Feb. 9, 1971 T. H. KRENGEL ET AL 3,561,096

METHOD OF CONTINUOUS TUBE FORMING AND GALVANIZING

Filed Nov. 7, 1968 2 Sheets-Sheet 1

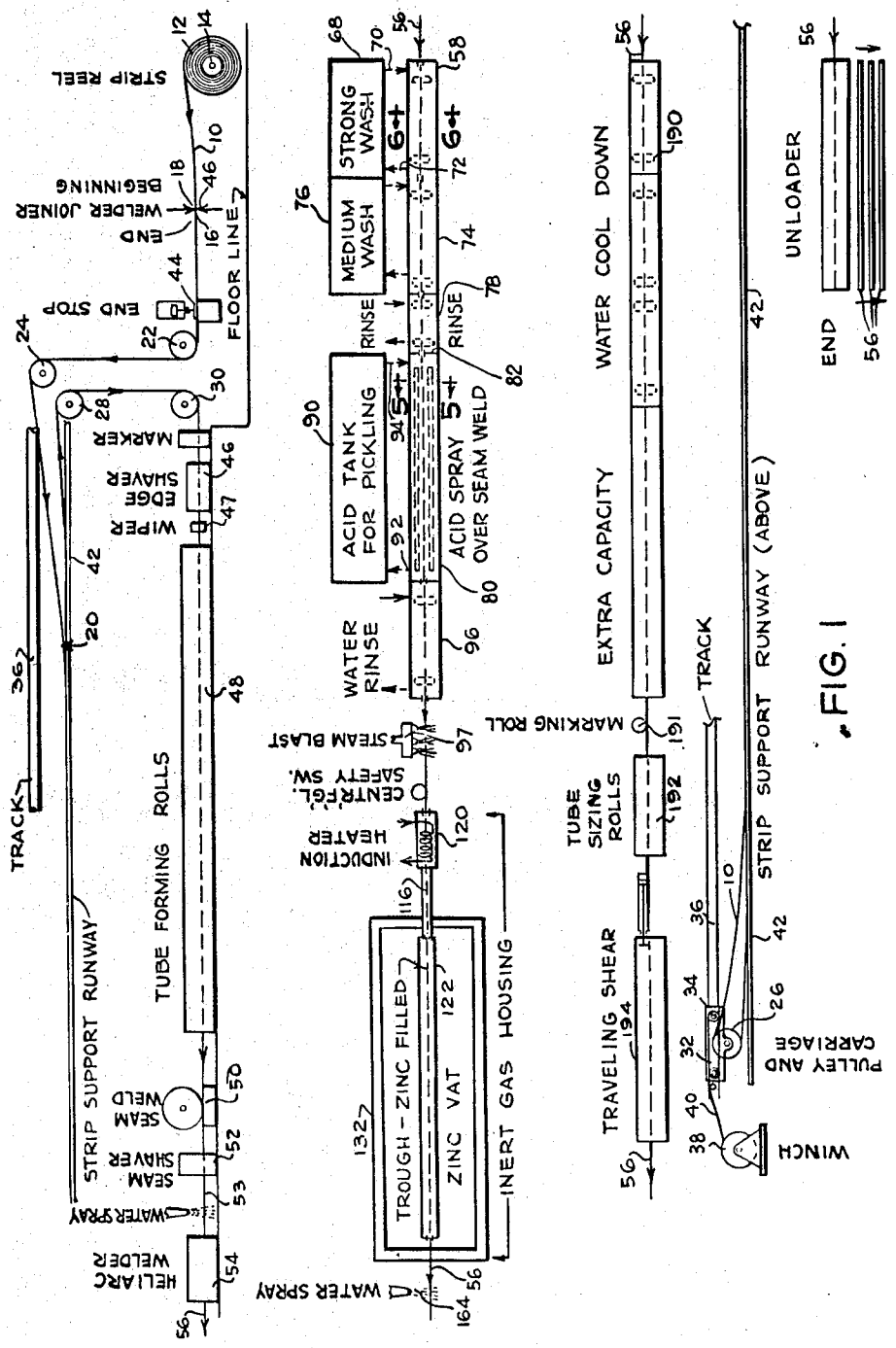


FIG. 1

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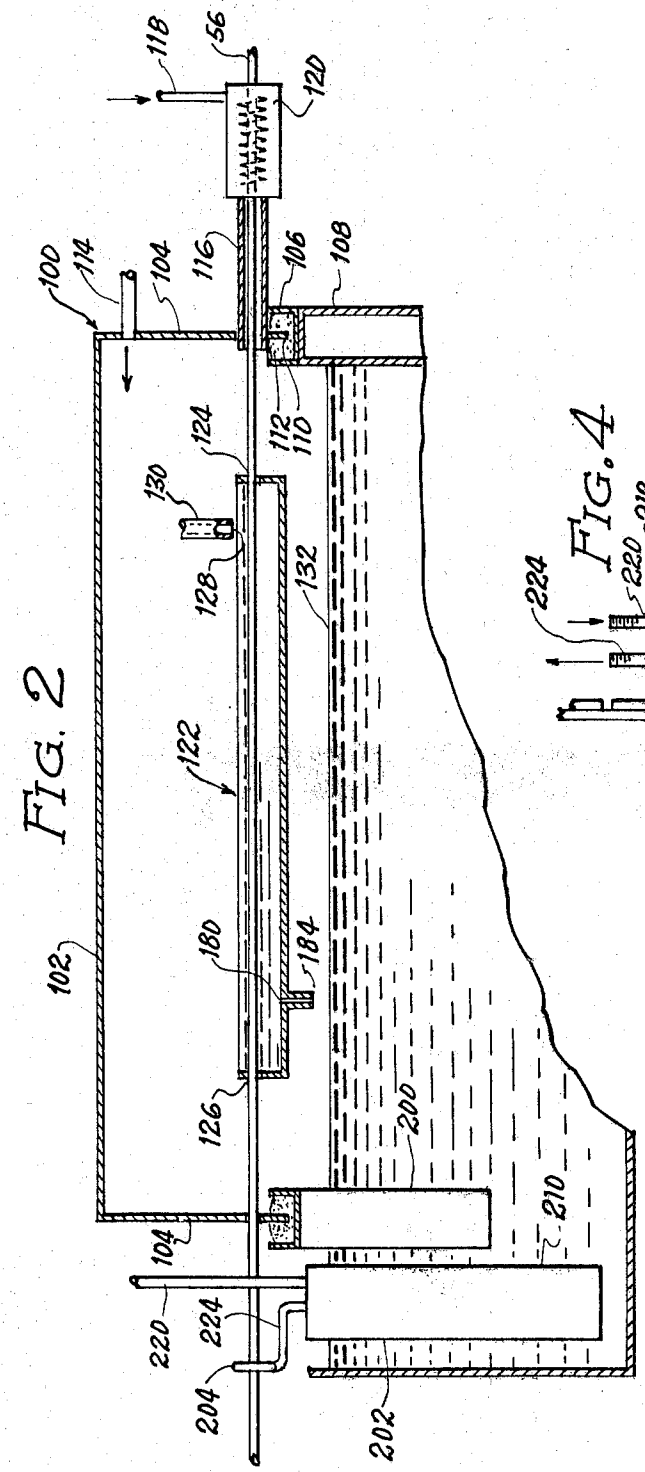


FIG. 2

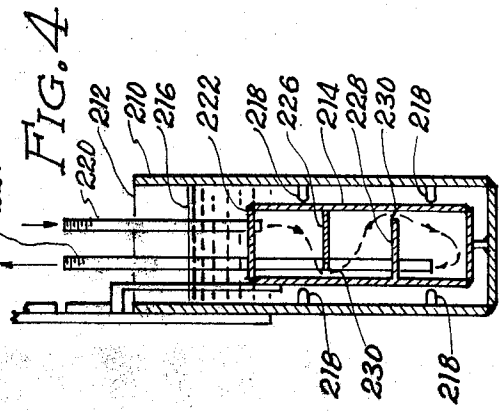


FIG. 4

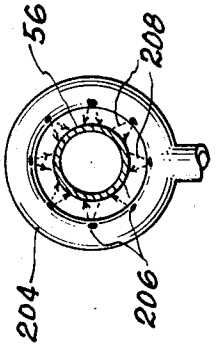


FIG. 3

United States Patent Office 3,561,096 Patented Feb. 9, 1971

3,561,096

METHOD OF CONTINUOUS TUBE FORMING AND GALVANIZING

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Continuation-in-part of application Ser. No. 341,043, Jan. 29, 1964, which is a continuation of application Ser. No. 106,699, May 1, 1961, now Patent No. 3,122,114. This application Nov. 7, 1968, Ser. No. 774,063

