

PATENT SPECIFICATION

(11)

1 498 201

1 498 261

- (21) Application No. 45805/75 (22) Filed 4 Nov, 1975
 (31) Convention Application No. 604 622 (32) Filed 14 Aug. 1975 in
 (33) United States of America (US)
 (44) Complete Specification published 18 Jan. 1978
 (51) INT. CL² B21B 23/00
 B21C 37/08 37/30 //
 F16L 9/14
 (52) Index at acceptance
 B3A 122J 26
 F2P 1B5D 1B7



(54) PRODUCTION OF POLYMER-COATED STEEL TUBING

(71) We, ALLIED TUBE & CONDUIT CORPORATION, a corporation organized under the laws of the State of Delaware, United States of America, of 16100 S. Lathrop Avenue, Harvey, State of Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to producing coated tubing from steel strip and to the tubing produced and more particularly to forming steel tubing from strip steel stock and providing a uniform polymeric coating on the exterior of said tubing.

It is well known to produce endless lengths of welded steel tubing from strip stock and to continuously galvanize that tubing by providing a zinc coating on the exterior surface as taught, for example, in U.S. Patents Nos. 3,122,114 and 3,230,615 which are owned by the assignee of this patent application. It is likewise known to continuously apply polymeric coatings to the exterior of such continuously formed tubing, employing various thermoplastic and thermosetting resins, as for example taught in U.S. Patents Nos. 3,559,280, 3,616,983 and 3,667,095.

The present invention provides a method for producing coated tubing from steel strip, which method comprises the steps of continuously supplying steel strip, roll-forming said steel strip into tubular configuration, welding said roll-formed strip into continuous tubing, sizing said welded tubing, cleaning the exterior surface of said welded tubing, heating said tubing, applying a polymeric coating to the exterior of said heated tubing, heating said polymer-coated tubing to a baking temperature, cooling said baked coated tubing, the tubing being physically unsupported by any support means situated

in the region in which the coating and baking occur, gripping said tubing over a longitudinal distance of at least two feet and pulling said tubing in a manner so as to maintain said tubing in precise spatial location throughout said heating, coating and baking.

Preferably the pulling is carried out in such a manner as to produce tension in the tubing. Preferably this tension is produced by monitoring the precise speed of said welded tubing at a location adjacent the sizing area and pulling with more power than is required to match the measured speed.

The polymer may be applied electrostatically as a powder e.g. to give a resultant coating of not less than 4 mils (i.e. 4/1000 inch) not more than 6 mils. Alternatively, the polymer may be applied as a spray of solvent-based liquid composition.

Coating may be carried out between said heating and said application of the polymeric coating.

The invention includes apparatus for producing lengths of coated tubing from steel strip, which comprises, in combination, means for continuously supplying steel strip, means for roll-forming said steel strip into tubular configuration, means for welding said roll-formed strip into continuous tubing, sizing roll means for treating said welded tubing, means for cleaning the exterior surface of said welded tubing, first heating means at a heating station, a coating station for applying a polymeric coating to the exterior of the heated tubing, second heating means at a baking station for heating said polymer-coated tubing to a desired baking temperature, a cooling station for lowering the temperature of said baked coated-tubing, there being a path through said stations such that tubing in said path is physically unsupported by any support situated between a location upstream of said coating station and a location downstream of its entry into said cooling station when

the apparatus is in use, pulling means downstream of said cooling station including a pair of elongate endless belts disposed, when the apparatus is in use in flanking relationship to said tubing for gripping said tubing over at least two feet of its length, travelling shear means downstream of said pulling means for cutting said coated tubing into desired lengths, and control means for controlling said pulling means so as to maintain said tubing in precise spatial location throughout said heating, coating and baking stations.

Preferably, additional coating means is provided to apply a liquid solvent-based primer to said tubing at a location upstream of said first heating means.

In the accompanying drawings:—

FIGURE 1 illustrates a diagrammatic view of a production line arrangement embodying various features of the present invention for carrying out continuous forming, galvanizing, and coating operations in the production of lengths of coated tubing; and

FIGURE 2 is an enlarged view of the take-off assist device shown in FIGURE 1.

