

2,841,111

Filed July 28, 1954



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1

2,841,111

SYSTEM FOR CONTROLLING LIQUID LEVEL

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Application July 28, 1954, Serial No. 446,233

22 Claims. (Cl. 118—7)

This invention is directed to an improved system for controlling the level of liquid material in a reservoir or receptacle and, more particularly, to a system for maintaining the level in a reservoir from which material is withdrawn gradually and constantly by working operations and to which make-up or replacement material is added periodically in large batches, the rate of material replacement being relatively high compared to its rate of withdrawal.

More specifically, the liquid level system of this invention is particularly adapted to maintenance of the surface level of a molten metal bath in metal coating operations in which a strip of steel is passed through the bath of coating metal and to which make-up metal is added in the form of pigs.

In galvanizing and other metal coating operations, steel strip is passed through a bath of molten coating metal to apply a covering of the coating metal thereto. Since the surface level of the bath affects the thickness of the coating on the strip, it is desirable to maintain the surface of the bath at a constant level. In conventional practice, this is accomplished manually under the control of an operator who adds pigs to the bath as needed and its surface level thus varies over wide limits depending upon the skill of the operator. The maintenance of the surface level of a coating metal bath is further complicated by reason of the fact that the movement of the strip through the bath withdraws coating metal therefrom at a gradual and continuous rate while the addition of a pig results in the make-up metal being supplied in a relatively large batch or quantity in a much shorter period of time. The addition of a pig in this manner thus causes an upward surge in the surface level of the coating metal bath which is determined by the size of the pig added.

One of the principal objects of this invention is to provide a liquid level control system for coating metal baths which does not depend on the skill of an operator.

A further object of the invention is to provide a system for controlling the surface level of fluid material in a reservoir from which it is withdrawn gradually by working operations and to which make-up material is added in relatively large batches.

Another object of the invention is to provide a system of the character just referred to which feeds batches of make-up material in accordance with the surface level requirements of the reservoir and which will tend to maintain such surface level within the limits determined by the addition of a single batch.

Another object of the invention is to provide a level control system of the character referred to having a batch feeding mechanism which is rendered operative to feed a single batch of material in response to changing conditions of the surface level and which has provisions for preventing the addition of a subsequent batch until after the surface level has responded to the batch previously added.

2

A still further object of the invention is to provide a system for controlling the surface level of a molten metal coating bath in metal coating apparatus having a feed mechanism effective upon each operation thereof for feeding a single predetermined quantity or batch of coating metal to the bath in the form of pigs, and which includes means responsive to the surface level of the bath falling to a predetermined minimum for rendering the pig feeding mechanism operative, together with a timing mechanism for introducing a predetermined minimum time interval between each operation of the pig feeding mechanism to enable the surface level responsive means to respond to changes in surface level resulting from a single pig feeding operation of the feeding mechanism before it is permitted another such operation.

Other objects and advantages of the invention will become apparent from the following description.

In the drawings there is shown a preferred embodiment of the invention. In this showing:

Figure 1 is a diagrammatic illustration of a level control system constructed in accordance with the principles of this invention and applied to a spelter pot in a galvanizing line; and

Figure 2 is a sectional view of a pressure differential regulator for controlling the flow of gas through the surface level responsive mechanism shown in Figure 1.

In the drawings, the numeral 1 designates a reservoir or receptacle containing a bath 2 of molten coating metal through which steel strip S is passed to apply a covering of the coating metal thereto. The bath 2, for example, may be spelter and the receptacle 1 may be the spelter pot in a conventional continuous galvanizing line. While the strip S is illustrated diagrammatically as being continuous, it will be understood that the principles of the invention as explained hereinafter are applicable to single sheet coating operations, and to coating operations using coating metals other than zinc. Movement of the strip S through the bath 2 removes metal therefrom and results in a lowering of its surface level 3.

