing the wire to small sizes, metal coating means located adjacent to and downstream from the drawing means along the direction of movement of the wire for coating the wire with a thin metallic coating. Tension control means are located downstream from the metal coating means through which the wire is threaded to control the tension on the wire and maintain a substantially fixed tension on the moving wire, and spooling means are located adjacent the tension means and are operatively connected thereto for spooling the wire at a speed related to the fixed tension.

According to the method and system of the invention it is possible continuously to feed hard copper wire through a series of dies and draw the wire to a size below .015 inch in diameter. After drawing, the wire can be fed at speeds of up to about 2500 feet per minute through a molten tin bath to coat the surfaces of the wire with a thin tin coating. The bath is maintained at a temperature sufficiently high to anneal the wire as it is being plated in spite of the high linear speeds at which the wire is traveling. The tension of the moving wire is then fixed in relation to the speed of the wire and spooling of the wire is performed at the fixed tension to form a wire spool package in which the turns have been wound with the same tension.

In a preferred embodiment the wire is wound on a spool having a generally cylindrical body portion and flared flanged portions extending from the body portion, preferably at an angle of 45° to the axis of the body portion.

A multiplicity of turns of wires are wound about the body portion and along a part of the flared flanged portion. The package thus formed is characterized by having each of the turns contained on the spool being applied thereto with the same initial linear tension whereby the wire turn in any one layer is not forced below the wire turns of the underlying layer.

Formerly in the wire industry, the spool used had a generally cylindrical body portion with flange portions extending from the ends of the body portion at an angle perpendicular to the axis of the cylindrical body portion. The packages of wire formed on these perpendicular flange spools were characterized by high lateral pressure due to the winding caused by the wedging action between the perpendicular flanges. Also, should the spool become distorted or bent, it is relatively impossible to wind properly and the wire becomes buried or excessively built up along the flange. Inherent disadvantages were also present in payoff from the spool. Turns of the wire sometimes began to be trapped at the pocket formed along the juncture defined by the flange portions extending at an angle of 90° from the body portion. This was particularly true when using the flyoff or flipping technique in which it happened that the turns of the wire would not clear the flange. To remedy this situation the practice has been to limit the barrel to flange dimensions, and of course this limited the amount of wire which could be contained on the spool.

With the package of the invention lateral pressure which is present in the perpendicular flange spools is decreased due to the flange angle which will permit some limited lateral movement of wire upon increase in lateral pressure. Furthermore, minor distortions in the construction of the spool will not seriously interfere with the winding and when wound at a fixed tension it is virtually impossible to bury a strand at the flange. The new package is also particularly useful when using the flyoff or flipping technique since the wire turns will easily clear the flared flanges and also permits ultra high speed payoff of the wire.

A preferred embodiment of the invention is described hereinbelow with reference to the drawings wherein:

FIG. 1 is a side elevation partly schematical showing the system for performing the continuous wire processing of the invention;

FIG. 2 is a section taken substantially along the lines 2—2 of FIG. 1;

FIG. 3 is a section taken substantially along the lines 3—3 of FIG. 1; and

FIG. 4 is a schematical wire diagram showing the electrical winding of the system of FIG. 1.

The method and system for the process of the invention is shown in reference to FIGS. 1 to 4. In FIG. 1 an elongated length of wire **10** is being continuously stripped from a conically shaped payoff reel **11** and is fed into a wire drawing machine **12**. The wire drawing machine **12** shown is a commercial multiple die unit, preferably a 16 die position wire drawing machine of commercial design, in which a wire of say .032 inch diameter can be drawn to a diameter of .005 inch. The number of dies used is determined in accordance with established practices by the differences in diameter between the stock available for input and the desired final diameter of the wire. The wire **10** is pulled through the wire drawing machine **12** by means of a capstan **13** of generally commercial design which sets the linear speed of the wire as it emerges from the wire drawing machine and in this example the linear speed is 2400 feet per minute. The hard draw wire is then fed directly from the wire drawing machine **12** into a bath **14** of molten tin which not only coats it with tin but also simultaneously anneals it. The period of time which the element of wire remains in the tin bath is controlled by the linear speed and the length immersed. In order both to plate and anneal properly a delicate balance must be maintained between the period of residence and the temperature of the bath. Obviously, a minimum of time and temperature is required to coat the surface of the wire 10 and excessive exposure would result in solution of the wire. In the example being described, at the speed and with the size of wire being used, the wire was fed through a tin bath at a temperature of 380° C. and its immersion length was approximately two feet and its residence time about .05 second, and in another example the wire was run at a linear speed of 2400 feet per minute with a tin bath temperature of 360–370° C. and a residence time of .044 second.