A preferred embodiment of the apparatus made in accordance with the invention is illustrated in FIGURE 1 wherein certain stations are shown only diagrammatically, particularly the upstream portion of the production line wherein the continuous forming, welding and galvanizing occurs. A more detailed description of these various stations is found in the aforementioned patents.

Although the overall production line is illustrated as including a galvanizing station, as well as a station where a primer coating can be applied, in its broadest aspects, the invention relates to the coating of galvanized and non galvanized tube, and the use of the primer coating station is clearly optional. Although the following detailed description is directed to the application of a polymeric coating in powdered form at a powder-coating station, should it be desired to apply the polymeric coating as a part of solvent-based liquid system, the station denoted the primer station could be used for this purpose and the powder-coating station inactivated. On the other hand, if an extrusion coating should be desired, suitable equipment could be substituted for that at the spray-coating station. Likewise, although the term "galvanizing" is used, this term is to be understood to mean the application of a coating of zinc or an alloy thereof, for example, an alloy of zinc with aluminum could be used.

The overall apparatus of FIGURE 1 depicts a production line in which each of the stations is considered to be treating steel strip moving from right to left. At the

upper righthand corner, strip 8 is shown which is being supplied from a suitable roll source (not shown). The strip travels past an end welder, known in the art for splicing an end of one roll to another roll at the required time, and enters an accumulator 10 wherein a sufficient length of strip is stored to supply the line while adjacent ends are being welded. Likewise, the edges of the strip may be appropriately treated so as to be ready for welding at the time that the strip 8 enters a tube former 12. The tube former 12 is constituted by a series of conventional forming rolls whereby the strip is continuously deformed from its initial flat character to that of a rounded tube with the edges of the strip in approximately abutting relation to form the seam of the tube upon welding.

The continuous tubular form created by the tube-former 12 advances directly to a welder 14 where the edges of the strip are joined by welding, preferably using a continuous resistance welder that is designed to keep the upset on the inside of the formed tubing at a minimum. After the welding is complete and scarfing of the outer surface in the welded region is effected, the tubing is passed to a washing and pickling station 16 where cleaning and removal of oxides occur. This station may include an alkali wash for removing grease from the surface of the tubing, followed by rinsing and then acid treatment for pickling the surface, followed by a further rinse, all of which are well known in the prior art and described in the earlier-mentioned patents.

Following the cleaning station 16, the tubing passes to a first heating station 18 which is located prior to a galvanizing tank 20 and which preferably utilizes induction heating, although other types of heating can be employed to bring the tubing up to the desired temperature prior to its entry into the galvanizing tank 20. In order to guard against oxidation of the cleaned tubing, an inert or nonoxidizing atmosphere, for example, nitrogen, is used to surround the tubing from the time at which it enters the heating station 18 until it passes into the zinc bath. The details of preferred embodiments with respect to providing such an atmosphere are set forth in the aforementioned patents.

In the heating station, the tubing is preferably pre-heated to a temperature above the melting point of the galvanizing material, and as a result, the continuously moving heated tubing picks up a uniform coating of zinc or zinc alloy as it passes through the tank. Appropriate wiping is effected at the exit from the zinc tank 20 to avoid carrying excess zinc therefrom, and the galvanized tubing proceeds immediately to a cooling station 22, which may be a water-filled

quench tank. After cooling to the desired temperature is effected, the galvanized tubing next enters a sizing and straightening station 24.

- 5 Following straightening, an optional metal-treating station 26 is provided wherein the galvanized tubing is treated by chromating, phosphating or the like. By treating the galvanized surface with a chromate and
10 nitric acid solution, a zinc chromate outer film is created which provides even greater resistance to oxidation. If such a metal treating station 26 is provided, a rinse and an air dryer station 28 is included
15 immediately thereafter.

