

Nov. 28, 1961

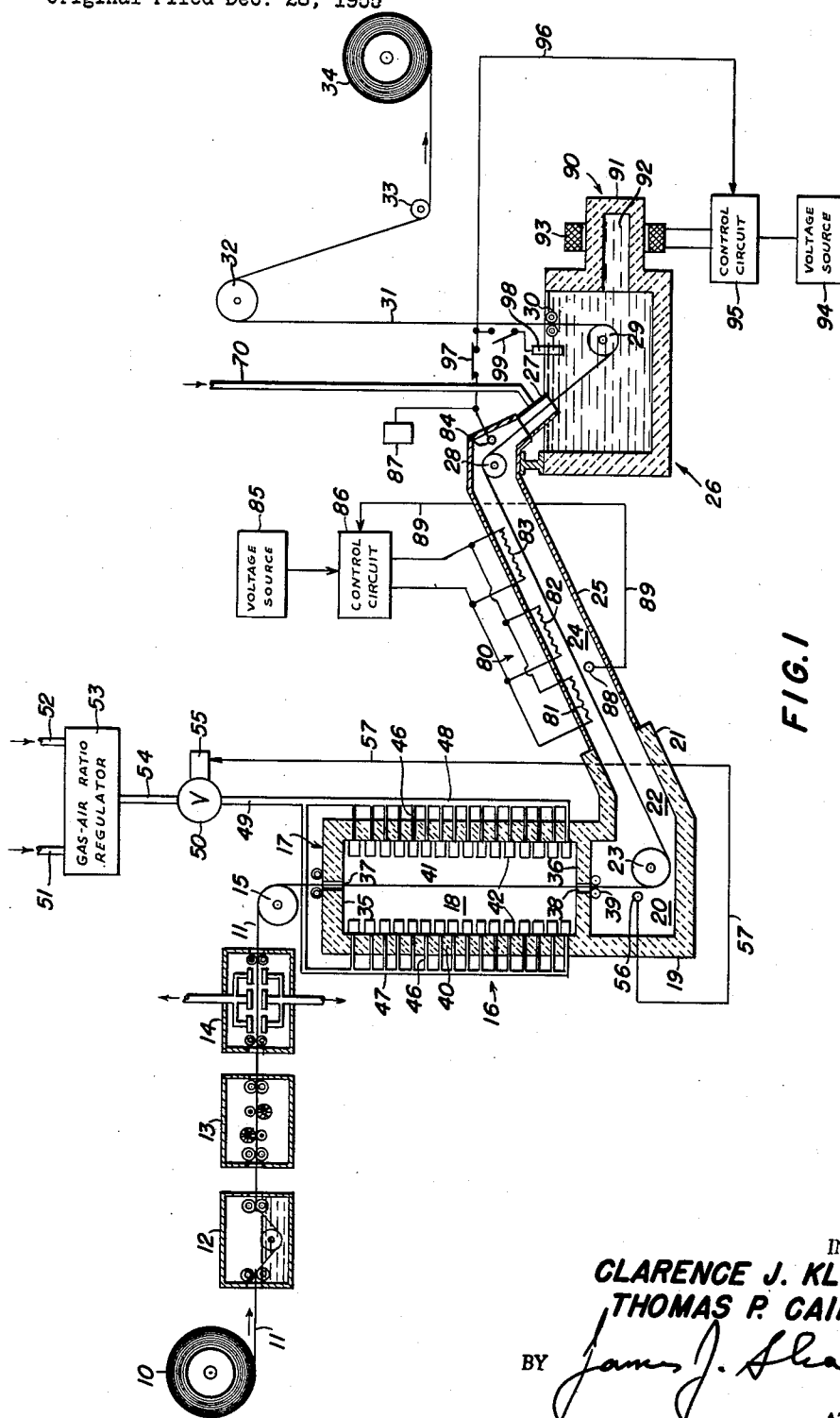
C. J. KLEIN ET AL

3,010,844

GALVANIZING

Original Filed Dec. 28, 1955

2 Sheets-Sheet 1



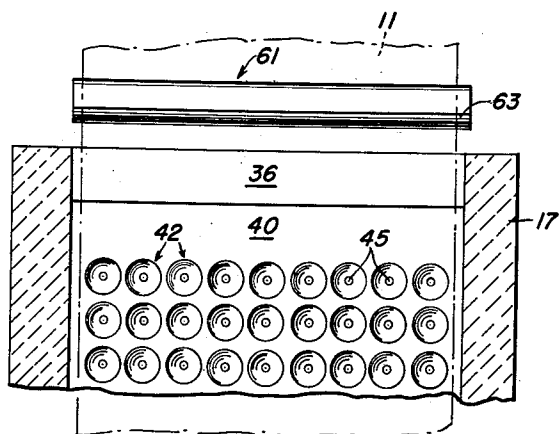
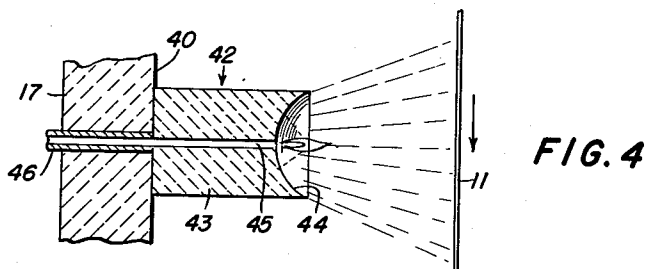
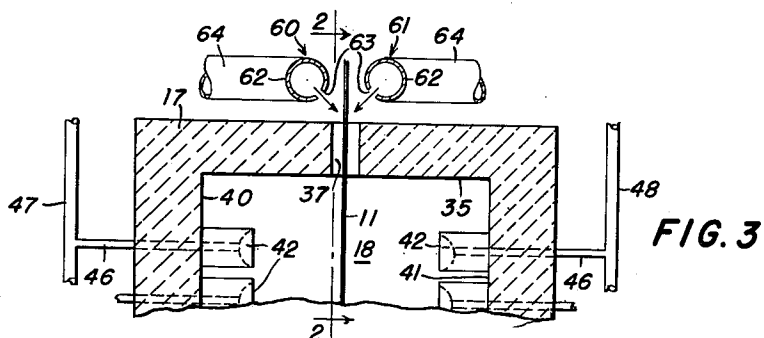
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3,010,844

GALVANIZING

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Continuation of application Ser. No. 761,654, Sept. 17, 1958, which is a continuation of application Ser. No. 555,919, Dec. 28, 1955. This application Jan. 6, 1961, Ser. No. 81,198

6 Claims. (Cl. 117—51)

This invention relates to the coating of strip material with molten metal and more particularly to improvements in continuous tight coat galvanizing of iron or steel strip material.

It is known in the art that tight coat galvanized iron or steel products may be obtained by the addition of aluminum to a coating bath of molten zinc. In galvanizing ferrous materials a layer of iron-zinc alloy is formed at the interface between the coating and the surface of the ferrous material and the thickness of the alloy layer is a measure of the tightness of the coating, the thinner the alloy layer greater adherence exists between the coating and the ferrous material. The presence of aluminum in the zinc bath prevents zinc from forming an alloy with the surface of the ferrous material and obtains the production of a tight coat galvanized product. However, since the aluminum prevents zinc from forming an alloy with the surface of the ferrous material being coated, the aluminum in the bath causes rapid erosion of steel pots ordinarily employed to contain the bath of molten zinc. This is due primarily to circulation of molten zinc in contact with interior surfaces of the pot upon application of heat to the pot. Prior lines for continuous tight coat galvanizing of strip material overcome this problem by supplying the necessary heat to the pot through the strip material entering the coating bath to thus eliminate the necessity to fire the pot.

Before the present invention it was believed that a tight coat galvanized product could not be obtained with an aluminum addition in the zinc bath unless the surface of the ferrous material was entirely free of oxides. This belief led to the development of two types of continuous tight coat galvanizing lines. In the first type a special flux coating is applied to the surfaces of the strip material, and the coated strip material enters the bath of molten zinc at a temperature below the optimum coating temperature. Thus heat must be applied to the pot, and a specially constructed pot is employed which is not subject to erosion due to the aluminum in the zinc bath. The second type of prior continuous tight coat galvanizing line employs a reducing furnace to remove oxides from the surfaces of the strip material. Since a high temperature is required to reduce the oxides on the surfaces of the strip material, an annealing furnace is employed and unannealed strip material is fed to the line. Such annealing of the strip material produces a relatively hard product as compared to the product produced by box annealing and temper treatment. Thus prior galvanizing lines of the second type are not capable of producing substantially full hard or relatively soft tight coat galvanized strip material by a continuous process.