To replace metal removed from the bath 2 by the strip S, there is provided a magazine 4 containing a stack of pigs 5. An air cylinder 6 having a piston 7 therein operates an ejector 8 to deliver the lowermost pig in the magazine 4 to a conveyor chute 9 for delivery thereby to a pre-melt pot 10. The pre-melt pot 10 has an overflow passage 11 connecting it with the spelter pot 1 and has heating apparatus (not shown) for maintaining the body of metal 12 therein in molten condition and for melting pigs 5 fed thereto. The spelter pot 1, similarly, and in accordance with conventional practice, has heating apparatus (not shown) for maintaining the bath 2 at a proper temperature. When a pig 5 is fed to the pre-melt pot 10, the level of the metal 12 therein is raised and a quantity of molten metal equivalent to that in the pig 5 delivered thereto overflows through the passage 11 into the main pot 1. In this manner, the surface level 3 in the main pot 1 is elevated by the overflowing metal delivered through the passage 11 upon each operation of the cylinder 6 to eject a pig from the magazine 4. The parts of the apparatus thus far described are conventional and form no part per se of this invention, this invention being directed to a system for controlling the delivery of pigs 5 to the pre-melt pot 10 and thereby for controlling the level of the surface 3.

In accordance with the principles of this invention, the operation of the pig ejecting cylinder 6 is controlled in such manner that the level of the surface 3 is maintained above a predetermined minimum. This is accomplished, in a manner to be described by a surface level responsive apparatus designated as a whole by the letter L which produces a control pressure varying with the

3

level of the surface 3, a pressure responsive recorder-controller designated as a whole by the letter P, and a control circuit designated as a whole by the letter C which controls the operation of a reversing valve R for the air cylinder 6.

The reversing valve R is of conventional construction and is diagrammatically illustrated. It comprises a valve rod 14 mounted for endwise movement to either of two positions in a valve casing 15 for reversing the connections of the ends of the cylinders 6 through conduits 16 and 17 with respect to an air supply connection 18. A spring 19 biases the movement of the rod 14 to the right as viewed in Figure 1 to a position seating a pair of valve elements 20 mounted thereon and opening a similar pair of valve elements 21. In this position, the conduit 17 is connected with the air supply connection 18 through one of the open valve elements 21 and the conduit 16 is connected to the atmosphere through the other of the open valve elements 21 and an exhaust port connection 22 in the valve casing. A solenoid 23 is provided for moving the valve rod 14 to the left against the action of the spring 19 to close the valve elements 21 and open the valve elements 20 and thereby reverse the connections of the conduits 17 and 16 with the atmosphere and with the air supply passage 18. Movement of the valve rod 14 by the solenoid 23 in this manner is effective to move the piston 7 and plunger 8 to the right for delivering a pig 5 to the pre-melt pot 10. When the solenoid 23 is de-energized, the spring 19 returns the valve rod 14 to the position illustrated, and the piston 7 and plunger 8 are returned to the position shown in the drawings for effecting another pig ejecting operation.

Operation of the reversing valve R by the solenoid 23 is controlled by the circuit C which in turn is actuated by the pressure responsive recorder-controller P and the level responsive device L. The parts L and P are conventional structures which may be purchased on the market in a form suitable for the purposes of this invention. For example, the pressure responsive device L may be obtained from the Fischer & Porter Co. of Hatboro, Pennsylvania and is of a type illustrated in its catalogue 10-A-29 dated February 9, 1954. Similarly, the pressure recorder-controller P may be obtained from The Bristol Company of Waterbury, Connecticut and is of a type illustrated in its publication entitled "Bulletin F1605." Since this invention is not concerned with the specific construction of the units L and P, they have been shown diagrammatically in the drawings for the purpose of illustrating the manner in which they operate the control circuit C.

The level responsive device L comprises a conduit 25 which delivers gas at a constant rate to a vertically extending dip tube 26 having an outlet 24 at its lower end positioned below the surface 3 and through which gas escapes or bubbles through the bath 2. Gas is delivered to the conduit 25 from a suitable source under pressure by a conduit 27 and through a pressure reducing valve 28, a constant pressure differential valve 29, and a throttle or needle valve 30, the valve 30 being adjustable to control the quantity of gas being supplied to the dip tube 26. The gas supplied to the tube 26 is a non-oxidizing gas, preferably NX gas although any other non-oxidizing gas may be used, which will not oxidize the molten metal 2 through which it escapes. The valves 28, 29 and 30 operate to deliver gas at a constant rate through the dip tube 26 and the pressure of the gas in the conduit 25 thus provides an indication of the level of the surface 3 and which varies with changes in the distance between the surface 3 and the outlet 24.