- In this upstream region of the production line, there is ample opportunity to support the tubing against sagging as a result of gravity, and of course the sizing and
20 straightening rolls provided such support as well as drive the tubing longitudinally. However, the final support 30 for the tubing downstream of the metal treating station 26 until it reaches the take-off assist device is
25 located just past the drying station 28. The support rollers 30 assure both vertical and horizontal alignment of the tubing at the location.

- Just downstream of this point of last
30 support, the tubing enters a liquid spraying station 32 where a coating, in liquid form, can be applied, as for example by a plurality of atomizing spray heads. The station 32 is designed to provide a primer coating prior
35 to applying a thicker polymeric coating in powder form at a downstream location, and it is generally used in instances wherein the galvanizing and chromating or phosphating steps are omitted, so that such a primer coating
40 is applied upon the new surface of the welded tubing; however, in some instances it may be desirable to apply a primer over a galvanized surface. Moreover, a primer
45 may also be applied after chromating or phosphating. Usually, the liquid coating composition will be solvent-based (either organic or water), and will include natural or synthetic resinous polymers and may or may
50 not include a pigment. However, should it be desired to provide such a solvent-based coating composition as the final exterior coating of the tubing, then the downstream powder-coating station to be described hereinafter would not be employed. This
55 might occur in a case where the galvanizing and metal treating stations are used and where, in addition, it is desired to provide a translucent polymeric overcoating on the tubing.

- 60 The tubing next proceeds to an induction heating station 34 which preheats the tubing prior to its entry into the powder coating station 36 which is next in line. However, whenever a liquid coating is applied to the
65 tubing, the induction heating station 34

serves to dry the coating by removing the remainder of the solvent and to also cure the resin which might be included therein. In those instances where the liquid coating is to serve as the final exterior coating, solvent-release is achieved at the heating station 34.

Under the usual conditions the primary function of the heating station 34 is to raise the temperature of the tubing to that desired for the powder-coating application. This temperature will vary with the particular powder composition being used; however, it will generally be in the range from about 150°F. to about 400°F. Because the tubing
80 will usually already have been either galvanized or coated with a primer, it is not felt necessary to provide a nonoxidizing atmosphere at the induction heating station 34, and in any event, the temperature will
85 usually not be as high as that employed in the heating station 18 just prior to galvanizing.

The powder coating may be applied in any manner suitable for treating a fast-moving article, for example, electrostatically, by a fluidized bed process, or by an electrostatic-fluidizing bed process, all of which are known in the prior art. The employment of such powder-coating processes for coating pipe is shown in U. S. Patent No. 3,616,983. The powder composition will be a plastics material and may include pigments, plasticizers and the like. Both thermoplastic and thermosetting resins
100 may be employed, as for example, polyamides, polyvinylchlorides, polyesters, polyvinylidene chlorides, polyvinylacetates, butrates, polyolefins, acrylics, epoxys, as well as blends of the foregoing.

It is considered important that it be possible to closely control the thickness of the coating which is applied in this powder-coating operation, and polymeric coating thicknesses between about 0.5 mil and about 25 mils can be applied uniformly by such powder-coating arrangement at the speeds of operation at which it is desired to run the tubing mill. For example, when vinyl coatings are employed, they are usually used at a nominal thickness of about 5 mils. It is feasible to produce vinyl-coated conduit of this type, ranging from about 1.3 inches to 2.4 inches in outer diameter, wherein the thickness of the vinyl coating will uniformly be not less than 4 mils and not more than 6 mils, at high production-line speeds.

Immediately following the powder coating station, the tubing enters a further heating station 40, preferably containing one or more induction heating units, where baking and/or curing of the powder coating takes place. The heating pattern is determined by the specific resin coating composition that is being used, because different heating criteria
130

are employed to obtain the optimum melt-flow of the polymeric coating. A temperature range from about 200°F. to 650°F. is considered to be representative of such baking and/or curing operations, and for example, a temperature of approximately 500°F. might be used for a vinyl coating. Initially the induction heating at the station 40 will begin the actual baking, and the subsequent heating determines the precise melt-flow performance. Of course, the amount of heat absorbed by a continuously moving tube is a function of both time and temperature, and there are many variables, e.g., thickness, color and chemical composition, which influence the baking conditions of the polymeric material.

