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P. L. KNIGHT ET AL
COATING APPARATUS INCLUDING MEANS IN CONTROL
OF THERMAL-PRETREATING DEVICE
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3,215,115

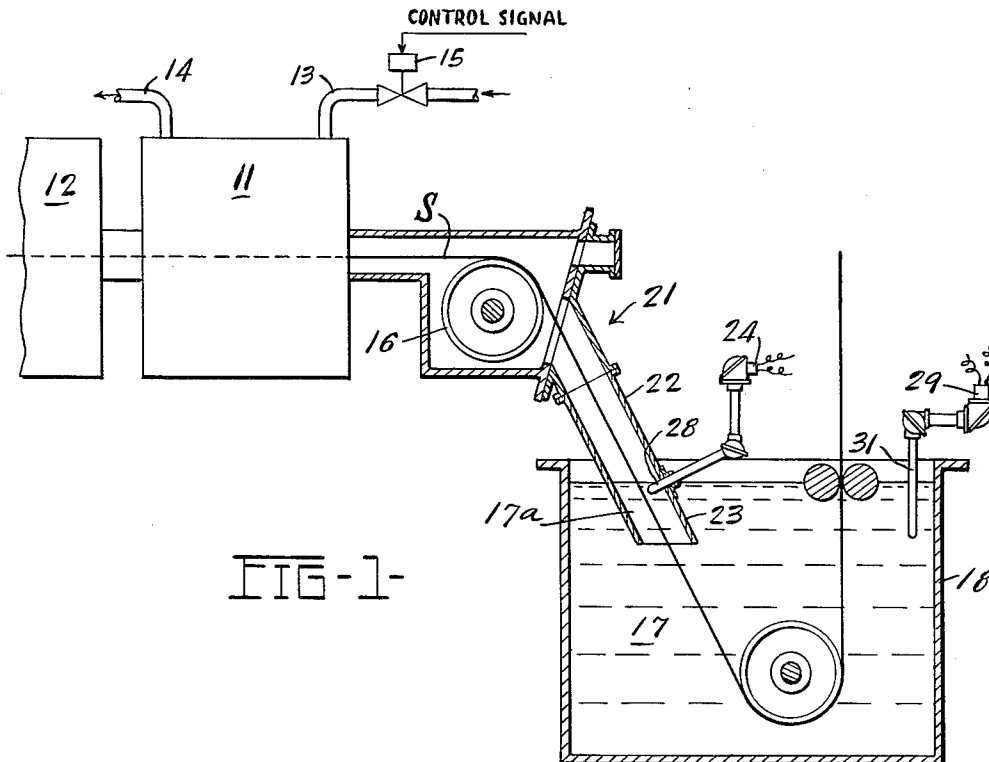


FIG-1-

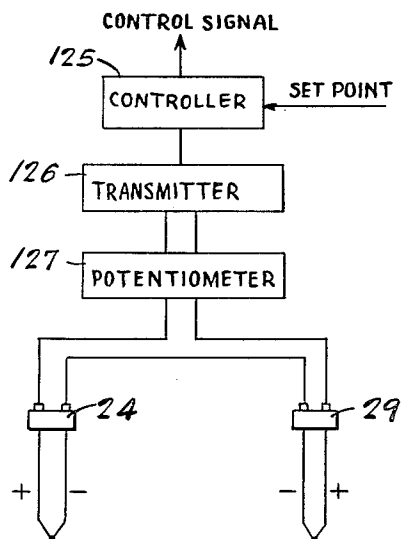


FIG-3-

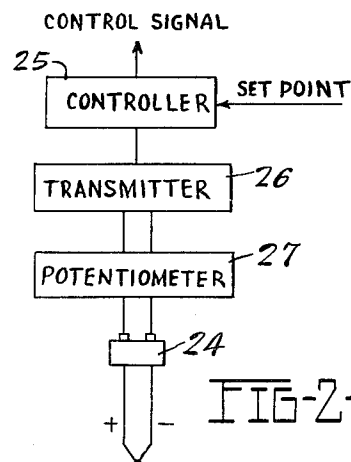


FIG-2-

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COATING APPARATUS INCLUDING MEANS IN CONTROL OF THERMAL-PRETREATING DEVICE

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3 Claims. (Cl. 118—5)

This invention relates to an improvement in apparatus for processing a moving metal strip of indefinite length of the type having a bath of a liquid through which the strip is passed after being subjected to a thermal treatment. More particularly, the invention relates to a control system for such apparatus for controlling the degree to which the heat content of the strip is altered during the thermal treating process. The invention is of particular value in apparatus for coating the moving metal strip with a coating metal wherein the strip is passed into a bath of molten coating metal. However, the invention is also applicable to apparatus for annealing moving metal strip wherein the final strip cooling step is accomplished by passing the strip through a tank of water or other coolant. (See U.S. Patent 3,021,236 to D. Beggs et al.)