A pair of guides 15 and 16 are immersed in the tin bath and served to guide the moving wire along a path of travel parallel to the path of the tin bath 14. A wiping die 17 is positioned at the surface of the tin bath downstream along the path of travel of the wire and has an aperture therein of substantially the same diameter as that of the tin wire. The wiping die does not reduce the wire diameter but merely smooths out and controls the thickness of the coating. As shown since the wire leaves the bath at an angle to horizontal the die is tilted so that the axis of its aperture is parallel to or coincident with the axis of the wire. It is to be noted that immediately after drawing, the wire is passed to the molten bath and thus there is little or no oxidation occurring on the surface of the wire and it is unnecessary to include a flux in the bath for the tinning operation.

Immediately upon leaving the wiping die 17, the wire 10 is fed through an inclined trough 18 twisted downstream from the die along the path of travel of the wire along which a steady flow of water is being fed from a spout 19. The water can contain a limited amount of a cleaning agent so that the wire being fed along a trough is not only cooled but also cleaned in the same operation. The wire 10 is then fed thru an air wipe at 19A to remove moisture from the wire.

The wire 10 is then fed into a dancer roll setup 20. The dancer roll arrangement is of substantially conventional design. It consists of a frame 21 in which the first roll 22 is rotatably mounted. Positioned beneath the first roll 22 is a dancer roll 23. The dancer roll 23 is mounted on an endless chain 24 which rides on a pair of spaced idler sprocket wheels 25 and 26. A weight 27 is positioned on the endless chain 24 to compensate for weight of the dancer roll 23 and to keep the dancer roll 23 positioned at a relatively fixed point. The wire is threaded around the first roll 22 and around the dancer roll 23 back around the first roll 22 and once again the dancer roll 23. Finally it passes around the first roll 22 again and is then fed to a rewind or spooling machine 28. By this arrangement the dancer roll is suspended by the turns of wire wound about it. Depending from the dancer roll 23 is a yoke-mounted cable 29 from which a fixed weight 30 is suspended. It is this fixed weight 30 in such a dancer roll apparatus which fixes the tension applied to the linearly moving wire 10. Extending from the endless chain 24 is a member 31 which is connected to an electrical position sensing device 32 to react in relation to the movement of the endless chain 24 and thus in relation to change in tension of the moving wire 10. The purpose of this switching arrangement will be understood more fully below in relation to FIG. 4 and the wiring diagram.

As the wire is fed to the spooling machine 28 it is threaded through a traversing guide arm 33 which leads the wire back and forth across a spool 34. As shown the spool is of a type having a generally cylindrical body portion 35, with flange portions 36 and 37 flaring outwardly from the cylindrical body portion 35 at an angle of 45°. With this type spool the number of turns between the flanges increases continuously as the spool fills up and thus means are provided within the spooling machine to increase the width of traverse of the guide arm 33 in relation to the size of the spool.