The manner in which the pressure differential valve 29 maintains the flow of gas through the conduit 25 at a constant rate will be best understood by referring to Figure 2. In this showing, a diaphragm 31 is positioned between an upper pressure chamber 32 and a lower pressure chamber 33. The chamber 32 is connected by a

4

conduit 34 with the conduit 25 so that the pressure therein corresponds to the pressure of the gas in the conduit 25. The lower chamber 33 has an inlet 35 and an outlet 36 connected in the conduit 27 so that the pressure therein corresponds to the pressure in the conduit 27. The force of the pressure in the chamber 33 acting against the diaphragm 31 is balanced by the pressure in the chamber 32 and the action of a biasing spring 37 which acts downwardly against the diaphragm 31. A valve 38 having a spring 44 biasing it upwardly to a position engaged with the diaphragm 31 controls the effective connection between the inlet 35 and the outlet 36. When the diaphragm 31 moves downwardly in response to increased pressure in the chamber 32, the valve 38 is moved downwardly to increase the effective size of the valve connection between the inlet 35 and outlet 36. In this manner, the pressure of the gas moving through the outlet connection 36 is increased to compensate for the increased pressure in the conduit 25 so that the flow of gas through the conduit 25 will not be diminished. Increases of pressure in the conduit 25 and chamber 32 are caused by a rising level of the molten metal bath surface 3. When the surface 3 of the molten metal bath falls, the pressure of the gas in the conduit 25 and chamber 32 decreases and the diaphragm 31 moves upwardly to render the valve 38 effective to reduce the pressure of the gas delivered to the outlet 36 while maintaining its rate of flow through the conduit 25 constant. By maintaining the rate of flow of gas through the conduit 25 constant, the pressure therein provides an indication of the vertical position of the surface level 3.

A relief device 39 is provided for relieving the system of surging pressures in the conduit 25 and for eliminating the effects of such pressures on the differential valve 29. The relief device 39 comprises a container partially filled with a body of mercury 40 and having a port 41 to the atmosphere. A tube 42 is connected with conduit 25 and has its lower end 43 immersed in the mercury 40. Surging pressures in the conduit 25 will thus be absorbed by the relief device 39 and will be effective only to move the level of the mercury in the tube 42 upwardly or downwardly depending upon whether the surge is an increase or decrease.

Energization of the circuit C to operate the solenoid 23 is made responsive to the surface 3 falling to a predetermined level at which the pressure in the conduit 25 will be at a predetermined minimum. This is accomplished by a recorder-controller P which, as indicated above, has been shown diagrammatically for the purpose of illustrating the manner in which this action takes place. In the drawings, the recorder-controller P is shown as having a stationary contact 45 and a movable contact 46 connected to a rotatable pointer or indicator 47 which moves relatively to a scale 48. The pointer 47 is operated by a float 49 which moves vertically with the level of the body of mercury 50 in a low pressure chamber 51 which is ported to the atmosphere by a tube 52. A high pressure chamber 53 in the form of a sealed container has its upper end connected by a conduit 54 with the conduit 25 and is partially filled with a body of mercury 55. The lower end of the container 53 is connected with the chamber 51 by a tube 56 so that the level of the mercury 50 in the chamber 51 varies with the pressure in the upper portion 57 of the chamber 53, the pressure in the chamber 57 varying with the pressure in the conduit 25 and thereby with the level of the surface 3 of the molten metal bath in the reservoir 1.