Int. Cl. B23p 3/00, 19/04

U.S. Cl. 29—460 4 Claims

ABSTRACT OF THE DISCLOSURE

A process for continuously forming and galvanizing tubing from strip in which the steel strip is formed to rounded shape while being advanced continuously in one direction to bring the lateral edges together, continuously welding the abutting edges of the strip to seal the formed tubing and scarfing the welded portion of the tubing to cut off the portions of the weld projecting beyond the periphery, cleaning the outer surfaces of the tubing with cleaning solutions and rinsing the cleaned tubing with water for removal of the cleaning solutions, advancing the cleaning tubing continuously through an enclosure maintained at elevated temperature to preheat the tubing, advancing the preheated tubing through a bath of molten zinc arranged in linear alignment with the formed tubing in a position so that the tubing enters and leaves the bath and passes through the bath at a level below the surface of the bath to avoid contact with oxides on the surface of the bath, continuously adding molten zinc to the bath in an amount in excess of that taken by the tubing to cause overflow from the edges of the bath beyond the tubing to continuously flush oxides and slag from the bath, enclosing the bath within a housing which communicates with the enclosure for preheating and introducing non-oxidizing gas into the enclosure for maintaining a relatively non-oxidizing atmosphere during preheating and galvanizing, removing excess zinc from the surface of the tubing after leaving the bath by means of an air knife through which air at elevated temperature is projected angularly onto the surface of the tubing and then freezing the coating of molten zinc on the tubing surface.

This is a continuation-in-part of our copending application Ser. No. 341,043 filed Jan. 29, 1964 now abandoned, and entitled "Continuous Tube Forming and Galvanizing," which application was a continuation of our then copending application Ser. No. 106,699, filed May 1, 1961, now Pat. No. 3,122,114, entitled "Continuous Tube Forming and Galvanizing."

This invention relates to a continuous process for forming and galvanizing tubing of endless strips of steel and it relates more particularly to the processing of endless strips of steel to form tubing in a continuous operation and in the treatment of the external surfaces of the formed tubing for galvanizing as a continuous operation in combination with tubing formation.

It is an object of this invention to provide a new and improved process for the continuous forming of tubing from endless lengths of strip steel and for continuous galvanizing of the formed tubing as a continuous operation with the formation of the tubing and it is a related object to produce a new and improved machine for use in the practice of same.

Another object is to provide a machine and process for the continuous forming and galvanizing of tubing from sheet steel in a simple and efficient manner to produce a galvanized tubing at less cost from the standpoint of labor,

from the standpoint of material utilization and cost, from the standpoint of space requirements, and from the standpoint of heat and power requirements, and it is a related object to produce and to provide a method for producing galvanized tubing having improved characteristics and appearance without substantial variation in such characteristics and appearance between lengths.

These and other objects and advantages of this invention will hereinafter appear and, for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawings in which:

FIG. 1 is a schematic flow diagram of the continuous forming and galvanizing of tubing in accordance with the practice of this invention;

FIG. 2 is a sectional elevational view of the furnace for the continuous galvanizing of the formed tubing in accordance with the practice of this invention;

FIG. 3 is a sectional view of the air knife for removal of excess zinc; and

FIG. 4 is a sectional elevational view of a means for preheating the air to the air knife.

Since the important concepts of this invention reside in the method and means for the continuous forming and galvanizing of tubing by the processing of endless lengths of strip steel, the invention will be described with reference to a continuous process for forming the metal tubing and in the processing of the formed tubing in a galvanizing, sizing and shearing operation for cutting the finished tubing into desirable lengths.

Referring now to FIG. 1 of the drawings, the tubing forming mill is fed with strip steel **10** supplied in the form of coils **12** mounted on a pay-out reel **14** for free rotational movement to pay out strip steel as it is required by the continuous tube forming mill. In a continuous mill for forming tubing the strip steel is processed substantially continuously at a relatively constant rate through the mill. Advancement is effected primarily by engagement between the strip steel and the forming and sizing rolls rotating at relatively constant speed whereby the strip steel is drawn into the mill for processing.