In a galvanizing process the coating bath should be maintained at an optimum temperature or within a relatively narrow optimum temperature range, and the ferrous material being coated must be at the temperature of the bath before leaving the bath in order to obtain a good product. Therefore, by passing the strip material into the bath at a temperature at least equal to the optimum temperature of the bath, the strip material may

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be passed through the bath at high speed and a relatively short strip bath through the bath is required. In view of the relatively high temperatures required for reducing oxides on the surfaces of the ferrous strip material in prior tight coat galvanizing lines as discussed above, difficulties have been experienced when attempting to supply heat to the pot through the strip material and maintain the coating bath at an optimum coating temperature especially in cases where the line is required to process strip material of different gage.

The continuous galvanizing line provided by the present invention utilizes an aluminum addition in the bath of molten zinc to provide a tight coat product, and the heat required to maintain the bath at an optimum coating temperature is supplied by the strip material to prevent pot erosion. The novel process and apparatus provided by the present invention is capable of producing a tight coat galvanizing product in which the ferrous strip material is relatively soft as compared to the product produced by prior galvanizing lines including a continuous reducing step, and is also capable of producing tight coat galvanized substantially full hard ferrous strip material. Also, the present line includes novel features which make it possible to accurately maintain the coating bath at an optimum coating temperature or within an optimum range of coating temperatures throughout a wide range of strip speeds and strip gages.

According to the present invention, annealed strip material, or full hard strip material, is first treated to remove oxides from the surfaces of the strip material through an acid bath such as a muriatic acid bath. The strip material is then passed through a furnace by which its temperature is increased and accurately maintained at a value above the optimum coating temperature but materially below a reducing temperature, such that the strip material is capable of supplying the necessary heat to the pot to maintain the pot at the optimum coating temperature. From the furnace, the strip material is passed through a chute and introduced directly into the bath of molten metal contained in the pot. The chute is provided with controllable heating means operable to accurately control the temperature of the strip material passing therethrough and entering the coating bath. The chute and the furnace are provided with means for maintaining therein a non-oxidizing atmosphere under super atmospheric pressure to prevent formation of oxides on the surfaces of the strip material passing therethrough.

The foregoing will be more fully understood from reference to the following detailed description considered in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are designed for purposes of illustration only and not as a definition of the limits of the invention, reference for the latter purpose being had to the appended claims.

In the drawings, in which similar reference characters denote similar elements throughout the several views:

FIGURE 1 is a diagrammatic view, partially in section, of a continuous galvanizing line embodying the principles of the present invention;

FIGURE 2 is a fragmentary view, in section of a portion of the apparatus employed in the line shown in FIGURE 1;

FIGURE 3 is an enlarged detailed view, in section, showing another feature of the invention, and

FIGURE 4 is a detailed view of another feature of the present invention.

A continuous galvanizing line embodying the principles of the present invention is shown in FIGURE 1 of the drawings. A coil 10 of strip steel material to be coated is located at the input of the line. The coil 10 may be supported by a conventional uncoiler, not shown, which

may be of the single or two mandrel type. Also, the entry end of the line following the uncoiler may be provided with conventional equipment for feeding continuous strip into the line, such as a strip welding device and a looping pit, for example. Such equipment has no direct relation to the present invention and is not shown in the drawings for the sake of clarity. Strip material 11 from the coil 10 is first passed through a treating tank 12 containing an acid bath such as muriatic acid solution for removing oxides from the surfaces of the strip material, and is then passed through a scrubbing tank 13 and a drying tank 14, which may be of conventional construction. From the drying tank 14 the strip material passes over a deflector roll 15 and then passes vertically downwardly through a furnace 16, the operation and purpose of which will be described more fully below. The furnace includes an upper casing 17 defining a heating chamber 18 and a lower casing 19 forming a chamber 20. The casing 19 includes an extension 21 comprising the boot of the furnace and forming an outlet chamber 22. The strip material leaving the chamber 18 passes around a deflector roll 23 through the outlet chamber 22 and into a chamber 24 of a chute 25. The chute 25 extends to above a pot 26 containing molten coating metal and is provided with a downwardly depending portion 27 extending to beneath the surface of the coating metal. A roll 28 is located in the upper end of the chute for directing the strip material downwardly through the portion 27 into the bath of molten metal and around a sinker roll 29. The strip material then passes upwardly between coating rolls 30 and out of the coating bath. From the coating rolls 30 the strip material passes upwardly through a cooling section 31, around a deflector roll 32 and then downwardly and around a roll 33 from thence it is formed into a coil 34 at the exit end of the line. The cooling section 31 may comprise conventional cooling tower, not shown, and coiling devices may be located at the exit end of the line upon which the coil is formed.