When a thermosetting polymeric coating is being applied, in addition to the heating which leads up to and achieves the desired melt-flow of coated powder, a final curing is effected after the coating material has been uniformly distributed over the tubing. This curing step, which is the chemical crosslinking of the thermosetting material, is the final stage of the baking operation, and reference is made to earlier mentioned U. S. Patent No. 3,667,095 with respect to coating with thermosetting resins.

Subsequent to baking, a cooling station 42, preferably utilizing a water quench, is employed to quickly lower the temperature of the polymeric exterior coating to a level that it will not be adversely affected by contact with the take-off assist device 44, which is located immediately thereafter. In addition, the water quench is employed to assure that the heat-history of the coated polymer does not exceed a desired amount, such that degradation or decoloration of the polymeric material might result. An ancillary roller support for the continuously moving tubing could be provided at a location in the water quench station 42 where the temperature of the polymer will have fallen below a suitable level where such contact may occur without detriment to the surface. However, inasmuch as this point would of necessity be quite close to the take-off assist device 44, such additional support might be considered to be unnecessary.

The take-off assist device 44 includes a pair of endless belts 48 which flank the continuously moving tubing, being located respectively above and below. The belts 48 are made of a material having desired frictional characteristics so as not to mar the polymeric coating, such as synthetic rubber, e.g., Neoprene, having an appropriate hardness, e.g., 40 to 50 durometer (short durometer). The belts 48 are appropriately driven from a single drive means, preferably an electric motor 50, so that both belts will travel at precisely the same speed. Each endless belt 48 is supported on two large

pulleys 52 at the forward end and rearward end thereof, and the take-off assist device 44 is constructed so that the upper belt and pulley assembly is movable vertically while the lower belt and pulley assembly are fixed. This arrangement allows the device 44 to be opened and closed in a way to assure that the tubing will be positioned at a precise location.

The take-off assist device 44 is dimensioned so that there is an extended area of contact between each belt 48 and the coated tubing, and this contact should extend for at least 24 inches in length and preferably for more than 36 inches in length. The employment of such an extended area of contact between the coated tubing and the belts 48 contributes substantially to the ability of the device to grip and tension the tubing without marring the just-applied exterior polymeric coating. To assure that the contact is distributed evenly throughout the length of the so-called "compression section" of the belt drive, a plurality of back-up idler rollers 54 are provided along the length of the compression section. The rollers 54 have a configuration that mates with the rear surface of the belts, and although a simple V-belt configuration could be used, preferably a multiple-grooved belt 48 and complementary multiple-grooved rollers 54 are employed to assure there is no lateral shifting of the belt. The take-off assist device 44 is designed to drive the belts 48 at a speed up to about 800 feet per minute. For economically practical operation, speeds of at least about 60 to 70 feet per minute are used, and speeds of 400 feet per minute or higher can be obtained using the invention.

The sizing and straightening roll station 24 also serves to drive the welded tubing and can be employed to provide most of the driving force i.e. to effectively push the tubing through to the traveling shear 46 if the distance is not too great and/or if intermediate support points e.g. rollers 30 can be provided along the way for the tubing. However, the rate at which the production line is operated has an effect upon the practicability of pushing the tubing through the exterior coating section.

In the illustrated apparatus, the last point of support 30 for the tubing is located upstream of the spray coating station, and there is no further point of support until the take-off assist device 44 is reached (although, as indicated, a support roller could be provided near the downstream end of the water quench bath). This extended length of tubing will, as a result of the force of gravity, form a natural catenary curve. The depth of the catenary will depend upon the stiffness of the tube being produced and will be a function of the steel material, the wall

thickness and the outer diameter. The employment of the take-off assist device 44, particularly when operated to maintain the tubing in tension between it and the sizing rolls, tends to slightly flatten out this catenary.