Since the lengths of the steel strip in the coils **12** come to an end after a short period of operation of the mill and since strip is taken up continuously by the mill in its continuous operation, it is essential to provide means for splicing the end of one coil **16** with the leading end **18** of another coil for joinder of the strips into continuous lengths without stoppage of the mill in its continuous operation. For this purpose, a loop **20** is taken in the strip of steel dimensioned to have a length sufficient continuously to feed strip to the mill while the trailing end **16** of the strip is stationarily held for splicing, as by welding, onto the leading edge of the new reel which has beeen displaced into position of use. The loop is formed by feeding the strip **10** under the roller **22** and over the roller **24** to about the roller **26** and back over the roller **28** and under the roller **30** into the mill. The rollers are each mounted for free rotational movement while the roller **26** is carried by a carriage **32** having wheels **34** rotatably positioned upon a track **36** for endwise displacement of the carriage in one direction to make strip available to the mill and in the other direction, responsive to the actuation of the winch **38** through the cable **40**, to return the carriage and to reform the loop.

Normally, the carriage is in its retracted position to provide a full loop **20** of strip steel which rests upon a platform **42** overlying the mill and underlying the track. When the end is reached, a portion adjacent the end is locked in a clamping member **44** to hold the end section while the end **16** of the coil is joined, as by welding, to the beginning of the next coil in the joiner **46**. The operation takes but a few seconds. In the meantime, the mill continues to draw its requirements of strip from the loop to displace the car-

riage **32** in the direction away from the winch as the loop is shortened. When the ends of the coils have been joined, the clamping device **44** is inactivated to free the strip whereby strip can thereafter be supplied from the new coil as the winch **38** and cable **40** are effective to return the carriage to normal retracted position and replenish the loop in preparation for the next splicing operation. It will be apparent that the strip **10** feeds from the coil through the loop to the mill for continuous operation.

Hereafter description will be made of the sequence of operations effected in the mill with the elements in the mill longitudinally aligned for the passage of strip and the tubing formed thereof continuously linearly therethrough. The strip enters a series of aligned conventional tube forming rolls, identified by the numeral **48**, whereby the strip is deformed from a flat section to a rounded tubing having the freshly cut edges of the strip in abutting relation to form the seam of the tubing.

From the tubing forming roll section **48**, the formed tubing is advanced directly to the seam welder **50** where the abutting free edges of the strip formed to tubular shapes are joined by welding, preferably using a continuous resistance welder in order to keep the upset on the inside of the formed tubing at a minimum. Otherwise, it would require the use of a support within the tubing and/or an upset removing tool employed in combination with a water suction device. Since sufficient space is not available in small diameter tubing for housing such support, upset removal tool and water suction means, it has been found to be expedient, in accordance with the practice of this invention, to make use of a continuous welder in the form of a roller adjusted to effect the major upset on the outside of the tubing where access is available for removal.

When, as in the practice of this invention, the upset is concentrated on the outside, the upset or flash can be removed by a seam shaving tool **52** which follows immediately after the seam welder. The seam shaver embodies a scarfing tool which shaves the seam to leave a smooth surface on the outer periphery of the formed tubing and whereby the seam would be concealed except for the presence of a heat line indicated by a dark discoloration of metal oxide formed along the weld surface.

To this point, welded tubing is continuously formed of strip steel with the exception of the possible short lengths of formed tubing which remain with an open seam in the event of skidding of the tubing and the machine when the mill is stopped for one reason or another. As a result, in the described continuous processing for forming tubing, an auxiliary welder **54** in the form of a heliarc welder may be employed, where desired, to take over the welding operation whenever the seam welder fails to weld the seam of the formed tubing. When employed, an overlap is effected with the stop and start of the mill continuously to weld the seam and to insure closure of the seam throughout the length of the tubing. In actual practice with good controls, it has been found that the heliarc welder is not essential.