As the level of the surface 3 drops, the pressure in the chamber 57 decreases thereby causing the level of the body of mercury 55 to rise and the level of the body of mercury 50 to fall. As the level of the mercury 50 falls, the float 49 moves downwardly and pivots the pointer 47 in a counter-clockwise direction. Pivotal movement of the pointer 47 continues in this manner until the contact 46 carried thereby engages the contacts

5

45. Engagement of the contacts 45 and 46 energizes the circuit C in a manner to be described to render the cylinder 6 effective to deliver a pig 5 to the pre-melt pot 10 to thereby raise the level of the surface 3 of the bath 2 as explained above. Raising the level of the surface 3 increases the pressure in the chamber 57 thereby reversing the flow of mercury through the tube 56 to raise the float 49 and pivot the pointer 47 to disengage the contacts 45 and 46.

The indicator 48 may be calibrated in terms of the position of the surface 3 so that it provides a continuous indication of its level. As in the commercial form of recorder-controller P obtained from the Bristol Company as mentioned above, the pointer 47 may conveniently be a recording pen cooperating with a rotating chart for providing a permanent record of the level of the surface 3 at any given time. In addition, and as in the Bristol Company form of recorder-controller P, closure of the circuit C may be effected by causing movement of the pointer P to vary the impedance of an electrical circuit coupled to an amplifier which in turn operates a relay, operation of the relay in such case corresponding to closure of the contacts 45 and 46.

With reference to the control circuit C, operation of the reversing valve operating solenoid 23 is controlled by energization of a control relay 60 having a control relay switch 61 and a holding relay switch 62. An energizing circuit for the control relay 60 is completed across alternating current supply buses L1—L2 through a main circuit 63 connected at the point 64 to the bus L2 and having a limit switch 65 connected in series therewith, and through a pair of branch circuits 66 and 67 connected respectively with the bus L1 at the points 68 and 69. The branch circuit 66 is connected with the circuit portion 63 upon closure of the holding relay switch 62 and the branch circuit 67 is similarly connected with the circuit portion 63 upon engagement of a rotating contact 70 with a stationary contact 71 of arcuate shape respectively in the branch circuit 67. The rotatable contact 70 is operated by a synchronous motor 72 which is connected across the buses L1 and L2 by conductors 73 and 74 upon engagement of the contacts 45 and 46.

In the operation of the circuit C, engagement of the contacts 45 and 46 connects the motor 72 through the leads 73 and 74 to the supply buses L1 and L2 so that it becomes effective to rotate the contact 70. When the rotating contact 70 engages the contact 71, and it will be noted that the contacts 70 and 71 engage only momentarily because of the rotating movement of the contact 70 the branch circuit 67 will be energized and, since it is connected directly with the main circuit portion 63 at the point 75, an energizing circuit for the relay 60 will be completed through its operating coil 76 to the connection 64 with the supply bus L2. Relay 60 will thus be energized to close relay contacts 61 and 62. Closure of relay contact 62 will be effective to establish a holding circuit through the branch circuit 66 for maintaining relay 60 operated after the rotating contact 70 moves beyond the stationary contact 71 and opens the branch energizing circuit 67.

Closure of relay contact 61 established an energizing circuit for the operating coil 77 of the solenoid 23 which may be traced from the connection 68 with the bus L1 through the branch circuit 66, relay switch 61, coil 77, and the connection 78 with the bus L2. Energization of the coil 77 in this manner operates the reversing valve R by moving the valve stem 14 against the action of the biasing spring 19 to cause the piston 7 to move to the right as viewed above and deliver a pig 5 to the pre-melt pot 10. As the piston 7 moves to the end of its pig ejecting stroke, a lug 80 secured to its piston rod engages and moves the limit switch 65 to open position against the action of a biasing spring 81 which is effective normally to hold it in a closed position. Opening of the limit switch 65 interrupts the energizing circuit for the

6

coil 76, and the relay 60 drops out and switches 61 and 62 open. Opening of relay switch 61 de-energizes the operating coil 77 for the solenoid 23 and the reversing valve R is then operated by its biasing spring 19 to reverse the connections of the cylinder 6 and return the piston and ejector 8 to the position shown in the drawings.