In processes for coating a moving metal strip with a coating metal, such as zinc, aluminum, or tin, it is customary to thermally treat the metal strip prior to passing it into a bath of molten coating metal. In an article entitled "Continuous Strip Galvanizing Developments" by Cone in Iron and Steel Engineer, March, 1962, there are described a number of processes for coating a ferrous-based metal strip with zinc. Common to all the processes described therein is a thermal treatment step prior to the coating step. Because of the fact that the thermal treating step according to most processes comprises a cooling step the invention will hereafter be described with particular reference to such a process but it is to be understood that the invention is also applicable to coating processes in which the coating step is preceded by a heating step.

In the operation of apparatus to practice a strip coating process wherein the strip is cooled prior to passing into the coating bath it is desirable to control the cooling effect imparted to the strip by the strip cooling means so that the temperature of the strip passing into the coating bath will be within acceptable limits. In the prior art it was customary to control the operation of the strip cooling apparatus in response to a signal indicative of the temperature at a point within the chamber where the cooling step was being carried out. This technique has not been altogether satisfactory, however, because the temperature of the strip leaving the cooling chamber depends on factors other than the chamber temperature including strip speed, thickness, and, in cases where strip cooling was predominantly by radiation heat transfer, variations in emissivity on the strip surface. In one known case wherein cooling chamber temperature was maintained substantially constant by such a control system, the user was operating the apparatus in such a way as to begin the strip cooling step in a temperature holding zone of the heating means to reduce the cooling rate required in the cooling chamber to a rate which would yield an acceptable degree of control over the temperature of the strip entering the coating pot. This mode of operation results in ineffective capitalization on the metallurgical benefits obtainable from soaking the strip at temperature prior to the commencement of the cooling step.

It is, therefore, an object of this invention to provide an improved system for controlling the degree to which the thermal content of moving metal strip is altered by heat

altering means in a process where the metal strip is passed into a bath of liquid subsequent to the heat alteration step. For other objects of the invention and for a further consideration of what is considered to be novel and inventive, attention is directed to the following portion of the specification, the drawing, and the appended claims.

In the drawing:

FIG. 1 is an elevational sectional view of apparatus for practicing the present invention;

FIG. 2 is a schematic diagram of an embodiment of the temperature control system of the present invention; and

FIG. 3 is a schematic diagram of an alternate embodiment of the temperature control system of the present invention.

In apparatus for practicing the present invention there is provided heat altering means 11, shown schematically, such as an internally cooled chamber, for cooling a moving metal strip S of indefinite length which has previously been heated to an elevated temperature in heating chamber 12, a portion of which is shown schematically. Cooling chamber 11 is provided with an inlet line 13 for the admission thereto of coolant, such as air or water, and an outlet line 14 to exhaust spent coolant therefrom. Inlet line 13 is provided with a flow control valve 15 operable in response to a control signal, as hereinafter described, to control the flow of coolant through cooling means in order to control the cooling effect imparted thereby to strip S. Cooling means 11 may comprise a lined chamber 30 equipped with internally cooled heat sinks, as in the manner described in U.S. Patent 2,983,497 to W. H. Dailey, Jr. In such an arrangement the cooling is accomplished predominantly by thermal radiation from the strip to the heat sinks and the coolant normally is air.

After leaving cooling means 11, strip S passes, by way of deflector roller 16, into molten coating metal 17 contained in pot 18. Strip S is circumsposed by wall means 21 to protect it from contact with air as it passes from cooling means 11 into molten metal 17. Wall means 21 comprises an element 22, commonly known as a snout, which has a lower portion 23 submerged in molten metal 17 to form an atmosphere seal.

The control system for controlling the operation of flow control valve 15, as shown in FIG. 2, comprises temperature sensing means, such as thermocouple 24, and a controller 25 adapted to provide a control signal, such as a pneumatic signal of variable pressure, indicative of difference between a set point signal and an input signal from transmitter 26 which, in turn, is proportional to the electrical signal from potentiometer 27 to which thermocouple 24 is attached.

The apparatus thus far described is familiar to those versed in the prior art wherein it was customary to locate thermocouple 24 within cooling chamber 11 thereby maintaining a substantially constant temperature therein. However, from an operational standpoint, it is more desirable to maintain the temperature of the strip entering molten coating metal 17 at a constant value than the temperature within chamber 11. Since the temperature of the strip leaving cooling chamber 11 is influenced by factors other than the temperature of cooling chamber temperature the operation of such strip coating apparatus was often characterized by wide variations in the temperature of the strip leaving the cooling chamber. In some instances attempts have been made to overcome these shortcomings of the prior art by using a temperature sensing device, such as a radiation pyrometer, adapted to directly measure the temperature of the strip before it enters the molten coating metal. Commercially available temperature sensing devices of this type do not have the desired degree of accuracy, however, and their utilization has not been widespread.

It is proposed, therefore, to operate flow control valve 15 in response to a control signal from controller 25 sensitive to a condition which is a function of the temperature at a point, as sensed by a sensing device of high accuracy such as a thermocouple, that is more indicative of the temperature of the strip entering molten coating metal 17 than the temperature within cooling chamber 11. An appropriate point for effecting such a temperature measurement is at a point in molten coating metal 17 close to the point where strip S passes thereto. The temperature at such a point is directly influenced by conductive heat transfer between the strip and the molten metal which, in turn, is normally maintained at a relatively constant value by means of an independent temperature control system which controls the firing rate of the burners which fire the pot setting (not shown) wherein pot 18 is located. In the apparatus illustrated the most appropriate point for sensing the temperature of the molten metal to detect heat exchange between the strip and the molten metal is at a point within the small body of molten metal 17a circumscribed by lower portion 23 of snout 22. Accordingly, the junction of thermocouple 24 is located in a well 28 which extends through the wall of the lower portion of snout 22 into the small body of molten metal 17a. Because of the physical segregation of this small body from the remainder of molten metal 17 its temperature can change rapidly in response to change in the temperature of the strip passing thereto. Thus, change in the temperature of this small body of molten metal provides a better indication of change in the temperature of the strip passing thereto than does change in the temperature within cooling zone 11. It is to be noted that perforations may be provided in lower portion 23 of snout 22 to provide for a controlled rate of interchange of molten metal between small body 17a and the remainder 17.

A more refined control system is shown, schematically, in FIG. 3. In this system a lead from thermocouple 24 is connected to a lead of like polarity of a second thermocouple 29, which is located in a well 31 immersed at a point in molten metal bath 17 remote from the point where strip S passes thereto, and the opposite leads of thermocouples 24 and 29 are connected to potentiometer 127. In this system the millivoltage signal applied to potentiometer 127 is equal to the difference between the millivoltages generated by thermocouples 24 and 29 and the signal transmitted from transmitter 126 to controller 125 will be indicative of the difference between the temperatures sensed by thermocouples 24 and 29. Thus, the control signal from controller 125 to control valve 15 will tend to control the cooling effect of cooling means 11 on strip S to maintain a relatively constant difference between the temperature of the small body 17a from the remainder of the molten metal whereas the control signal from controller 25 to valve 15 will tend to maintain the temperature of small body 17a at a constant value without regard to the temperature of the remainder of molten metal 17. Thus, the influence of inherent deviations in the temperature of the molten metal on the operation of valve 15 will be reduced. Also, the system is capable of somewhat more accurate operation since it only need operate in response to variations in a small quantity.

We claim:

1. In apparatus for treating moving metal strip comprising thermal altering means for altering the heat content of the strip, a pot containing a liquid, and means for passing the strip from the thermal altering means into the liquid in the pot, the improvement comprising, in combination: wall means circumscribing a small body of liquid in the pot in the region where the strip passes thereto; temperature sensing means located within the liquid closely adjacent the point where the strip passes into the liquid, said temperature sensing means being responsive to the temperature at a point in said small body of liquid; and control means operatively associated with and responsive to the temperature sensed by the sensing means and operatively associated with the thermal altering means for controlling the thermal altering means in a manner to control the temperature of the strip at the point at which said strip enters the liquid in said pot.

2. Apparatus according to claim 1 wherein the wall means comprises the lower portion of a snout which circumscribes the strip as it passes into the liquid.

3. In apparatus for treating moving metal strip comprising thermal altering means for altering the heat content of the strip, a pot containing a liquid, and means for passing the strip from the thermal altering means into the liquid in the pot, the improvement comprising, in combination: wall means circumscribing a small body of liquid in the pot in the region where the strip passes into the liquid; first temperature sensing means located within the liquid closely adjacent the point where the strip passes into the liquid, wherein said first temperature sensing means is responsive to the temperature at a point in the small body of liquid; second temperature sensing means located in the liquid at a point in the pot remote from the point where the strip passes into the liquid, wherein said second temperature sensing means is responsive to the temperature of the liquid in the pot at a point external to the small body of the liquid; and control means operatively associated with and responsive to the first and second temperature sensing means and operatively associated with the thermal altering means in a manner to control the temperature of the strip at the point at which the strip enters the liquid in the pot as a function of the difference between the temperature sensed by the first temperature sensing means and the temperature sensed by the second temperature means and to maintain said temperature difference substantially constant.

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