The bath of molten metal in the pot 26 comprises zinc including an aluminum addition in order to provide a tight coat on the strip material. Since aluminum is present in the molten bath, and in order to minimize erosion of the pot lining due to the presence of the aluminum, the pot is not continuously fired during the coating process and the heat required for maintaining the metal molten and the bath at the optimum coating temperature is provided by the strip material. It has been determined that the temperature of the coating bath should be at an optimum value in order to obtain a good product. Thus, a definite quantity of heat must be continuously added to the pot to compensate for heat losses and maintain the bath at the optimum coating temperature. Pot heating means may be provided to melt the zinc and initially raise the temperature of the bath to the region of the optimum coating temperature.

The housing 17 of the furnace 16 is formed of refractory material and is provided with suitable insulation. The chamber 18 is of sufficient width for the passage of strip material of maximum width to be processed by the line, and is of sufficient length to provide the required heating effect. The upper and lower ends 35 and 36 of the furnace housing are provided with transverse slits 37 and 38, respectively, for the passage of the strip material through the chamber 18. Elongated sealing rolls 39 are located in the lower chamber 20 adjacent the slit 38. The furnace housing 17 includes interior side walls 40 and 41, and a plurality of heating units 42 are mounted on the interior side walls in contiguous relation throughout the area of the interior side walls as shown in FIGURES 1 and 2. The heating units function to heat, by radiation, the strip material passing through the chamber 18.

With reference more particularly to FIGURES 3 and 4, each of the heating units 42 includes a cylindrical member 43 formed of refractory material. One end of the

cylindrical member 43 is secured to an interior side wall of the housing 17, such as the side wall 40, while its other end terminates in a smooth concave surface 44. A longitudinal passageway 45 extends through the member 43 and terminates at the center of the concave surface 44 as a burning element, the other end of the passageway being connected to a feed conduit 46. The feed conduits 46 for the heating units on the wall 40 are connected to a manifold 47, while the feed conduits 46 for the heating units on the wall 41 are connected to a manifold 48, and the manifolds 47 and 48 are fed with a combustible mixture through a conduit 49 controlled by a regulating valve 50. Streams of air and combustible gas, from sources not shown, are conducted through conduits 51 and 52 to a gas-air ratio regulator 53, and the output from the regulator is conducted through a conduit 54 to the inlet of the valve 50. The valve 50 is provided with an operating mechanism 55 which may be adjusted to establish a desired temperature in the chamber 18 and which functions responsively to the temperature of the strip material passing from the heating chamber of the furnace. For the latter purpose a photoelectric cell type of temperature sensing means 56 is located in the chamber 20 adjacent the path of the strip material and is connected to the valve operating mechanism 55 through a conductor 57. The regulator 53 is adjusted to feed to the conduit 54 a composite stream of air and combustible gas of the proper ratio so that the gaseous products of combustion of the heating units 42 are of a non-oxidizing nature. A combustible gas, free of moisture and sulphur, may comprise the source supplying the conduit 52.