After the tubing has been welded to provide a continuous weld throughout the length thereof, the tubing is advanced from the welders to elements linearly aligned therewith for washing and pickling the outer surfaces of the formed tubing in preparation for continuous galvanizing. The welded tubing **56** is advanced first into a housing **58** having a removable cover **60** for access thereto. The housing is provided with a plurality of axially aligned ring members **62** in the form of headers having a plurality of spray nozzles **64** arranged equally spaced about the inner periphery for directing a spray **66** onto the outer periphery of the tubing **56** advanced axially therebetween. Each spray head is connected to a reservoir **68** of wash water for recirculating the wash water from the reservoir through pipe **70** to the spray head **62** and from the drain in the housing back through pipe **72** for return to the reservoir. In the illustrated modification the reservoir is shown alongside the housing but it may equally be arranged in other positions such as beneath the housing. A pump means is interposed between the reservoir and the spray heads for displacement of wash water forcibly to spray the wash water onto the exposed surfaces of the tubing as it passes through the housing. For purposes of washing to remove grease and the like, use can be made of an alkali wash which may be represented by a solution of 5 ounces of alkali per gallon of water and it is preferred to heat the wash water to a temperature below the boiling point of the alkali solution, such as a temperature of 200° F., to accelerate removal of grease from the surface.

From the hot alkali wash, the tubing **56** is advanced continuously into the adjacent section of housing **74** in which the tubing is treated with a dilute alkali wash. The housing **74** is similar to that of the housing **58** for the hot alkali wash including spray heads to direct the dilute alkali wash onto the periphery of the tubing and with a separate reservoir **76** connected to the headers to feed dilute alkali from the reservoir to the headers and connected to the drain in the base of the housing for returning the dilute alkali wash from the housing back to the reservoir. The dilute alkali wash is employed for more complete removal of grease and dirt from the surface of the tubing and the use of the dilute alkali wash following immediately after the strong alkali wash operates to save alkali loss since strong alkali carried on the surface of the tubing from the strong alkali wash will be recovered in the wash with dilute alkali to supply some of the alkali for maintaining the desirable concentration thereof. The dilute alkali wash may be formulated to contain about 2 ounces of alkali per gallon and it may also be heated to an elevated temperature such as to a temperature below boiling, or up to 200° F. more effectively to remove grease and other undesirable material from the surface of the welded tubing.

From the alkali washes, the tubing is advanced into a rinse housing **78** aligned endwise with the alkali wash housing and similarly constructed. The rinse housing is fitted with a number of axially aligned spray heads, similar to the rings employed in the alkali wash systems, from which rinse water is sprayed onto the surface of the tubing as it passes therethrough to rinse remaining alkali from the surface before passing the tubing into the pickling bath. The rinse water is circulated under pressure from a water supply source to the spray heads and the water collected in the bottom of the rinse housing can be released to the drain unless water is at a premium, in which event the water is recirculated with sufficient makeup water to provide for substantial removal of alkali. The rinse water may be used either cold or warm, but it is economically undesirable to invest in warming the water unless the warm water is recirculated between the housing and a water storage reservoir for reuse.

From the rinse, the tubing **56** is advanced directly into a pickling housing **80** of similar construction as the wash and rinse housings and separated therefrom only by a separating wall **82**. The pickling housing is provided with a pair of longitudinally arranged, laterally spaced apart spray pipes **84** arranged in the upper portion of the housing to overlie the tubing **56** which passes linearly through an intermediate portion of the housing beneath the spray pipes to face the weld seam in the direction of the pipes. The pipes are each provided with a plurality of spray nozzles **86** in the underside positioned to direct the spray **88** angularly downwardly to converge on the weld seam positioned uppermost in the tubing passing therethrough. Thus the spray is directed forcefully from the spray nozzles onto the seam to react with the oxides on the surface which are formed at the weld. Use can be made of conventional pickling solutions for removal of the metal oxide, such for example as an acid solution containing about 30 percent by volume HCl dissolved in aqueous medium. For best results, it is desirable to make use of a pickling solution heated to an elevated temperature such as at a tem-

perature of 100–120° F., but a heated pickling solution is not essential.

The solution is stored in a suitable reservoir **90** and is connected with the spray heads through lines **92** and **94** and circulation is effected by means of a displacement pump. The reservoir, pump and housing are all provided with a rubber lining to protect the metal parts from the acids of the pickling solution.

From the pickling housing **80**, the pickled tubing is advanced into an aligned section of housing **96** for rinsing the pickling solution from the surface of the tubing. The rinse housing following pickling is very similar to the rinse housing **76** wherein water is sprayed from spray rings onto surfaces of the tubing passing therethrough to rinse the pickling solution from the surface.

In the aforementioned alkali washes, rinses, pickling and final rinse, the housings can be of a unitary construction subdivided into separate sections by separating walls each of which is provided with aligned openings dimensioned to enable the tubing to pass lengthwise therethrough in and out of the housings. Instead, the housings can be separated members with aligned openings in the end walls for the continuous passage of the tubing from one to another without bending.