It will be recalled that the contacts 70 and 71 engage momentarily and that rotation of the contact 70 by the motor 72 is effective to move it out of engagement with the contact 71 after completion of the holding circuit 66 through the relay switch 61. Since opening of the limit switch 65 causes the holding relay switch 61 to move to open position, it will be apparent that a second operation of the solenoid 23 and an addition of another pig 5 to the pre-melt pot 10 will not be had until the contact 70 rotates to a position in which it again engages with the stationary contact 71, and this action will not take place until a predetermined time interval has elapsed after the first pig ejecting operation of the cylinder 6. To provide the time interval for this purpose, the motor 72 is a synchronous motor which is connected with the contact 70 through a speed reducing connection 83 which is effective to rotate the contact 70 at a speed of from about $\frac{1}{2}$ to 1 R. P. M. If rotated at a speed of about 1 R. P. M., an interval of about 45 seconds will elapse between successive engagements of the contacts 70 and 71, if rotated at a speed of about $\frac{1}{2}$ R. P. M., an interval of about $1\frac{1}{2}$ minutes will elapse between successive engagements of the contact 70 and 71. The timed intervals between the successive engagements of the contacts 70 and 71 control the rate at which pigs are delivered to the pre-melt pot 10 and enable the apparatus L and P to respond to changing levels of the surface 3 due to each addition of a pig 5. If the elevation of the surface 3 by the addition of a pig 5 is sufficient to open the contacts 45 and 46, the motor 72 will stop and the delivery of pigs to the pre-melt pot 10 will be discontinued until a subsequent engagement of the contacts 45 and 46 in response to the level 3 falling below a predetermined point. Under normal operating conditions, the contacts 45 and 46 can be expected to open after the addition of a single pig, and the operation of the apparatus will be effective to maintain the surface 3 at a level which varies between upper and lower limits determined by the metal in a single pig.

The time delivery interval provided by the synchronous motor 72 and speed reducing connection 83, and intermittently engaging contacts 70—71 may be conveniently effected by a timing mechanism produced by Eagle Signal Corporation of Moline, Illinois as shown in its "Bulletin 320" of December 1950 wherein it is designated by the name "Flexopulse" repeat cycle timer.

A manually operable push button 85 is provided for transferring operation of the apparatus from automatic to manual control. Actuation of the switch 85 opens the connection of branch circuit 67 to the intermittently engaged contact 71 and renders effective a manually operable energizing circuit 86. A push button switch 87 controls energization of the circuit 86 and, when it is operated to closed position, the main circuit 63 is energized through the circuit 86. Energization of the main circuit 63 will operate the reversing valve R as described above, and a pig 5 will be delivered to the pre-melt pot 10 on each operation of the push button switch 87 as long as the switch 85 is in a position rendering the circuit 86 operative.

In the operation of the apparatus, coating of strip S gradually and continually withdraws coating metal from the bath 2. When its surface 3 drops to a predetermined level, the decreasing pressure in the level responsive device L operates the recorder-controller P to close the contacts 45—46. Closure of the contacts 45—46 energizes the circuit C to effect a single working cycle of the reversing valve R and thereby to deliver a single pig to the reservoir of molten coating metal contained in

7

the pots 1 and 10. The delivery of a single pig will be effective normally to raise the surface 3 above the predetermined minimum level, and the device L will operate through the recorder-controller P to open the contacts 45—46 and de-energize the circuit C. If the addition of a single pig is insufficient to raise the surface 3 above its predetermined minimum level, the apparatus will continue to deliver pigs at timed intervals until the surface 3 rises above its predetermined minimum level.

From the foregoing, it will be apparent that the apparatus of this invention is effective to replace the coating metal in the bath 2 in accordance with withdrawals therefrom by the strip S, and that this is accomplished without attention on the part of an operator. Attention is particularly directed to the fact that the apparatus goes into operation whenever the level of the surface 3 drops below a predetermined minimum and stops when the surface 3 is above the predetermined minimum. When it is considered that each batch or pig delivery results in the metal in each pig delivery being distributed over the relatively large area of the surface 3, it will be appreciated that the level of the surface 3 is maintained within close limits. In this manner, and notwithstanding each pig delivery results in an instantaneous addition of a relatively large batch of coating metal to the reservoir of molten coating metal, the apparatus operates to maintain the surface 3 at a level which is substantially constant so that a coating of uniform thickness will be applied to the strip S moving through the bath 2.