The gaseous products of combustion formed in the chamber 18 of the furnace flow outwardly through the transverse slot 37 in the upper end of the furnace housing. The effective area of the slot 37, that is the area of the slot minus the cross-sectional area of the strip material, is small relative to the rate of production of gaseous products of combustion in the chamber 18 and the chamber 18 is maintained under super atmospheric pressure. Also, the flow of products of combustion through the slot 37 prevents air from entering the chamber 18 therethrough. However, the strip material entering the furnace tends to drag air into the chamber 18 due to adherence of air to the surfaces of the strip material. In order to prevent this action, a pair of air stripping devices 60 and 61 are positioned outside the chamber 18 adjacent the entry end of the transverse slot 37 on opposite sides of the strip material. As shown more particularly in FIGURES 2 and 3, each of the air stripping devices comprises an elongated tube 62 mounted transversely of and adjacent the path of the strip material. The tube 62 is provided with a restricted discharge slot 63 extending throughout the width of the strip material and located to discharge in a direction toward the strip material. The tube is fed with a source of compressed air through a feed conduit 64, and a high velocity sheet of air is discharged from the slot 63. The restricted discharge slots of the stripping devices 60 and 61 are disposed to direct the sheets of high pressure air at an angle toward the surfaces of the strip material downwardly toward the transverse slot 37. The sheets of air ejected onto the strip material break up the air adhering to the surfaces of the strip material and prevent entry of such air into the chamber 18. The air thus disentrained from the surfaces of the strip material, as well as the air injected through the slots 63 is swept outwardly through the slot 37 by the outgoing stream of combustion gases.

For the purpose that will appear below, the lower chamber 20 of the furnace, the outlet chamber 22 and the chamber 24 of the chute 25, including the chamber formed by the downwardly depending portion 27 of the chute, are fed with a non-oxidizing atmosphere under super atmospheric pressure. For this purpose a stream of non-oxidizing gas, such as a mixture of hydrogen and nitrogen, under super atmospheric pressure, is fed through a conduit 70 to within the chamber formed by the portion

27 of the chute. The gas flows through the chute chamber 24, the chambers 22 and 20 and through the heating chamber 18 of the furnace from which it is discharged by way of the slot 37.

In accordance with the principles of the present invention the strip material passing through the chamber 18 of the furnace 16 is heated by radiation to a relatively high temperature greater than the optimum coating temperature of the bath of molten metal in the pot 25 but less than the temperature required for a reducing process. The heat generated in the chamber 18 and hence the temperature of the strip material is determined by the valve 50 which controls the rate of flow of combustible mixture fed to the heating units. The valve 50 may be manually set to provide a desired strip temperature, and the desired temperature may be maintained by operation of the temperature sensing means 56 through the valve operator 55. As described below, the predetermined temperature of the strip material leaving the furnace chamber 18 is related to the temperature of the strip material entering the bath of coating metal which is necessary to compensate for heat losses and to maintain the bath at an optimum coating temperature.

Heating means 80 is provided in the chamber 24 of the chute 25 for controlling the temperature of the strip material on its way from the furnace 16 to the coating pot 26. The heating means may comprise a plurality of electrical heating units, such as heating units 81, 82 and 83. However, it is to be expressly understood that the invention is not limited to the number of heating units shown and that any desired number of heating units may be employed in order to provide the required temperature control as discussed below. The heating units are positioned lengthwise of the chute, beginning adjacent the end of the chute communicating with the furnace outlet and extending along a substantial length of the chute and terminating in a region of the upper end of the chute on the furnace side of the roll 28. The heating units may also extend transversely of the chute to provide heat across the width of the strip material. The heating units are connected in parallel to a voltage source 85 through a control circuit 86. The control circuit 86 comprises a voltage regulating device that may be adjusted to establish a required application of heat to the chute chamber so that the strip material leaving the chute is maintained at a critical temperature. The temperature of the strip material leaving the chute may be determined by any suitable temperature measuring device 84, such as a photo-electric cell type located in the upper end of the chute and connected to a visual indicator 87. The control circuit 86 may be adjusted to establish a desired strip temperature at the exit end of the chute as shown by the indicator 87. In order to compensate for temperature variations and maintain the strip material at the desired temperature, the control circuit 86 operates responsively to a temperature sensing device 88 such as a thermocouple temperature indicator, through a conductor 89. With this arrangement, the voltage fed to the heating units is automatically increased or decreased, as the case may be, to maintain the strip material at a preselected critical temperature.

As mentioned above, in order to maintain the coating bath at the optimum coating temperature by means of heat supplied by the strip material, the strip material must enter the bath at a critical temperature higher than the optimum coating bath temperature in order to compensate for heat losses. While the critical temperature of the strip material entering the coating bath, or the temperature difference between the optimum coating temperature and the critical temperature of the strip material entering the coating bath, may vary in accordance with the heat losses, the speed of the strip material and the gage of the strip material, it is a feature of the present invention to operate the furnace 16 to heat the strip material to a predetermined temperature above the high-

est critical temperature that may be required and to utilize the heating means 80, under control of the temperature sensing device 88, to maintain the strip material entering the coating bath at the required critical temperature.