An important concept of this invention resides in the means and method for continuously galvanizing the formed tubing as a continuous operation with the described forming, welding and cleaning operations. For this purpose, it is desirable to contact the cleaned surface of the steel tubing with molten zinc for sufficient time to enable the desired reactions to take place to form the desired thickness of galvanize on the surface and it is important to carry out the reactions under non-oxidizing conditions, otherwise undesirable oxides of the metal will form at the elevated temperatures under which the reactions are carried out.

The desired reducing or non-oxidizing atmosphere can be maintained by the enclosure of the galvanizing zone within a sealed housing into which an inert, or reducing gas can be introduced for maintenance of a non-oxidizing atmosphere. This can be accomplished by a sealed enclosure but it is preferable to make use of an enclosure which is capable of removal to gain access to the interior of the galvanizing zone but without interfering with the ability to achieve atmospheric control, when in position of use.

The desired characteristics have been achieved in the construction illustrated in FIG. 2 of the drawings by the use of a rectangular hood **100** having a horizontally disposed top wall **102**, side and the end walls **104** which depend perpendicularly downwardly from the edges of the top wall into a trough **106** facing upwardly from a frame **108** which extends all about the galvanizing zone. The bottom edges **110** of the side walls are received within the trough for support of the hood on the bottom wall thereof. The trough is at least partially filled with a pulverulent material **112**, such as fine sand, into which the lower edge of the side walls become embedded to effect a sealing relationship all around which militates against the flow of free gases all around for atmospheric control. One or more inlets **114** for the inert or reducing gas are provided in the walls of the hood for introduction of such inert or reducing gases in amounts to maintain a non-oxidizing atmosphere therein.

It has been found that the galzanizing reactions can be carried out more rapidly with greater uniformity when the tubing is preheated to an elevated temperature, such as to a temperature above the melting point temperature for the zinc, such as at 750° F., before being contacted with the molten zinc, although it is not essential to preheat. When preheating is effected, it is again important to achieve the desired preheat without exposure of the metal surface to oxidizing conditions, otherwise the metal oxides that would form at an accelerated rate while the tubing is heated to an elevated temperature would interfere with the formation of a suitable galvanize on the surface. In the illustrated modification, the preheat section comprises a tubular housing **116** which has its center aligned with the line of travel of the formed tubing through the machine and which communicates with the enclosure **100**. Inert gas is introduced into the tubular housing through an inlet **118** in the forward end of the tubular member for the circulation of the inert or reducing gas lengthwise through the housing into the hood or enclosure **100** to maintain non-oxidizind conditions within the tubular housing during passage of the tubing therethrough.

The tubing can be heated to elevated temperature by the introduction of heat from suitable and conventional internal or external heaters but it is preferred to make use of induction heating means **120** within the tubular housing to accelerate the build-up of temperature within the tubing walls in minimum time thereby to minimize the lengths necessary for the tubular housing.

Having described the preheat of the tubing and the introduction of the preheated tubing into the inert galvanizing zone maintained to reducing or non-oxidizing conditions, description will now be made of the new and novel means by which the tubing is maintained in contact with a molten bath of zinc as a continuous operation with the tubing forming process.

Referring now more particularly to FIGS. 2 and 3, the galvanizing means comprises an elongate, horizontally disposed housing **122** in the form of a trough aligned axially with the line of travel of the tubing for passage of the tubing axially through an intermediate section of the housing from an inlet **124** at one end to the outlet **126** at the opposite end. The housing is provided with one or more inlets **128** which are connected by a passage **130** to a reservoir **132** of molten zinc with means for displacement of the molten zinc from the reservoir to the inlets at a rate sufficient to maintain the housing substantially filled with molten zinc to cover the tubing advanced therethrough. The inlet **128** is preferably, though not necessarily, located in the portion of the housing adjacent the inlet end **124** through which the tubing is introduced into the housing for concurrent flow of the molten zinc through the housing with the tubing and in position to overlie the tubing so as to direct the stream or streams of molten zinc onto the tubing.