The control of the drive motor 50 in a manner to maintain a predetermined amount of tension in the tubing assures the precise spatial positioning of the tubing at every location along its length from the straightening rolls 24 to the take-off assist device 44, and it is this preciseness of positioning that allows consistent uniformity to be achieved in the thickness of the coating being applied. Regardless of the coating system used, but particularly when spray nozzles are employed, precise spatial positioning of the longitudinally moving tubing relative to the spray heads is very important. Without using the take-off assist device 44 and relying solely upon the sizing and straightening rolls 24 to push the tubing throughout the coating, baking and cooling stations, every fluctuation in the speed of the straightening rolls will be reflected in the travel of the tubing downstream through the coating stations. Such fluctuations may result, for example, from upstream deviations in the speed at which the tube mill 12 is operating, and if permitted to be reflected in the downstream speed of the tubing, will detract from the uniformity of the exterior coating which is being applied.

A control system 60 for the take-off assist device utilizes an electronic control which receives an input signal from a monitor 62 that is located at the sizing and straightening roll station near the downstream exit thereof. This monitoring device 62 provides the controller 60 with an extremely precise reading of the speed of the tubing. This is important because there will be variations in the speed of the tubing exiting from the sizing and straightening rolls, and it is desired to control the take-off assist device 44 accordingly. These deviations in the speed may occur for various reasons, and one of the most common occurs when the roll of steel strip periodically runs out and needs to be replaced. As pointed out in U. S. Patent No. 3,259,148, an accumulation device 10, such as a looper, is employed to hold a reserve quantity of the strip so that the trailing end of one roll of strip can be welded to the front edge of the new roll of strip without halting the feed to the tube former 12. As soon as the welding operation is completed, the accumulation device 10 is refilled, and this refilling creates some drag on the strip being fed to the tube mill 12 which slightly slows the speed of the continuous tube production.

Although various means can be provided for precisely monitoring the speed of the tub-

ing exiting from the sizing and straightening rolls, a digital, photoelectric, pulse generator is preferred. This type of generator is commercially available and delivers an exact number of shaped pulses for each revolution of a central shaft. The shaft carries a small pickup wheel which is in surface contact with the undersurface of the tubing. Alternatively, a digital, magnetic, pulse generator might be employed which likewise produces an exact number of output voltage pulses for each revolution of a central shaft. In its operation, an internal gear interrupts the lines of magnetic pickup and provides an alternating output voltage in the form of a sinusoidal wave.

The monitoring device 62 is electrically connected to the controller 60 and thus provides an input to the controller which precisely reflects the speed of the tubing as it exits from the sizing and straightening rolls 24. The controller 60 is designed to synchronize the drive motor 50 of the take-off assist device 44 in conjunction with the input signal which it is receiving, and various control modes can be employed. The preferred method is the one referred to as speed control with current-compounding, and in this mode, the controller 60 drives the take-off assist device to not only match the precise speed reflected by the signal being received from the monitor but to try to increase this speed by a predetermined increment. Because, physically, the continuous tubing cannot be moved faster at the take-off assist device 44 than it is moving at the sizing and straightening rolls, this additional increment is reflected as tension in the tubing. The tension is generated because of the characteristics of the endless belts 48 which, because of their frictional characteristics and their extended (at least 24 inches long) regions of contact with the tubing, securely grip the tubing and essentially eliminate slippage between the belts and the tubing. As a result, substantially all of the excess power which the controller 60 feeds to the drive motor 50 is reflected as tension in the continuously moving tubing, and this tension results in a slightly shallower catenary.

The drive motor 50 is preferably a regenerative DC motor, and the controller 60 is, in essence, reading the monitored speed of the tubing at the sizing and straightening rolls 24 and reporting that an amount of current equal to X is needed to cause the motor to drive the endless belts 48 at precisely this speed. The controller 60 is set to add an additional increment Y of current to achieve the desired amount of tension, and thus the compounded current which is fed to the DC drive motor 50 is equal to $X + Y$. The actual control is such that this increased amount of current is provided by increasing the voltage across the DC motor 50.