In this arrangement the linear speed of the wire is fixed by the drive of the capstan 13 and a fixed tension is applied to the moving wire by means of the dancer roll setup 20. This dancer roll setup is operatively connected to both the capstan drive motor and to the drive motor of the spooling machine. Thus, for any change in tension on the moving wire 10 the speed of the spool on the spooling machine will be varied in accordance with the change of this tension by electrical means so that the tension remains fixed and there will be no slack caused in the continuous wire and no opportunity for the wire to be stripped. The wire package spooled with this apparatus is characterized by turns of wire having initially the same tension as every other turn. The electrical equipment used is generally shown in schematic diagram of FIG. 4. The wire 10 is pulled through the die machine 12 by the capstan 13. The capstan is driven by a 10 H.P. D.C. motor 40 which sets the basic linear speed of the wire. The motor 40 is connected to a common power unit 41 by line 42 and receives its armature power from this power unit. As described above and indicated in this figure schematically, after the wire 10 is pulled through the die machine it is fed through a tin bath 14 around a dancer roll arrangement 20 and finally onto a rewind reel 28. The rewind reel is powered from a ¾ H.P. motor 43 which is connected by line 44 to the common power unit 41 and thus receives its armature power from this power unit. A booster generator 45 is also interconnected with the power unit 41 along line 44. Connected to the power unit 41 by line 46 is a field strength control unit 47 which is interconnected by its terminals A and A′ to the capstan motor 40, the rewind reel motor 43, and the booster generator 45. The field strength control unit 47 is regulated by rheostat 48. By means of the field strength control unit 47 both the capstan motor and the rewind reel motor as well as the generator can be regulated to run at speeds of a fixed ratio between each other.

Connected to the dancer roll 23 which is movable in relation to any variances in the tension of the wire 10, is a positioning sensing unit 32 which translates the physical change in position to an electrical impulse which is fed by line 50 to a secondary power unit 51. A secondary power unit is connected by lines 52 and 53 to the field of the booster generator 45 and to the field of the rewind motor 43. By this means as the tension on the wire 10 changes its position will be sensed by the positioning sensing unit 32 and the field of the motor 43 will be varied by the power unit 51 and its armature voltage will also be varied by the interconnection between the booster generator 45 and the secondary power unit 51. By controlling the armature at field strength of the motor 43 its speed can be closely controlled in relation to the tension on the wire.

By this system a fixed linear speed is placed on the moving wire passing through the system. This is easily done because of the electrical interconnection between the capstan motor and the rewind reel motor whereby the speed of both are run at a fixed ratio. Elongation of the wire sometimes occurs due to softening of the wire in the bath and as the layers of turns of wire build up on the spool adjustment in the speed of the rewind motor must be made. This is provided for by the tension sensing dancer roll setup which is electrically interconnected with the rewinding motor to vary its speed in relation to these changes.

By way of example hard copper starting wire ranging from .064 inch to .020 inch in diameter has been drawn to the sizes shown in the following table and successfully plated with tin according to the invention.

Starting size:	Drawn size
.064	.01
.051	.008
.04	.0063
.032	.005
.025	.004
.02	.0031

In a specific example hard copper wire drawn to a diameter of approximately .0063 inch in diameter was fed at speeds of 500 to 2400 f.p.m. with the temperature of the bath of molten tin at about 295° C. in a first series of tests and about 370° C. in the second series of tests and it was found that the immersion time of the wire in the bath varied from about .3 second at 500 f.p.m. to about .09 second at 2400 f.p.m. for an immersion length of 41 inches.

A similar test was performed with hard copper wire having drawn size of about .01 inch in diameter. Here the wire was also run at speeds of 500 f.p.m. to 2400 f.p.m. with a tin bath temperature of approximately 295° C. The immersion time varied from .4 second at 500 f.p.m. to about .09 second at 2400 f.p.m. for an immersion length of 41 inches. It was found that at these smaller diameters care must be taken to control the temperature of the bath in relation to the time of residence of the wire in the bath. With the higher bath temperature considerable softening and elongation of the wire will occur if the time of residence is not carefully controlled.

I claim:

A method of processing a wire strand in a continuous operation which comprises feeding a copper wire through a series of dies to draw the wire to a size below .015 inch in diameter, drawing the wire from the dies at speeds up to 2500 f.p.m. immediately passing the wire strand through about 24 inches of molten tin bath at a temperature of about 380° C. to coat the surface of the wire with a thin tin coating, passing the wire through a wiping die to fix the size of the tin coating, annealing the wire while coating, controlling the tension on the wire to maintain a substantially fixed tension on the moving wire, controlling the speed of the wire in relation to the tension, and spooling the wire at said fixed tension to form a wire spool with each of the turns of the winding at substantially the same tension.

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