The heating means 80 functions to maintain the strip material passing through the chute chamber 25 at substantially the predetermined temperature established by the furnace 16, while at the same time positively controls the strip temperature so that the strip material enters the coating bath at the required critical temperature. Preferably the temperature of the strip material should not vary abruptly during its passage through the chute chamber. However, a relatively small degree of gradual variation in the strip temperature is necessary in order to maintain the bath at an optimum coating temperature. For this reason the furnace is controlled to heat the strip material to a temperature slightly higher than the required critical temperature of the strip material entering the coating bath, and the heating means 80, extending along a substantial length of the chute, effectively controls the heat loss of the strip material passing through the chute to establish the critical temperature.

Since the temperature of the strip material passing through the chute may be varied gradually from the predetermined furnace temperature to the critical temperature, it is preferable to control the furnace to heat the strip material to a temperature only slightly higher than the required critical temperature. Such an arrangement allows the use of a chute of the shortest length mechanically necessary to provide a passageway for the strip material from the furnace to the pot. However, the temperature difference between the predetermined furnace temperature and the critical temperature should not be so small as to preclude any practical control of the temperature of the strip material passing through the chute. In a practical application of the present invention, it was determined that the critical temperature of the strip material entering the pot should be in the range of 940°-950° F. in order to maintain an optimum coating temperature. In this application the furnace was controlled to heat the strip material to 1000° F.

The pots 26 may be provided with induction heating means 90. The induction heating means may be utilized solely to melt the zinc initially and raise the temperature of the bath up to the region of the optimum coating temperature, or it may be employed continuously during the coating operation to provide a portion of the required heat to the pot. In either case the use of the induction heating makes it possible to use a ceramic pot to minimize erosion. The induction heating means 90 may comprise an extension 91 providing a passageway 92 communicating with the coating bath. An induction heating coil 93 may surround the extension and a voltage source 94 may be provided to energize the coil through a control circuit 95. The control circuit 95 may be manually operable, or it may also be operable responsively to the temperature measuring device 84 through a conductor 96 including a control switch 97 or to a thermocouple 98 immersed in the coating bath and connected to the conductor 96 by a switch 99. When it is desired to melt the zinc initially and raise the temperature of the coating bath up to the region of the optimum coating temperature, the switches 97 and 99 are open and the control circuit 95 is manually adjusted to provide the required heat to the pot. During continuous coating of strip material, the switch 97 may be closed so that the control circuit 95 operates responsively to a signal from temperature measuring device 84 and the induction coil 93 is energized to supply the required heat to the pot equal to the difference between the temperature measured by the device 84 and the critical temperature required to establish the optimum coating temperature. For this purpose the control circuit 95 may be provided with a differential circuit arrangement fed with the signal from

the device 84 and a reference signal corresponding to the critical temperature. Also during continuous coating operations the switch 97 may be open and the switch 99 closed so that the control circuit operates responsively to the thermocouple 98. In the latter operation the control circuit 95 is manually set to the optimum coating temperature and the bath is maintained at that temperature irrespective of the temperature of the strip material entering the pot. In induction type pot heaters it is necessary to continuously energize the induction coil to a small degree to prevent solidification of the coating metal in the passageway 92. The resulting heat added to the coating bath is insignificant, and it is not necessary to operate the control circuit 95 responsively to the device 84 or the thermocouple 98 when the coil 93 is energized only to the degree necessary to prevent solidification of the coating metal. However, in cases when the line is required to coat strip material throughout a wide range of gages and strip speeds the use of the induction heater under control of the device 84 or the thermocouple 98 aids or makes it possible to maintain the bath at the optimum coating temperature.