Another mode of control is referred to as the digital speed mode, and the controller 60 again receives the input signal from the monitoring device 62 and this time drives the take-off assist device belts 48 to precisely match this speed so that the tubing is pulled from the downstream end at the same speed as it is pushed from the upstream end. This mode also provides precision in the spatial relationship of the tubing downstream from the sizing rolls 24 through the water quench station; however, because of the absence of the tension, the tubing takes the form of a slightly deeper catenary throughout the heating, coating and baking stations.

The provision of a take-off assist device 44 of this type, which can grip the tubing without marring its finish, coupled with the control of the drive in conjunction with the monitored speed of the tubing as it leaves the sizing and straightening rolls 24 allows the overall tubing production line to be run at high speeds e.g., up to 400 feet per minute, and it also allows the installation to be constructed in a way that there is no physical contact with the tubing over a span of 70 to 80 feet or more. The ability to be able to precisely determine the spatial location of the tubing at any location along its length is not only of significant value as discussed hereinbefore, with respect to application of the coating composition from spray heads or the like, but also with respect to the heating of the tubing. This is particularly true when induction heaters in the form of electrical coils are used, because they will be arranged so that the axis of the longitudinal coil closely surrounds and is coaxial with the continuously moving tubing, and accordingly positioning becomes very important. Therefore, the achievement of a precise catenary curve by means of the provision and indicated control of a belt-type take-off assist device allows very high production speeds to be achieved without sacrificing uniformity of coating.

The belt-type take-off assist device 44 is able to achieve the desired objective in handling coated tubing and even applying tension thereto without marring the exterior surface of the polymeric coating, which inherently contains some residual heat and has not achieved its full hardness. Whereas previous systems of this type, for example that disclosed in U. S. Patent No. 3,616,983, used pairs of upper and lower rollers of concave peripheral shape to engage the peripheral surface of the coated tube to thereby grip the tubing, inherently such rollers can cause a blemishing effect upon the outer surface of the coated tubing because the outer portions of the concave rollers move at a faster speed than the innermost portions, whereas all points on the coated tubing are moving linearly at exactly the same speed.

In conclusion, it has been found that the employment of a take-off assist device of this construction in combination with its appropriate control significantly reduces the cost of providing polymer-coated lengths of steel tubing because such high production-line speed operation is reflected in lower unit cost.

It is to be understood that there is no particular order in which the sizing and cleaning steps must be performed in the making of welded tubing by the method of the invention, although cleaning is conventionally carried out before galvanizing or other surface coating processes.

Although the invention has been described with regard to certain preferred embodiments, it should be understood that various modifications as would be obvious to those having the ordinary skill in this art may be made without deviating from the scope of the invention, which is defined by the claims appended hereto.

WHAT WE CLAIM IS:—

1. A method for producing coated tubing from steel strip, which method comprises the steps of continuously supplying steel strip, roll-forming said steel strip into tubular configuration, welding said roll-formed strip into continuous tubing, sizing said welded tubing, cleaning the exterior surface of said welded tubing, heating said tubing, applying a polymeric coating to the exterior of said heated tubing, heating said polymer-coated tubing to a making temperature, cooling said baked coated tubing, the tubing being physically unsupported by any support means situated in the region in which the coating and baking occur, gripping said tubing over a longitudinal distance of at least two feet and pulling said tubing in a manner so as to maintain said tubing in precise spatial location throughout said heating, coating and baking.

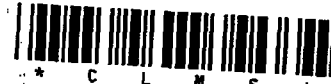
2. A method as claimed in claim 1 wherein said pulling is carried out in a manner to produce tension in the tubing.

3. A method as claimed in claim 2 wherein the tension is produced by monitoring the precise speed of said welded tubing at a location adjacent the sizing area and pulling with more power than is required to match the measured speed.

4. A method as claimed with any one of claims 1 to 3 wherein said polymer is applied electrostatically as a powder to form a uniform coating.

