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APPARATUS FOR FLOW BRIGHTENING ELECTROLYTIC TINPLATE

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Fig. 2

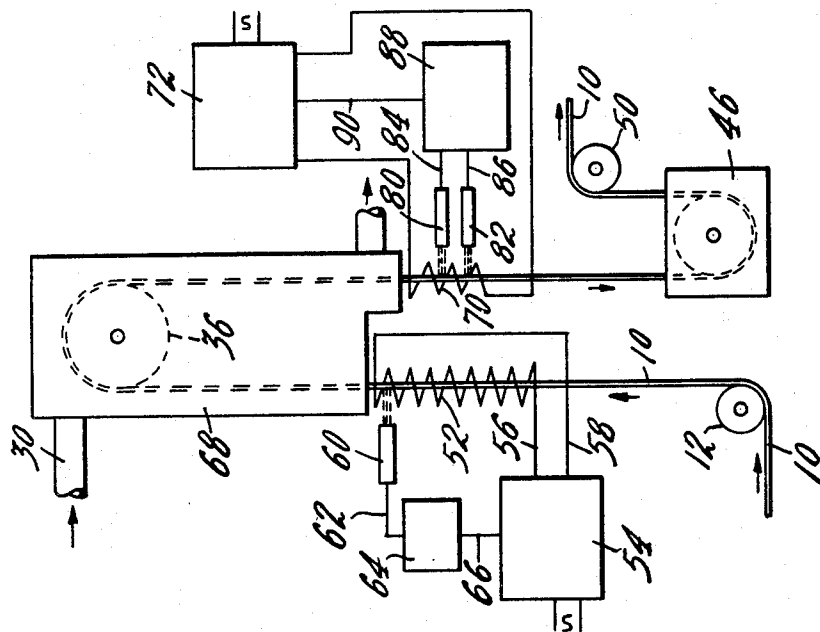
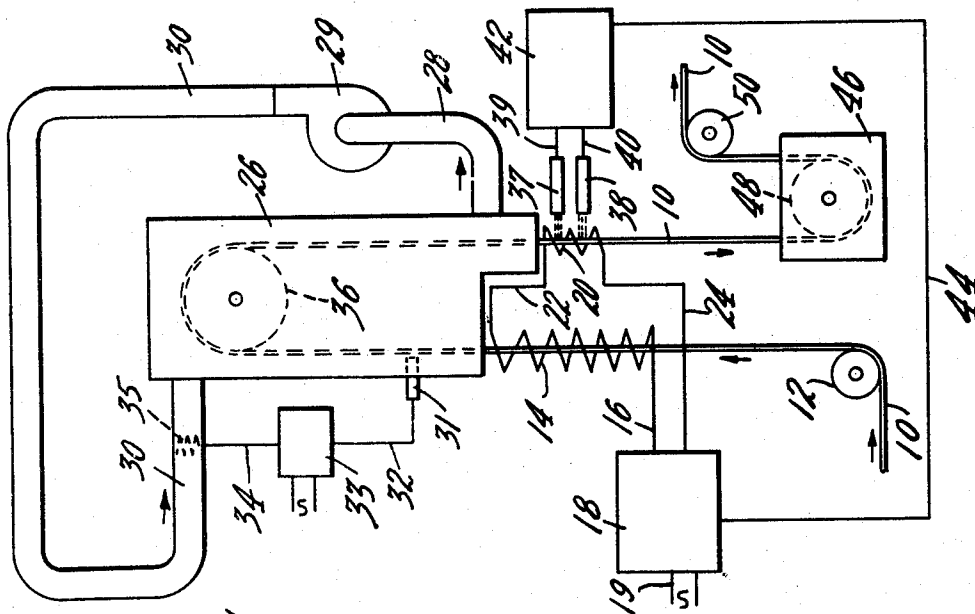


Fig. 1



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APPARATUS FOR FLOW BRIGHTENING ELECTROLYTIC TINPLATE

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The present invention relates to an apparatus for the continuous flow-brightening of electrolytic tinplate at high speed. More particularly, this invention pertains to an apparatus of the character described, having automatic temperature controls for carefully regulating the temperature of the tinplate as it proceeds through various steps in the flow-brightening procedure.

In my co-pending application, Serial No. 56,039 filed September 4, 1960, now Patent No. 3,087,871, there is described a process for the flow-brightening of matte tin produced from an acid electroplating bath. In general, this method involves the steps of raising the acid matte tin to a temperature of 400–449° F., maintaining the matte tin within this temperature range for a prescribed period of time for the purpose of producing a multitude of iron-tin alloy nuclei while the tin is in a solid phase, thereafter raising the heat treated matte tin to a temperature above its melting point to flow-brighten it, and, finally, quenching the molten tin.

As described in this co-pending application, it was found that acid tinplate produced by the above described method had remarkably improved corrosion resistance as compared to prior art acid tinplate.

It can be appreciated from the co-pending application, as well as the brief description thereof set forth above, that careful control of temperature conditions during the various steps of this method are critical. It can be further appreciated that since the production of electrolytic tinplate is on a mass production scale at high speed, automatic controls for governing the various temperature requirements in the method are a necessity.

It is, therefore, an object of the instant invention to provide an apparatus for flowing-brightening electrolytic matte tin having a series of automatic temperature controls.

Another object is to provide an apparatus for the flow-brightening of electrolytic matte tin involving a temperature holding step between initial temperature come-up and tin melting.

Yet another object is to provide an apparatus for the flow-brightening of electrolytic acid matte tin to produce acid tinplate having improved corrosion resistance.

A further object is to provide an apparatus for flow-brightening electrolytic matte tin at a high rate of speed.

Numerous other objects and advantages of the invention will be apparent as it is better understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment thereof.

The above objects are accomplished by passing electrolytic matte tin through a first induction heater to raise its temperature to 400–449° F., then through a heating oven to provide a temperature holding zone, then through a second induction heater to raise the temperature of the matte tin above its melting point, and, finally, through a quenching means to solidify the molten tin.

The current in-put to the two induction heaters is automatically controlled by temperature detecting means which continuously sense the temperature of the strip; and which detecting means, by suitable electric circuits, control the power in-put to the first and second induction heaters from a power supply.

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Referring to the drawings:

FIG. 1 shows a schematic elevational view of the apparatus in the instant invention, and,

FIG. 2 shows a schematic elevational view of a modified form of the instant apparatus.

As a preferred or exemplary embodiment of the invention, FIG. 1 shows a continuous strip 10 of tin plate entering the instant apparatus from an electrolytic tin plating apparatus (not shown). The electrolytic tin plating apparatus is of the well known acid tin plating type. As is also known in the art, the tin deposited from this apparatus is matte tin, i.e., a dull finished coating of tin having no tin-iron alloy between the matte tin and steel base.

To being its travel through the instant apparatus at speeds of up to thousands of feet per minute, the strip 10 passes around a drive roller 12 and thence upwards into an induction heater 14. Induction heaters of this type are well known in the art. In the instant invention, the spirally or helically wound conductor forming the induction coil surrounds the path of travel of the strip 10 so that the strip passes therethrough in its travel.

Electric power is supplied to the induction heater 14 by means of electrical connection 15 from a high frequency, alternating current generator 18. The generator 18 receives its power from the line connection 19 and can be of any suitable type, e.g. radio-frequency or motor generator, well known in the art. The induction heater 14 is connected in series to a second induction heater 20 by means of the electrical lead 22. Although a series circuit connecting the two induction heaters is preferred, the heaters may also be connected in parallel. The induction heater 20, the purpose of which will be described more fully hereinafter, is similar to the induction heater 14 in every respect except that its coil has fewer turns. The end of the induction heater 20 remote from its connection to the heater 14 is connected to the generator 18 by an electrical lead 24 thereby completing the circuit including the induction heaters 14 and 20.

Sufficient power is supplied to induction heater 14 to heat the matte tin coating from ambient temperatures, which will usually run from 80–100° F., to a temperature near but below the melting point of tin. In the preferred embodiment, the temperature of the matte tin as it leaves the induction heater 14 is about 445° F.

Immediately after leaving the induction heater 14, the strip 10 enters a closed oven or temperature holding zone 26. The temperature within the oven 26 is maintained at around 445° F. by any suitable means such as circulating hot air therein by means of a closed duct system. Circulated air leaves the oven 26 through the outlet duct 28 from which it passes through a centrifugal blower 29 and thence back into the oven through inlet duct 30.

To maintain the temperature within the oven 26 at the proper level, e.g. 440–445° F., a thermostat 31 extends into the oven. If the temperature within the oven falls below the predetermined level, the thermostat 31 generates a current which passes through wire 32 to a current control such as a relay 33 which thereupon transmits electrical line power through lead 34 to a heating grid 35 located within the inlet duct 30 adjacent the oven 26. The power supplied to the grid 35 heats the elements thereof which in turn heat the air passing thereover until the predetermined temperature within is re-established. In actual operation, the grid 35 will be activated only periodically since little heat is lost from the closed insulated air circulating system.

The strip 10 travels upwardly through the oven 26 around a drive roller 36 and then downwardly out of the oven. This design of the oven permits holding the heated matte tin therewithin for the necessary tempera-

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ture holding time to permit the formation of a multitude of tin-iron alloy nuclei at the interface of the tin and steel layers. The manner and purpose of this alloy nucleation is more fully described in my aforementioned co-pending application. In the preferred embodiment, the oven is designed and arranged so as to maintain the heated matte tin therewithin for a time of some 4-6 seconds, during which time the alloy nucleation occurs.

After leaving the oven 26 the strip 10 immediately enters the aforementioned second induction heater 20. The electric power flowing from the generator 18 is regulated so that during its passage through the induction heater 20, the matte tin on the strip 10 is rapidly raised to slightly above its melting point to flow-brighten it and cause alloy formation between the tin and steel layers.

It must be remembered that the strip 10 passes through all parts of the instant apparatus at the same speed. Traveling at this constant speed, the matte tin must be heated hundreds of degrees by the heater 14 before entering the oven 26; whereas the heater 20 need raise the temperature of the matte tin a relatively small amount, e.g. about 10-30° F., in order to melt the tin. Therefore, fewer coils are needed in the induction heater 20 than in the induction heater 14.

For proper control of the melting of the matte tin it is necessary that this melting take place while the strip 10 is within the coils of the induction heater 20. In other words, the tin melt line, i.e. that line which exists at the junction of the solid and molten tin, must be within the coil 20. To provide automatically for maintaining the melt line within the coil 20, upper and lower photoelectric cells, 37 and 38 respectively, are located adjacent the coil 20. The light projecting and detecting faces of each of these cells are directed between coils of the heater 20 and onto the tin on the strip 10.

The reflectance of matte tin and molten tin is different. The upper cell 37 is adjusted so that the detection of matte tin is normal whereas the detection of melted tin is abnormal and activates the cell. The lower cell 38 is adjusted so that the detection of melted tin is normal whereas the detection of matte tin is abnormal and activates the cell. By this arrangement, if the power supply to the heater 20 is too great, melting takes place before the point of detection by the cell 37 so that this cell detects an abnormal condition and reacts accordingly. On the other hand, if the power supply to the induction heater 20 is insufficient, melting if any will take place after the point of detection by the cell 38, whereby this cell will detect the abnormal condition of matte tin and react accordingly.

To adjust automatically the power supply to the induction coils from the generator 18, each of the cells 37, 38 is connected by an electric lead 39, 40 respectively, to an automatic power regulating device 42. The regulator 42 is a conventional device well known in the art and needs no further description. When the melt line wanders outside of the points of detection by the cells 37, 38, either up or down, depending upon over or under supply of power, an electric current is generated in either the cell 37 or 38 by its detecting the abnormal condition. This current passes into the regulator 42 through the appropriate lead (either 39 or 40) whereupon the regulator 42 automatically, through the lead 44, causes an increase or decrease in the power passing from the generator 18 to the induction coils 14 and 20. This correction continues until the melt line is again brought between the points of detection by the cells 37 and 38.

After leaving the induction coil 20 the molten tin is cooled to solidify it, such as by passing it through a water bath 46. After its passage through the water bath 46 and after the tin has been solidified, the strip then passes around a drive roller 48 and thence upwardly out of the bath 46 around a drive roller 50 to a subsequent operation (not shown) such as a chemical treatment, oiling and/or coiling.

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FIG. 2 shows a modified form of the invention wherein each induction heater is separately but automatically regulated. In this modified form the strip 10 having the electrically deposited acid matte tin thereon passes upwardly through an induction heater 52 similar in all respects to the induction heater 14. Power is supplied to the induction heater from a high frequency, alternating current generator 54 through a lead 56. The return lead 58 instead of leading to the second induction heater as in the preferred embodiment, goes directly back to the generator 54 thereby completing the circuit for the induction heater 52. A temperature sensing means such as a radiation pyrometer 60 is located adjacent the heater 52 with its detecting head directed toward the strip 10 just before it leaves the induction heater 52. The cell 60 is adjusted to react when the temperature of the matte tin about to leave the induction heater 52 varies outside a pre-determined limit; e.g. if the temperature of the matte tin goes above 449° F. or below 440° F. If such an abnormal condition is detected, an electric current generated by the pyrometer 60 is fed through a lead 6' into an automatic current regulator 64, which in turn by means of a lead 66 causes an increase or decrease in power from the generator 54 to the heater 52. This adjustment continues until the temperature of the matte tin leaving the induction heater 52 is brought back to within the pre-determined range.

After leaving the induction heater 52, the strip 10 passes through an oven 68 similar in all respects to the oven 26. Upon emerging from the oven 68, the strip 10 enters the second induction heater 70 similar in all respects to the induction heater 20. Power is fed to the heater 70 from a high frequency, alternating current generator 72 through a lead 74. The circuit between the induction heater 70 and the generator 72 is completed by the lead 78.

Induction heater 70, as with the coil 52, has its own detecting and regulating means, separate and distinct from these means associated with the heater 52. Upper and lower photoelectric cells 80, 82 respectively, identical in structure, function, and location with cells 34, 36, are connected by means of leads 84, 86 to an automatic regulator 88. When the tin melt line wanders outside the point of detection by the cells 80, 82, due either to an under or over supply of power to the heater 70, the appropriate cell is activated, sending a current to the regulator 88 which in turn, through lead 90, automatically adjusts upwardly or downwardly the power supplied to the heater 70 from the generator 72. This adjustment continues until the melt line is reestablished between the points of detection by the photoelectric cells 80, 82.

After leaving the induction heater 70 the molten tin on strip 10 is cooled to solidify the tin and the strip then passes to a suitable place of storage such as a coil.

If desired a temperature sensing device such as the pyrometer 60 or a photoelectric cell similar in construction and operation to the cell 37 may be located adjacent the junction of the heater 14 and the oven 26 in the embodiment illustrated in FIG. 1 to detect the temperature of the strip entering the oven 26. During start-up of the apparatus, cell 38 will detect matte tin and will continue to call for more power in the induction heaters until the strip leaves the oven 26 at the proper temperature. To prevent overheating and burning of the strip going through the heater 14, the pyrometer or photoelectric cell can sense that the strip leaving the heater 14 is at the proper temperature and override the signal from the cell 38. This condition can continue until the melt line is established between the cells 37, 38.

It is thought that the invention and many of its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction, and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing all of its material

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advantages, the form hereinbefore described being merely a preferred embodiment thereof.

I claim:

1. An apparatus for flow-brightening electrolytic tin plate in the form of continuous strip comprising in combination, means for conveying said strip along a predetermined path of travel at a constant rate, a first and second induction heater located at spaced points in said path with the longitudinal axis of each substantially coincident with said path whereby the coils of each heater surround a portion of said moving strip, means electrically connected to each heater to supply electric power thereto to increase the temperature of the strip moving there-through, said first heater increasing the temperature of said strip to between 400-449° F., and said second heater increasing the temperature of said strip to above the melting point of tin, substantially constant temperature oven means situated in said path between said first and second heaters adapted to maintain said moving strip at a temperature of 400-449° F. for a predetermined time, temperature detecting means separate from said oven means situated adjacent said second heater to detect the line at which said tin melts, control means operatively connected to said detecting means and to the power supply means connected to said second heater to adjust automatically the power input to said second heater to maintain said tin melting line in proximity to said second heater, and cooling means situated in said path subsequent to said tin melting line to quench and solidify said molten tin.

2. The apparatus set forth in claim 1 wherein the number of coils in said first induction heater is greater than the number of coils in said second induction heater to produce a greater temperature rise in said strip passing through said first heater than the temperature rise of said strip passing through said second heater.

3. The apparatus set forth in claim 1 wherein said oven means encloses the strip passing therethrough.

4. The apparatus set forth in claim 3 wherein said oven means has heating means connected thereto to maintain the temperature within said oven means substantially constant.

5. The apparatus set forth in claim 4 wherein said heating means are hot gas inlet and outlet ducts.

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6. The apparatus set forth in claim 1 wherein said temperature detecting means comprises at least one photoelectric cell.

7. The apparatus set forth in claim 6 wherein said detecting means comprises a pair of photoelectric cells disposed at spaced intervals along said path with their detecting faces directed toward said strip between the coils of said second heater, each cell adapted to react to a different condition of the tin on said strip passing through said second heater whereby said tin melting line is maintained within the length of said second heater.

8. The apparatus set forth in claim 7 having a single power supply means electrically connected to both said first and second heaters, and a single control means operatively connected to said pair of photoelectric cells and to said single power supply means whereby said control means automatically adjusts the power supply to both said first and second heaters when a change in said tin melting line causes a reaction in one of said photoelectric cells.

9. The apparatus set forth in claim 1 having a separate power supply means electrically connected to each of said first and second heaters.

10. The apparatus set forth in claim 1 having a second temperature detecting means situated adjacent the outlet end of said first heater operatively connected to the power supply for said first heater through a control means for said first heater, said second temperature detecting means adapted to maintain the temperature of the tin on said strip entering said oven means within a predetermined range.

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