In operation, the strip material to be tight coat galvanized is fed from the coil 10 through the acid bath 12 to remove oxides from its surfaces. The strip material is then scrubbed and dried and passed through the furnace 16. The regulator 53 is adjusted so that the products of combustion formed in the furnace chamber 18 are of a non-oxidizing nature, and the valve 50 is set to supply the necessary fuel to the furnace to heat the strip material to a predetermined value above the strip temperature necessary to establish the optimum coating temperature. This temperature is materially below the temperature range required for a reducing effect. For example, the furnace 18 may be operated to heat the strip material to 1000° F. The temperature of the strip material leaving the furnace is maintained substantially constant by the temperature sensing device 56 through the valve operator 55. The strip material enters the chute chamber 25 at a temperature substantially corresponding to the temperature established by the furnace, and the temperature of the strip material passing through the chute is controlled by the heating means 80, as determined by the control circuit 86 and maintained by the temperature sensing device 88, to establish the critical temperature of the strip material entering the coating bath required to obtain the optimum coating temperature; the critical temperature being less than the predetermined strip temperature established by the furnace and the strip temperature may be gradually reduced from the furnace temperature to the critical temperature by means of the controlled heating means 80. The heating means 80 controls the temperature of the strip material passing through the chute chamber 24 by controlling the degree of heat lost by the strip material between the furnace and the pot. This type of temperature control responds rapidly to changing conditions and is capable of accurately establishing and maintaining the critical temperature of the strip material entering the coating bath.

The furnace 16, including a plurality of burners, is capable of precisely maintaining the strip material at a predetermined temperature and thus makes it possible to accurately control the temperature of the strip material entering the coating bath by the controlled heating means in the chute. The feature of the furnace 16 of providing a non-oxidizing atmosphere under superatmospheric pressure by the products of combustion of the burners eliminates the necessity of special equipment to prevent the formation of oxides during the process of heating the strip material. Also, this type of furnace is adaptable to the use of a controllably heated chute for forming a path for the strip material from the furnace to the pot by which the strip material entering the pot may be accurately controlled to maintain an optimum coating temperature. Moreover, particularly in view of the fact that the furnace

heats the strip material by radiation, there exists a minimum of latent heat in the furnace, and the furnace temperature may be caused to respond rapidly to changing conditions, such as strip speed.

There is thus provided by the present invention a novel method of and apparatus for continuous tight coat galvanizing of steel or iron strip material. The tight coat product is obtained by employing aluminum addition to the zinc coating bath and the problem of pot erosion is overcome by supplying the necessary heat to the pot through the strip material being coated. By the novel method and apparatus provided by the present invention, the strip material is only heated to a temperature necessary to controllably maintain the strip material entering the coating bath at a critical temperature necessary to compensate for heat losses and establish an optimum coating temperature. Such an arrangement not only allows more accurate control of the optimum coating temperature but makes it possible to tight coat galvanize box annealed or substantially full hard ferrous strip material.

Although only several embodiments of the method and apparatus inventions have been disclosed and described, it is to be expressly understood that various substitutions and changes may be made therein without departing from the spirit of the invention as well understood by those skilled in the art. Reference therefore will be had to the appended claims for a definition of the limits of the invention.

This application is a continuation of copending application Serial No. 761,654, entitled "Galvanizing," filed September 17, 1958, which was a continuation of the then copending application Serial No. 555,919, entitled "Galvanizing," filed December 28, 1955.

We claim:

1. Method of continuously producing tight coat galvanized ferrous strip material using a coating bath of molten zinc and aluminum additions at an optimum coating temperature which comprises treating ferrous strip material to remove oxides from the strip material including passing the strip through an acid bath, passing the treated strip material through a heating zone containing a non-oxidizing atmosphere to heat the strip material to a temperature substantially below annealing temperature for the ferrous strip material, passing the heated strip material without contact with the atmosphere through a transfer zone containing a non-oxidizing atmosphere and from the transfer zone into a coating bath without contact with atmospheric air and then through the bath, controlling the temperature of the strip material passing through the transfer zone to avoid abrupt changes in the temperature of the strip material, and maintaining the strip material entering the bath at a critical temperature higher than the optimum coating temperature of the bath by controllably adding heat to the transfer zone to control the heat content of the strip material, the critical temperature being such that the strip material entering the bath continuously supplies a quantity of heat to the bath to maintain the bath at a temperature within an optimum coating temperature range.