The housing is further provided with a drain opening **180** in the bottom wall **182** of the housing with a downpipe **184** leading from the drain to the reservoir. The drain opening is of small dimension to enable a thin stream of molten zinc constantly to flow therethrough but at a rate that is considerably less than the rate of introduction of molten zinc into the housing less the amount that escapes through the openings so that there will be an overflow of molten zinc over the ends of the trough forming the inlet and outlet to the housing but with an amount of molten zinc in the trough to cover the tubing passing therethrough. The drain opening **180** is effective in the event of some failure in operation or stoppage of the machine thereby to drain molten zinc from the housing before the zinc has cooled to a temperature below its melting point, otherwise the zinc would become solidified within the housing and thereby render the housing unfit for future use until the solidified zinc is passed from the housing or otherwise, with difficulty, removed.

The zinc in the reservoir can be heated by suitable burners or other heating means to maintain the zinc in the bath at a temperature above its melting point temperature of about 750° F. and preferably at a temperature above 850° F. Access means are provided in the hood **100** for addition of pigs of zinc to the reservoir in amounts corresponding to the zinc that is used or otherwise removed with the tubing.

It is important to provide sufficient weight of coating of molten zinc onto the surface of the formed tubing but it is undesirable to enable excess molten zinc to be car-

ried off with the tubing thereby to increase the cost of galvanizing and/or prevent bead formation by excess zinc remaining on the surface. Excess molten zinc is wiped off of the surface of the freshly galvanized tubing by means of an air knife which is preferably located outside of the housing but while still overlying the bath of molten zinc for return of excess zinc, removed from the coated tubing, to the bath.

For this purpose, the bath is extended beyond the cover **102** with a suitable dam **200** extending downwardly into the bath to provide a small section **202** which communicates with the bath but is otherwise open to the atmosphere. This enables fresh pigs of zinc to be added to the bath without the need to remove the cover and it provides an area wherein the excess molten zinc can be cut off the coated tubing and returned to the bath.

An important concept of this invention resides in the use of an air knife, in the form of a tubular member or doughnut **204**, having an internal diameter which is slightly larger than the outer wall to wall dimension of the tubing **56** so as to enable the tubing to pass therethrough. The tubular member is formed with a plurality of nozzle openings **206** arranged about the inner periphery thereof, in closely spaced circumferential relation, for directing streams **208** of air radially onto the outer surfaces of the tubing as it approaches the tubular member and passes through the opening. It is preferred to angle the jets in the direction towards the oncoming tubing for most effective cut-off. The air knife overlies the open portion **202** of the bath for return of the zinc removed from the surfaces of the tubing to the bath.

It has been found that a smoother and more uniform zinc galvanized coating can be achieved when the air projected from the tubular member into engagement with the freshly coated surface of the tubing is heated to elevated temperature. Noticeable improvement in operation of the air knife is secured when the air is heated to a temperature above 300° F. but below 1200° F. and preferably with the air engaging the tubing at a temperature within the range of 600° to 900° F. Under these conditions, the zinc is less rapidly solidified on the surface of the tubing thereby to provide more time to effect removal of excess molten zinc and to smooth the coating.

The air issuing from the air knife can be heated by conventional means, such as by passing the air in heat exchange relationship through an indirect heat exchange apparatus heated with gas burners, electrical resistance heaters or the like. A novel means which makes use of the sensible heat of the bath of molten zinc more uniformly to heat the air comprises an assembly which is immersed into the bath of molten zinc including an outer housing **210** formed of a metal having good heat conductivity but which is resistant to molten zinc and which is open at its upper end **212**, and an inner housing **214** dimensioned to have a height less than the height of the outer housing and a length and width less than that of the outer housing to provide a spaced relationship therebetween which is filled with lead **216** or other heat transfer material which is fluid at the temperature of the molten zinc. Spacers **218** are provided on the inner wall of the outer housing properly to position the inner housing therein.

A conduit **220** extends through the top wall **222** of the inner housing into the upper end portion of the housing while another conduit **224** extends downwardly through the top wall of the housing and through the interior thereof to the lower end portion of the housing. The interior of the housing is provided with a plurality of vertically spaced apart baffle plates, such as plates **226** and **228**, with passages **230** in opposite sides of successive plates to force the air to travel in a sinuous path through the housing from the inlet at the top to the outlet at the bottom to maximize heat exchange. The conduit **220** communicates with an accumulator or other source of air under pressure while the conduit **224** communicates with the tubular member **204** for the transmission of hot gases thereto.