5. A method as claimed in claim 4 wherein said powder is uniformly applied in a manner so that the resultant coated tubing has a polymeric coating not less than 4 mils thick and not greater than 6 mils thick.

6. A method as claimed in any one of



Another mode of control is referred to as the digital speed mode, and the controller 60 again receives the input signal from the monitoring device 62 and this time drives the take-off assist device belts 48 to precisely match this speed so that the tubing is pulled from the downstream end at the same speed as it is pushed from the upstream end. This mode also provides precision in the spatial relationship of the tubing downstream from the sizing rolls 24 through the water quench station; however, because of the absence of the tension, the tubing takes the form of a slightly deeper catenary throughout the heating, coating and baking stations.

The provision of a take-off assist device 44 of this type, which can grip the tubing without marring its finish, coupled with the control of the drive in conjunction with the monitored speed of the tubing as it leaves the sizing and straightening rolls 24 allows the overall tubing production line to be run at high speeds e.g., up to 400 feet per minute, and it also allows the installation to be constructed in a way that there is no physical contact with the tubing over a span of 70 to 80 feet or more. The ability to be able to precisely determine the spatial location of the tubing at any location along its length is not only of significant value as discussed hereinbefore, with respect to the application of the coating composition from spray heads or the like, but also with respect to the heating of the tubing. This is particularly true when induction heaters in the form of electrical coils are used, because they will be arranged so that the axis of the longitudinal coil closely surrounds and is coaxial with the continuously moving tubing, and accordingly positioning becomes very important. Therefore, the achievement of a precise catenary curve by means of the provision and indicated control of a belt-type take-off assist device allows very high production speeds to be achieved without sacrificing uniformity of coating.

The belt-type take-off assist device 44 is able to achieve the desired objective in handling coated tubing and even applying tension thereto without marring the exterior surface of the polymeric coating, which inherently contains some residual heat and has not achieved its full hardness. Whereas previous systems of this type, for example that disclosed in U. S. Patent No. 3,616,983, used pairs of upper and lower rollers of concave peripheral shape to engage the peripheral surface of the coated tube to thereby grip the tubing, inherently such rollers can cause a blemishing effect upon the outer surface of the coated tubing because the outer portions of the concave rollers move at a faster speed than the innermost portions, whereas all points on the coated tubing are moving linearly at exactly the same speed.

In conclusion, it has been found that the employment of a take-off assist device of this construction in combination with its appropriate control significantly reduces the cost of providing polymer-coated lengths of steel tubing because such high production-line speed operation is reflected in lower unit cost.

It is to be understood that there is no particular order in which the sizing and cleaning steps must be performed in the making of welded tubing by the method of the invention, although cleaning is conventionally carried out before galvanizing or other surface coating processes.

Although the invention has been described with regard to certain preferred embodiments, it should be understood that various modifications as would be obvious to those having the ordinary skill in this art may be made without deviating from the scope of the invention, which is defined by the claims appended hereto.

WHAT WE CLAIM IS:—

1. A method for producing coated tubing from steel strip, which method comprises the steps of continuously supplying steel strip, roll-forming said steel strip into tubular configuration, welding said roll-formed strip into continuous tubing, sizing said welded tubing, cleaning the exterior surface of said welded tubing, heating said tubing, applying a polymeric coating to the exterior of said heated tubing, heating said polymer-coated tubing to a making temperature, cooling said baked coated tubing, the tubing being physically unsupported by any support means situated in the region in which the coating and baking occur, gripping said tubing over a longitudinal distance of at least two feet and pulling said tubing in a manner so as to maintain said tubing in precise spatial location throughout said heating, coating and baking.
2. A method as claimed in claim 1 wherein said pulling is carried out in a manner to produce tension in the tubing.
3. A method as claimed in claim 2 wherein the tension is produced by monitoring the precise speed of said welded tubing at a location adjacent the sizing area and pulling with more power than is required to match the measured speed.
4. A method as claimed with any one of claims 1 to 3 wherein said polymer is applied electrostatically as a powder to form a uniform coating.
5. A method as claimed in claim 4 wherein said powder is uniformly applied in a manner so that the resultant coated tubing has a polymeric coating not less than 4 mils thick and not greater than 6 mils thick.
6. A method as claimed in any one of



claims 1 to 3 wherein said polymer is applied by spraying a solvent-based liquid composition to form a uniform coating.

7. A method as claimed in any one of claims 1 to 6 wherein galvanizing is carried out between said heating and said application of the polymeric coating.

8. A method as claimed in any preceding claims wherein the speed at which the tubing moves is from 600 to 400 feet per minute.

9. A method as claimed in any one of the preceding claims wherein the tubing is physically unsupported by any support means situated in the region in which the heating, coating and baking occurs.

10. Apparatus for producing lengths of coated tubing from steel strip, which comprises, in combination, means for continuously supplying steel strip, means for roll-forming said steel strip into tubular configuration, means for welding said roll-formed strip into continuous tubing, sizing roll means for treating said welded tubing, means for cleaning the exterior surface of said welded tubing, first heating means at a heating station, a coating station for applying a polymeric coating to the exterior of the heated tubing, second heating means at a baking station for heating said polymer-coated tubing to a desired baking temperature, a cooling station for lowering the temperature of said baked coated-tubing, there being a path through said stations such that tubing in said path is physically unsupported by any support situated between a location upstream of said coating station and a location downstream of its entry into said cooling station when the apparatus is in use, pulling means downstream of said cooling station including a pair of elongate endless belts disposed, when the apparatus is in use in flanking relationship to said tubing for gripping said tubing over at least two feet of its length, travelling shear means downstream of said pulling means for cutting said coated tubing into desired lengths, and control means for controlling said pulling means so as to maintain said tubing in precise spatial location throughout said heating, coating and baking stations.

11. Apparatus as claimed in claim 10 wherein said pulling means is powered by an electric motor and the control means supplies electric power to the electric motor so as to produce tension in the welded tubing between said sizing roll means and said pulling means.

12. Apparatus as claimed in claim 10 or claim 11 wherein means is provided adjacent the sizing roll means for monitoring the pre-

cise speed of said welded tubing and creating a signal related thereto and wherein said control means is adapted to receive said signal from the speed-monitoring means and provide more power to the pulling means than is required to match the measured speed.

13. Apparatus as claimed in any one of claims 10 to 12 wherein said flanking endless belts are made of a material having a sufficiently high coefficient of friction that slippage between said belts and said coated tubing is essentially eliminated.

14. Apparatus as claimed in any one of claims 10 to 13 wherein said coating station applies said polymer electrostatically as a powder to form a uniform coating.

15. Apparatus as claimed in claim 14 wherein said powder is uniformly applied in a manner so that said cut lengths have a polymeric coating not less than 4 mils thick and not greater than 6 mils thick.

16. Apparatus as claimed in any one of claims 10 to 13 wherein said coating station applies said polymer as a solvent-based liquid coating to form a uniform coating.

17. Apparatus as claimed in any one of claims 10 to 16 wherein a cleaning means is provided downstream of the welding station and galvanizing means is located between said cleaning means and said first heating means, for applying a zinc coating to said welded steel tubing.

18. Apparatus as claimed in any one of claims 10 to 17 wherein additional coating means is provided to apply a liquid solvent-based primer to said tubing at a location upstream of said first heating means.

19. Apparatus as claimed in any one of claims 10 to 17 wherein the said path through the stations is such that tubing in the path is unsupported by any support situated between a location upstream of the heating station and downstream of its entry into the cooling station.

20. A method of producing coated steel tubing from steel strip substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

21. An installation for producing coated tubing from steel strip substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

ALLIED TUBE AND CONDUIT CORPORATION

Per: BOULT, WADE & TENNANT,
34 Cursitor Street,
London EC4A 1PQ.
Chartered Patent Agents.