2. Method of continuously producing tight coat galvanized ferrous strip material using a coating bath of molten zinc and aluminum additions at an optimum coating temperature which comprises treating annealed ferrous strip material to remove oxides from the strip material including passing the strip material through an acid bath, passing the treated strip material through a heating zone containing a non-oxidizing atmosphere to heat the strip material to a temperature substantially below annealing temperature for the ferrous strip material, passing the heated strip material without contact with atmospheric air through a transfer zone containing a non-oxidizing atmosphere and from the transfer zone into a coating bath without contact with atmospheric air and then through the bath, controlling the temperature of the strip

material passing through the transfer zone to avoid abrupt changes in the temperature of the strip material, and maintaining the strip material entering the bath at a critical temperature higher than the optimum coating temperature of the bath by controllably adding heat to the transfer zone to control the heat content of the strip material, the critical temperature being such that the strip material entering the bath continuously supplies a quantity of heat to the bath to maintain the bath at a temperature within an optimum coating temperature range.

3. Method of continuously producing tight coat galvanized substantially full hard ferrous strip material using a coating bath of molten zinc and aluminum additions at an optimum coating temperature which comprises treating substantially full hard ferrous strip material to remove oxides from the strip material including passing the strip material through an acid bath, passing treated strip material through a heating zone containing a non-oxidizing atmosphere, controlling the heating zone to heat the strip material to a temperature substantially below a temperature required to anneal the strip material, passing the heated strip material through a transfer zone containing a non-oxidizing atmosphere and then passing the strip material through a coating bath, controlling the temperature of the strip material passing through the transfer zone to avoid abrupt changes in the temperature of the strip material, and maintaining the strip material entering the bath at a critical temperature higher than the optimum coating temperature of the bath by controllably adding heat to the transfer zone to control the heat content of the strip material, the critical temperature being such that the strip material entering the bath continuously supplies a quantity of heat to the bath to maintain the bath at a temperature within an optimum coating temperature range.

4. Method of continuously producing tight coat galvanized ferrous strip material using a coating bath of molten zinc and aluminum additions at an optimum coating temperature which comprises treating ferrous strip material to remove oxides from the strip material then heating the clean strip material in a heating zone containing a non-oxidizing atmosphere, controlling the heating zone to heat the strip material to a temperature below that required to anneal the strip material, passing the heated strip material through a transfer zone containing a non-oxidizing atmosphere and then passing the strip material through a coating bath, controlling the temperature of the strip material passing through the transfer zone to avoid abrupt changes in the temperature of the strip material, and maintaining the strip material entering the bath at a critical temperature higher than the optimum coating temperature of the bath by controllably adding heat to the transfer zone along a substantial portion of the length of the transfer zone to control the heat content of the strip material, the critical temperature being such that the

strip material entering the bath continuously supplies a quantity of heat to the bath to maintain the bath at a temperature within an optimum coating temperature range.

5. Method of continuously producing tight coat galvanized ferrous strip material using a coating bath of molten zinc and aluminum additions at an optimum coating temperature which comprises treating annealed ferrous strip material to remove oxides from the strip material then heating the clean strip material in a heating zone containing a non-oxidizing atmosphere to a temperature substantially below an annealing temperature for the ferrous strip material, passing the heated strip material through a transfer zone containing a non-oxidizing atmosphere and then passing the strip material through a coating bath, controlling the temperature of the strip material passing through the transfer zone to avoid abrupt changes in the temperature of the strip material, and maintaining the strip material entering the bath at a critical temperature higher than the optimum coating temperature of the bath by controllably adding heat to the transfer zone along a substantial portion of the length of the transfer zone to control the heat content of the strip material, the critical temperature being such that the strip material entering the bath continuously supplies a quantity of heat to the bath to maintain the bath at a temperature within an optimum coating temperature range.

6. Method of continuously producing tight coat galvanized substantially full hard ferrous strip material using a coating bath of molten zinc and aluminum additions at an optimum coating temperature which comprises treating substantially full hard ferrous strip material to remove oxides from the strip material then heating clean strip material in a heating zone containing a non-oxidizing atmosphere, controlling the heating zone to heat the strip material to a temperature substantially below a temperature required to anneal the strip material passing the heated strip material through a transfer zone containing a non-oxidizing atmosphere and then passing the strip material through a coating bath, controlling the temperature of the strip material passing through the transfer zone to avoid abrupt changes in the temperature of the strip material, and maintaining the strip material entering the bath at a critical temperature higher than the optimum coating temperature of the bath by controllably adding heat to the transfer zone along a substantial portion of the length of the transfer zone to control the heat content of the strip material, the critical temperature being such that the strip material entering the bath continuously supplies a quantity of heat to the bath to maintain the bath at a temperature within an optimum coating temperature range.

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