While one embodiment of my invention has been shown and described it will be apparent that other adaptations and modifications may be made without departing from the scope of the following claims.

I claim:

1. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a single solid batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising actuating means for operating said feed device, means controlling the operation of said actuating means, and means responsive to the level of material in said reservoir falling below said predetermined minimum for operating said control means.

2. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a single solid batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising actuating means for operating said feed device, means for producing a fluid pressure varying with the level of material in said reservoir, and means responsive to said fluid pressure falling to a predetermined minimum value for operating said actuating means.

3. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a single solid batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising actuating means for operating said feed device, a tube extending into said reservoir and having an outlet positioned below the surface level of the fluid material therein, means for forcing a gas at a constant rate through said outlet whereby the pressure of the gas in said tube at a point remote from said outlet varies with the surface level of said fluid material, and means responsive to said pressure falling to a predetermined minimum for operating said actuating means.

8

4. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a relatively large batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising actuating means for operating said feed device, means controlling the operation of said actuating means, and means responsive to the level of material in said reservoir falling below said predetermined minimum for rendering said control means operative, said control means including means for effecting intermittent operations of said actuating means and for introducing a timed interval between each operation of said feed device thereby sufficient for said level responsive means to respond to the change in level of material in said reservoir caused by the batch of material added by each operation of said feed device.

5. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a single solid batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising an actuating mechanism for operating said feed device, a relay controlling the operation of said actuating mechanism, means responsive to the level of material in said reservoir falling below said predetermined minimum for operating said relay to render said actuating mechanism operative, and means responsive to the completion of a batch feeding operation of said feed device by said actuating mechanism for operating said relay to render said actuating mechanism inoperative.

6. An apparatus as defined in claim 5 characterized by said said level responsive means including means for rendering it inoperative to effect subsequent operations of said relay for a predetermined period of time after the completion of each batch feeding operation of said feed device by said actuating mechanism.

7. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a relatively large batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising an actuating mechanism for operating said feed device, an electrical relay controlling the operation of said actuating mechanism and including an energizing circuit effective when closed to render said actuating mechanism operative and when opened to render said actuating mechanism inoperative, a normally closed limit switch in said circuit, a control switch for closing said circuit, means responsive to the level of material in said reservoir falling below said predetermined minimum for operating said control switch to close said circuit, and means responsive to the completion of a batch feeding operation by said device for momentarily actuating said switch to open position to open said circuit.

8. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a relatively large batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising an actuating mechanism for operating said feed device, an electrical relay controlling the operation of said actuating mechanism and including an energizing circuit effective when closed to render said actuating mechanism operative and when opened to render said actuating mechanism inoperative, a normally closed limit switch in said circuit, a control switch in said circuit movable between open and

closed positions, means for operating said control switch between its open and closed positions and for maintaining it in its open position for a predetermined interval of time after each movement to closed position, means responsive to the level of material in said reservoir, falling below said predetermined minimum for operating said control switch operating means, and means responsive to the completion of a batch feeding operation by said device for momentarily actuating said limit switch to open position to open said circuit.

9. In an apparatus having a reservoir from which fluid material is withdrawn gradually by working operations and a feed device effective upon each operation thereof to deliver a relatively large batch of material to said reservoir to replace the material withdrawn, a control system for maintaining the level of material in said reservoir above a predetermined minimum comprising an actuating mechanism adapted each time it is rendered operative to effect a single batch delivery operation of said feed device, a control relay for rendering said actuating mechanism operative, a control circuit for energizing said control relay and having a normally open first relay switch therein, an operating relay, an operating circuit for energizing said operating relay and having a main circuit and a pair of branch energizing circuits connected therewith, a normally closed limit switch in said main circuit, one of said branch energizing circuits having a normally open second relay switch therein and the other having a control switch therein, means responsive to the level of material in said reservoir falling below said predetermined minimum for operating said control switch to energize said operating circuit and said operating relay, said operating relay having connections for closing both said first and second relay switches upon energization thereof, and means responsive to the completion of a batch delivery operation of said feed device by said actuating mechanism for momentarily operating said limit switch to open position to open said operating circuit and de-energize said operating relay to thereby de-energize said control circuit and control relay.

