HEAT TRANSFER APPARATUS FOR CONTINUOUSLY MOVING STRIP

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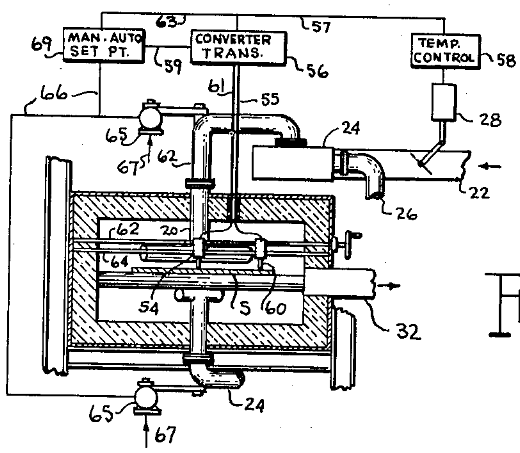

FIG. 1.

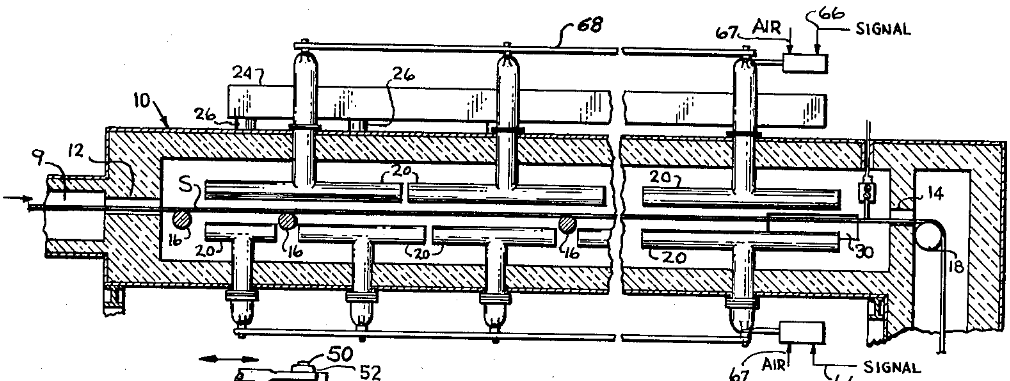

FIG. 2.

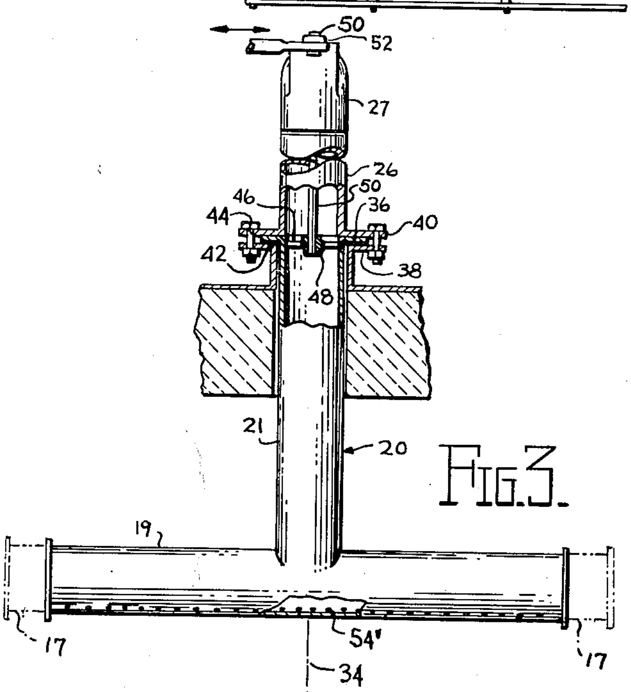

FIG. 3.

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Original application Dec. 29, 1958, Ser. No. 783,466, now Patent No. 3,033,539, dated May 8, 1962. Divided and this application Dec. 21, 1961, Ser. No. 168,862
4 Claims. (Cl. 34—54)

This invention relates to altering the heat content of strip material and more particularly to the convection cooling of metal strip during an annealing process.

One of the problems encountered in the annealing of strip is the forming of wrinkles because of unbalanced temperature conditions within the heating and/or cooling chambers of annealing apparatus.

A condition most frequently encountered in the rapid cooling of metallic strip is one where the edges of the strip tend to cool faster than the center portion and thus produce ruffled strip edges.

Various means and methods have been heretofore suggested as attempts to prevent ruffling or buckling of strip near its edges.

In Patent 2,205,915 Wean et al., it was suggested that hair-pin or V-shaped cooling tubes be disposed with the apex of the V toward the center of the heating chamber so that the shape of the tubes causes cooling of the strip to start at the middle and proceed toward the edges; however, it is admitted that additional thermal insulation is required in certain areas to prevent rapid cooling of the outer edges.

In Canadian Patent 556,114 Dailey, Jr. a plurality of tubes arranged in a series or bank extending longitudinally of the strip are provided wherein the flow of cooling fluid is adjusted individually from tube to tube with separate valve means.

The defects of the prior art are that there exists no automatic control means for effecting the distribution of the cooling fluid medium across the width of a strip and where a plurality of tubes in a bank are employed individual control means for each tube are required. Further, the cooling tubes are not adapted to accommodate varying widths of strip, from one production run to another.

Having in mind the defects of the prior art, it is the primary object of our invention to provide novel control means for maintaining the temperature of a strip in a cooling zone substantially uniform transversely across the strip.

Another object of our invention is to provide cooling means having a minimum number of elements, which can be adapted to accommodate cooling strips of varying widths.

The foregoing objects and others ancilliary thereto we prefer to accomplish as follows:

According to our invention, we dispose within the cooling zone through which the strip travels a first temperature measuring device for the center portion of the strip and a second temperature measuring device for another selected portion of the strip. A temperature differential signal transmitter sends an impulse, which represents the difference in temperatures between the center and the other portion of the strip, to the cooling fluid distributor positioning means.

In the embodiment of our invention, the cooling fluid distributor is in the form of a rotatable ported T-conduit. When the narrowest strip is being processed, and it is desired to concentrate all of the cooling to the center of the strip, the distributor head is in longitudinal alignment with the strip. When wider strips are being processed, or when the temperature differential between the center and edges of strip is such that it is desired to concentrate less cooling at the center, the distributor head is rotated to increase the distribution of the cooling medium transversely across the strip. The maximum distribution will occur when the distributor head is perpendicular to the longitudinal axis of the strip.

If it is desired to accommodate strips of additional width, or a plurality of strips in a single chamber, the distributor head may be provided with telescoping ends to extend the length thereof.

The novel features which we consider characteristic of our invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiment when read in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic illustration of the control system of the invention in connection with a rotatable coolant distributor in the cooling chamber of strip annealing process apparatus;

FIG. 2 is a transverse view of the apparatus shown in FIG. 1; and

FIG. 3 is an enlarged view of the rotatable distributor.

The numeral **10** generally indicates a cooling chamber of a continuous annealing line for treating metallic strip. Ordinarily the strip S is passed from a heating chamber (not shown) to a temperature holding zone **9**. The strip enters the chamber **10**, therein controlled cooling occurs, through opening **12** and leaves by exit **14**. A plurality of rolls **16** and **18**, at least one of which is power driven, are provided to support and transport the strip S through the cooling chamber **10**.

The chamber **10** is preferably formed of gas tight welded sheet metal lined with insulation. Cooling of the strip S in the chamber is effected by a suitable coolant distributed by one or more T-shaped conduits or distributors **20**.

The coolant is supplied from a suitable source to supply duct **22** which leads to header duct **24**. Branch pipes **26** connect each of the conduits **20** to the header duct **24**. The supply duct **22** has a control valve **28** which regulates the total volume flow of coolant, in a manner to be later described, to the header duct **24** and consequently to chamber **10**.

From the chamber **10** the coolant is exhausted through opening **30** leading to exhaust duct **32** which may be suitably connected to suction means (not shown). If the coolant is a special atmosphere and it is desired to conserve the same, the suction means may direct the coolant to a cooling exchanger and drier (not shown) and thence to supply duct **22** for recirculation in the chamber **10**.

The conduits **20** are preferably supported with the central axis of the leg of the T-portion on a vertical center line **34** of a transverse section of the chamber **10**.

Referring now more particularly to FIG. 3, the T-conduit **20** carries, near the extremity of its vertical leg **21**, a support flange **36**. The flange **36** is clamped, for rotational movement, between a first clamping ring **38**, which may be an extension of the outer casing, and a second clamping ring **40** secured to the branch pipe **26**. A bearing surface in the form of copper lining **42** or the like may be interposed between flange **36** and one or both rings **38** and **40** to facilitate rotational movement of the conduit **20**. Throughbolts **44** attach the first clamping **38** to the second clamping ring **40**.

Rotational movement is imparted to conduit **20** by means of a spider connection **46** having a hub portion

48. The hub 48 is supported on a shaft 50 suitably journalled in journal extension 27 of the elbow of pipe 26. The shaft 50 extends through extension 27 to receive arm 52. The arm 52 may be rotated manually or automatically by means to be later described.

The horizontal head portion 19 of conduit 20 is shown in FIG. 3 to be provided with two longitudinally disposed and aligned rows of holes or ports 54′ for distributing and discharging the coolant from said head. It is to be understood, however, that any number of holes or other port means, such as nozzles or a longitudinal slot may be employed. It is particularly advantageous to employ a longitudinally extending slot in conduits provided with one or more telescoping ends 17(as shown in discontinuous lines in FIG. 3. An arrangement wherein a slot extending the longitudinal length of the conduit is provided obviates the problem of port alignment when the telescoping ends are adjusted to various positions.

In operation, the temperature of the strips being cooled may vary across its width. Therefore, it is desirable to provide means for measuring the temperature of the strip at the critical portions and to provide means for controlling the distribution of the cooling medium in accordance with the differential in temperature of the critical portion. It is also desirable to provide means for controlling the total volume of coolant circulated in a chamber, or a zone, in accordance with the temperature at a control point.

The measuring and control system of this invention is characterized in that provision is made to automatically control and vary the distribution of the cooling medium in response to a deviation from a pre-selected temperature differential between selected portions, usually the center and edges, of the strip.

As seen in FIG. 1 a first temperature sensing means in the form of a thermocouple 54 is positioned at the center of the strip S to measure the temperature thereat. An electrical impulse representing that temperature is sent through line 55 to the converter and transmitter 56 which in turn transmits a pneumatic signal through line 57 to the temperature control 58 which controls the actuation of valve 28. If the temperature of the strip is above a preselected set point on the control 58, the valve 28 will be opened to increase the total volume of coolant admitted to header duct 24 and consequently chamber 10.

A second temperature sensing means, thermocouple 60, is suitably mounted for adjustment to measure the temperature at another portion of the strip, usually an edge portion. The thermocouple 60 may be mounted on a screw 62 and guide-rod 64 to accommodate the temperature measurement of different portions or strips of different widths. Suitable indicating means, not shown, may be provided externally of the cooling chamber in connection with the screw 62 to enable the operator to ascertain and set the position of the adjustable thermocouple 60.

An electrical impulse representing the temperature as sensed by thermocouple 60 is sent to converter and transmitter 56 through line 61. The transmitter 56 sends the signals from thermocouples 54 and 60 through lines 59 and 63 respectively to the manual-automatic set point instrument 69. A differential in temperature as measured by thermocouples 54 and 60 greater than the amount preselected on the set point instrument 69 will produce a signal which is transmitted to the motors 65 through line 66 and balanced against air furnished at constant pressure from a suitable source through line 67. The motors 65 are illustrated as being fluid operated; however, it will be understood that other types of motors may be employed with appropriate changes in signal transmission.

In operation, particularly with relatively narrow strips at the start of a production run, the head 19 of conduit 20 will be in longitudinal alignment with the longitudinal center line of chamber 10. When the set point instrument 69 receives signals from thermocouples 54 and 60 which indicate that the temperature at the edge of the strip as sensed by thermocouple 60 exceeds that of the strip center by a differential greater than that selected on the instrument 69, the motors 65 operatively connected to arm 52 through linkage 68 will cause the conduits 20 to rotate. The conduits 20 will then concentrate less coolant at the center of the strip S and distribute more coolant toward the edges of the strip.

Conversely, if the head 19 is in a position transversing part of the strip and it is indicated that the temperature of the strip center exceeds that of the strip edge portion by a differenial greater than that selected on instrument 64, the air pressure through line 67 will be greater than the signal through line 66 and cause the piston of fluid motor 65 to retract and actuate arm 52 to bring the longitudinal axis of head 19 into alignment with the centerline of the furnace.

While FIG. 2 illustrates all of the conduits 20 in a bank as being interconnected to be actuated by a single motor, it will be understood that individual motors may be provided for each of the conduits.

A cooling system as described comprises a cooling chamber through which a continuous strip is passed. Within the chamber are heat exchangers through which the coolant passes. These heat exchangers have selectively positionable means for proportioning the total volume flow between or among designated width portions of the strip. Controls, responsive to temperature measuring means positioned at the designated portions, are provided to automatically actuate the positionable means and distribute the coolant across the strip width in a manner that will maintain the temperatures of the strip portions within a prescribed range.

This application is a division of application Serial No. 783,466, now U.S. Patent 3,033,539.

We claim:

1. Apparatus for altering the heat content of a continuously moving strip which comprises, in combination: wall means forming an elongate treating chamber; means for advancing the strip through said chamber; a source of fluid heat transfer medium; heat transfer exchange means positioned within said chamber for circulating said medium in heat transfer relation with the strip, said exchange means having a positionable distributor portion; a plurality of temperature measuring means for measuring the temperature at laterally separated portions of the strip; signal transmitting means operatively associated with the temperature measuring means for transmitting a signal indicative of the temperature difference between said laterally separated portions; and means responsive to a signal from said signal transmitting means for selectively and automatically positioning said distributor portion whereby the heat transfer effect across the width of the strip is controlled.

2. Apparatus for cooling a continuously moving strip which comprises, in combination: wall means forming an elongate cooling chamber; means for advancing said strip through said chamber; a source of cooling fluid medium; heat transfer exchange means positioned within said chamber for circulating said medium in heat transfer relation with the strip, said exchange means having a positionable distributor portion; first temperature measuring means positioned to measure the temperature at a first selected portion of the strip width; second temperature measuring means, positionally adjustable, to measure the temperature at a second selected portion of the strip width laterally separated from the first position; means for receiving, from said first and second temperature measuring means, impulses indicative of the temperatures measured thereby and translating said impulses into a signal representing the difference between said temperatures; and means responsive to said signal for selectively and automatically positioning said distributor portion whereby the transverse cooling of the strip is controlled.

3. Apparatus for cooling a continuously moving strip which comprises, in combination: wall means forming an elongate cooling chamber; means for advancing said strip

through said chamber; a source of cooling fluid medium; a rotatably mounted heat transfer distributor for distributing said fluid medium, said distributor being rotatable from a position where its longitudinal axis is in parallel alignment with the strip length to one where the longitudinal axis is perpendicular to the strip length, said distributor also having a series of ports along a longitudinal axis for discharging the fluid medium toward said strip; a plurality of means for measuring the temperature of the strip at laterally separated portions thereof; a signal transmitter operatively connected with said temperature means for initiating a signal representing the temperature difference between said separated portions; means responsive to said signal to selectively and automatically position said heat transfer distributor to vary the alignment of said ports with the width of said strip and thereby control the flow distribution of the heat transfer fluid medium across the width of the strip.

4. Apparatus for cooling a continuously moving strip which comprises, in combination: wall means forming an elongate cooling chamber; means for advancing said strip through said chamber; a source of cooling fluid medium; a cooling fluid distributor having a head portion and a leg portion, said head portion being rigidly attached to said leg portion and being disposed in a plane parallel to the plane of the strip, said leg portion being mounted for rotational movement about its longitudinal axis and to vary the span of said head portion across the strip width, said head portion also being provided with an aperture for discharging said medium toward said strip; a plurality of temperature measuring means for measuring the temperature at laterally separated portions of the strip; signal means operatively associated with the temperature measuring means for transmitting a signal indicative of the temperature difference between said selected portions; and means responsive to said signal for selectively and automatically rotating said distributor to vary the discharge distribution of said medium across the strip width.

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