The outer housing **210** is immersed so that only a small fraction of the upper portion extends above the level of the bath of molten zinc. With molten zinc at a temperature of 800° to 850° F., air at a temperature of above 650° to 700° F. is projected from the tubular member onto the tubing. When higher temperatures are desired, the temperatures of the air delivered by the immersion heater can be supplemented by heat from gas burners or electrical resistance heaters and the like.

From the galvanizing section, the galvanized tubing is advanced sequentially through a series of water spray sections **190** to cool down the galvanized tubing if the tubing has not otherwise been sufficiently cooled in the freezing step, and, from the cool-down operation, to conventional tube sizing rolls **192**, and from the tube sizing rolls to a travelling shear section **194** where the endless tubing is cut into lengths of predetermined dimension for shipping. The water spray sections are similar to the rinse sections which follow alkali cleaning or acid etch and the tube sizing rolls and flying shear are of conventional construction.

As an alternative, the galvanized tubing, after being cooled, may be processed through a spray housing similar to the alkali cleaning, wherein the galvanized surface is wetted with a chromate and nitric acid solution for reaction to form a surface of zinc chromate whereby still greater resistance to oxidation is secured by comparison with a plain zinc galvanized surface. If a section of the spray housing is devoted to the chromate spray, an additional section should be provided for a water rinse to remove excess chromate solution from the surface.

As another innovation, the tubing is marked, as by means of a marking roll, after galvanizing as distinguished from the conventional practice of indenting to mark the tubing before galvanizing becomes filled with molten zinc so that it would no longer be visible and the marked depressions appeared also to interfere with the proper galvanizing of the tubing surface. Thus the marking roll precedes tube sizing, as indicated by the position **191**.

It will be apparent from the foregoing description that we have provided a simple, efficient and effective means for contiuously forming tubing of strip steel and for galvanizing the formed tubing as a continuous operation with the continuous tube forming process.

It will be understood that changes may be made in the details of construction, arrangement and operation, as well as in materials employed, without departing from the spirit of the invention, especially as defined in the following claims.

We claim:

1. In the method for the continuous forming and galvanizing of steel tubing from strip, the steps of

(1) advancing the steel strip endlessly in one direction;

(2) continuously forming the steel strip to rounded shape to bring the lateral edges in abutting relation;

(3) continuously welding the abutting edges of the strip to seal the formed tubing;

(4) continuously scarfing the welded portion of the tubing to cut off the portions of the weld extending outwardly beyond the periphery of the tubing;

(5) wetting the surface of the formed tubing with cleaning solutions;

(6) rinsing the cleaned tubing with aqueous medium to wash off the cleaning solutions;

(7) advancing the tubing continuously through an enclosure maintained at an elevated temperature to preheat the tubing;

(8) advancing the preheated tubing into a bath of molten zinc arranged in linear alignment with the formed tubing and in position for the tubing to enter and leave the bath and pass through the bath of

molten zinc at a level below the surface of the bath to minimize contact with oxides on the surface of the bath;

(9) continuously adding molten zinc to the bath in an amount in excess of that taken up by the tubing;

(10) overflowing the excess of molten zinc from the surface of the bath continuously to flush oxide and slag from the bath;

(11) enclosing the bath within a housing in direct communication with the preheating enclosure;

(12) introducing a non-oxidizing gas into the enclosure to maintain a relatively non-oxidizing atmosphere during preheat and during galvanizing;

(13) removing excess molten zinc from the surface of the tubing after leaving the bath of molten zinc by projecting circumferentially located preheated streams of air as an air knife onto the outer periphery of the tubing as it leaves the bath of molten zinc but before the zinc solidifies onto the surface of the tubing, to cut off excess zinc; and then

(14) freezing the coating of molten zinc remaining on the surface of the tubing.

2. The method as claimed in claim **1** wherein the air is preheated to a temperature for engaging the tubular member at a temperature within the range of 300° to 1200° F.

3. The method as claimed in claim **1** wherein the air is preheated to a temperature for engaging the tubular member at a temperature within the range of 600° to 900° F.

4. The method as claimed in claim **1** in which the air is preheated by passing the air under pressure through a metal housing immersed in the bath of molten zinc for indirect heat exchange with the molten zinc.

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CHARLIE T. MOON, Primary Examiner

U.S. Cl. X.R.

29—477.7; 117—51, 102