10. An apparatus as claimed in claim 9 characterized by said level responsive means including means for operating said control switch periodically and at timed intervals to closed position to thereby provide a predetermined timed interval between each of the batch delivery operations of said feed device required to raise the level of material in said reservoir at least to said predetermined minimum.

11. An apparatus as claimed in claim 9 characterized by said level responsive means comprising means for producing a fluid pressure varying with the level of material in said reservoir, an energizing circuit having an operating switch therein, and means responsive to said fluid pressure for actuating said operating switch.

12. An apparatus as claimed in claim 11 characterized by said pressure producing means comprising a tube extending into said reservoir and having an outlet positioned below the surface level of the fluid material therein, and means for forcing a gas at a constant rate through said outlet whereby the pressure of the gas in said tube at a point remote from said outlet varies with the surface level of said fluid material.

13. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, means for supplying pigs of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, and a feed device adapted each time it is operated to feed a single pig to said pig supply means for delivery to said bath, a system for controlling the operation of said feed device to maintain the surface level of said bath above a predetermined minimum comprising an actuating mechanism for operating said feed device, an electrical relay controlling the operation of said actuating mechanism and including an energizing circuit effective when closed to render said

actuating mechanism operative and when opened to render said actuating mechanism inoperative, a normally closed limit switch in said circuit, a control switch for closing said circuit, means responsive to the level of metal in said bath falling below said predetermined minimum for operating said control switch to close said circuit, and means responsive to the completion of a pig feeding operation by said feed device for momentarily actuating said limit switch to open position to open said circuit.

14. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, means for supplying pigs of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, and a feed device adapted each time it is operated to feed a single pig to said pig supply means for delivery to said bath, a system for controlling the operation of said feed device to maintain the surface level of said bath above a predetermined minimum comprising an actuating mechanism for operating said feed device, an electrical relay controlling the operation of said actuating mechanism and including an energizing circuit effective when closed to render said actuating mechanism operative and when opened to render said actuating mechanism inoperative, a normally closed limit switch in said circuit, a control switch in said circuit movable between open and closed positions, means for operating said control switch between its open and closed positions and for maintaining it in its open position for a predetermined interval of time after each movement to closed position, means responsive to the level of metal in said bath falling below said predetermined minimum for operating said control switch operating means, and means responsive to the completion of a pig feeding operation by said feed device for momentarily actuating said limit switch to open position to open said circuit.

15. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, means for supplying pigs of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, and a feed device adapted each time it is operated to feed a single pig to said pig supply means for delivery to said bath, a system for controlling the operation of said feed device to maintain the surface level of said bath above a predetermined minimum comprising an actuating mechanism for operating said feed device, a control relay for rendering said actuating mechanism operative, a control circuit for energizing said control relay and having a normally open first relay switch therein, an operating relay, an operating circuit for energizing said operating relay and having a main circuit and a pair of branch energizing circuits connected therewith, a normally closed limit switch in said main circuit, one of said branch energizing circuits having a normally open second relay switch therein and the other having a control switch therein, means responsive to the level of metal in said bath falling below said predetermined minimum for operating said control switch to energize said operating circuit and said operating relay, said operating relay having connections for closing both said first and second relay switches upon energization thereof, and means responsive to the completion of a pig delivery operation of said feed device by said actuating mechanism for momentarily operating said limit switch to open position to open said operating circuit and de-energize said operating relay to thereby de-energize said control circuit and control relay.

16. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, means for supplying pigs of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, and a feed device adapted each time it is operated to feed a single pig to said pig supply means for delivery to said bath, a system for controlling the operation of said feed device to main-

tain the surface level of said bath above a predetermined minimum comprising actuating means for operating said feed device, means for producing a fluid pressure varying with the level of metal in said bath, and means responsive to said fluid pressure falling to a predetermined minimum value for operating said actuating means.

17. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, means for supplying pigs of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, and a feed device adapted each time it is operated to feed a single pig to said pig supply means for delivery to said bath, a system for controlling the operation of said feed device to maintain the surface level of said bath above a predetermined minimum comprising actuating means for operating said feed device, means controlling the operation of said actuating means, and means responsive to the level of metal in said bath falling below said predetermined minimum for rendering said control means operative, said control means including means for effecting intermittent operations of said actuating means and for introducing a timed interval between each operation of said feed device thereby sufficient for said level responsive means to respond to the change in level of metal in said bath caused by the pig added by each operation of said feed device.

18. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, means for supplying pigs of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, and a feed device adapted each time it is operated to feed a single pig to said pig supply means for delivery to said bath, a system for controlling the operation of said feed device to maintain the surface level of said bath above a predetermined minimum comprising an actuating mechanism for operating said feed device, a relay controlling the operation of said actuating mechanism, means responsive to the level of metal in said bath falling below said predetermined minimum for operating said relay to render said actuating mechanism operative, and means responsive to the completion of a pig feeding operation of said feed device by said actuating means for operating said relay to render said actuating mechanism inoperative.

19. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, and a feed mechanism adapted each time it is operated to feed a single solid pig of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, a system for controlling the operation of said feed mechanism to maintain the surface level of said bath above a predetermined minimum comprising actuating means for operating said feed mechanism, means controlling the operation of said actuating means, and means responsive to the level of metal in said bath falling below said predetermined minimum for operating said controlling means.

20. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a cover-

ing of coating metal thereto, and a feed mechanism adapted each time it is operated to feed a single solid pig of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, a system for controlling the operation of said feed mechanism to maintain the surface level of said bath above a predetermined minimum comprising actuating means for operating said feed mechanism, means controlling the operation of said actuating means, means responsive to the level of metal in said bath falling below said predetermined minimum for operating said controlling means, and means responsive to a pig feeding operation of said feed mechanism by said actuating means for rendering said controlling means temporarily inoperative.

21. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, and a feed mechanism adapted each time it is operated to feed a single solid pig of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, a system for controlling the operation of said feed mechanism to maintain the surface level of said bath above a predetermined minimum comprising actuating means for operating said feed mechanism, a tube extending into said bath and having an outlet positioned below the surface level of the coating metal therein, means for forcing a gas at a constant rate through said outlet whereby the pressure of the gas in said tube at a point remote from said outlet varies with the surface level of said bath, and means responsive to said pressure falling to a predetermined minimum for operating said actuating means.

22. In metal coating apparatus having a bath of coating metal through which strip is passed to apply a covering of coating metal thereto, and a feed mechanism adapted each time it is operated to feed a single solid pig of coating metal to said bath to replace the coating metal withdrawn from the bath by the strip, a system for controlling the operation of said feed mechanism to maintain the surface level of said bath above a predetermined minimum comprising actuating means for operating said feed mechanism, a tube extending into said bath and having an outlet position below the surface level of the coating metal therein, means for forcing a gas at a constant rate through said outlet whereby the pressure of the gas in said tube at a point remote from said outlet varies with the surface level of said bath, and means responsive to said pressure falling to a predetermined minimum for operating said actuating means, said pressure responsive means including means for effecting intermittent operations of said actuating means and for introducing a predetermined time interval between each operation thereby of said feed mechanism.

References Cited in the file of this patent

UNITED STATES PATENTS

2,333,543	Martin	Nov. 2, 1943
2,415,644	Leonhard et al.	Feb. 11, 1947
2,670,708	Kalberkamp	Mar. 2, 1954

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,841,111

July 1, 1958

Preston L. Walker II

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 61, for "established" read --establishes--; column 8, line 37, strike out "said", second occurrence; line 60, before "switch" insert --limit--.

Signed and sealed this 7th day of October 1958.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents