

May 8, 1962

E. A. COOK ET AL

3,033,539

HEAT TRANSFER APPARATUS FOR CONTINUOUSLY MOVING STRIP

Filed Dec. 29, 1958

2 Sheets-Sheet 1

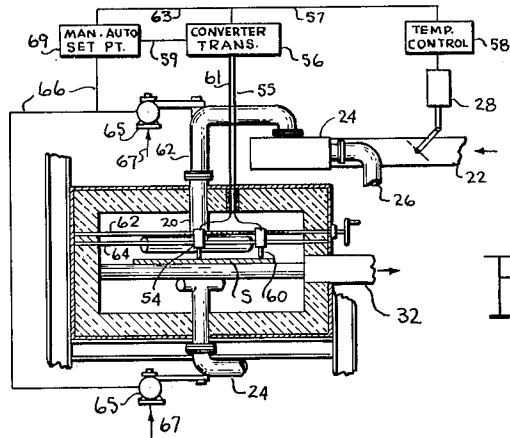


FIG. 1

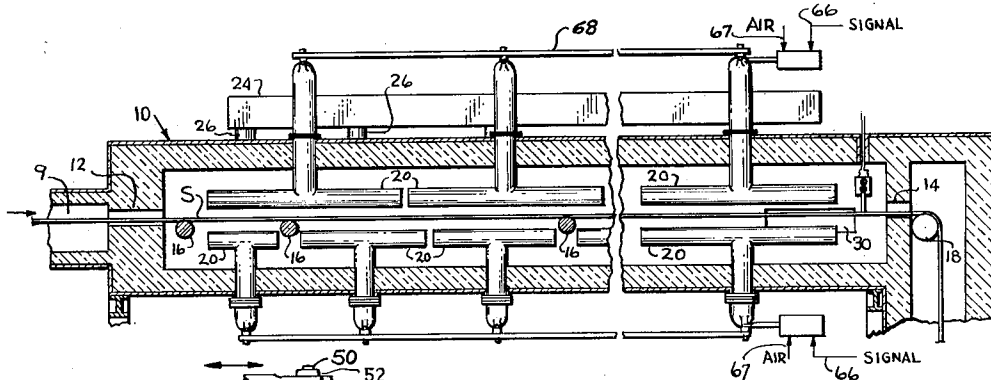


FIG. 2

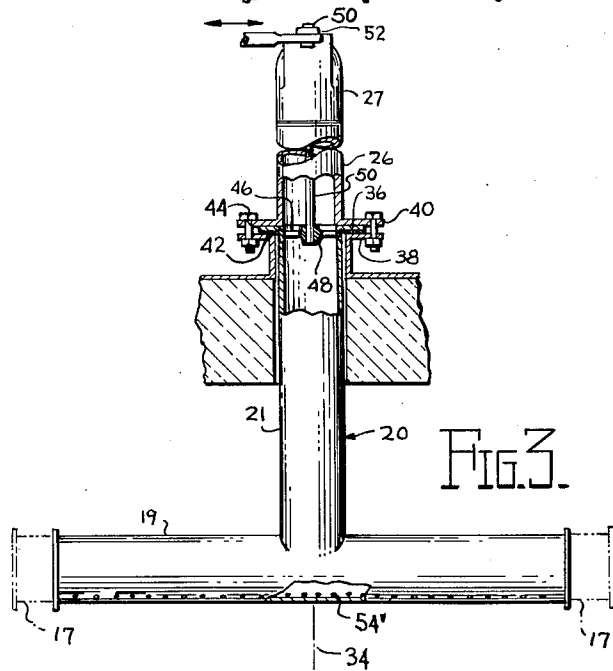


FIG. 3

INVENTORS
EUGENE A. COOK
CARROLL CONE

BY *Charles S. Haughey*
ATTORNEY

3,033,539

HEAT TRANSFER APPARATUS FOR CONTINUOUSLY MOVING STRIP

Filed Dec. 29, 1958

2 Sheets-Sheet 2

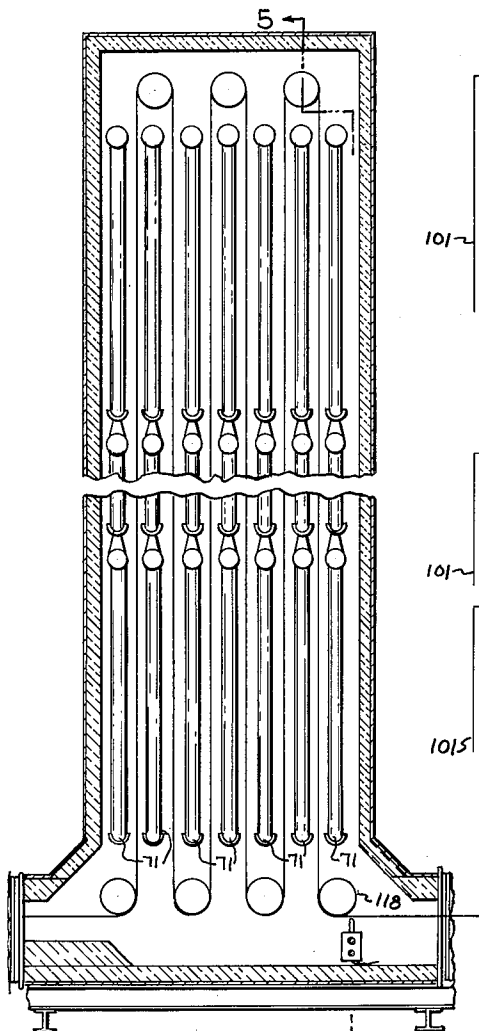


FIG. 4. 5 ← j

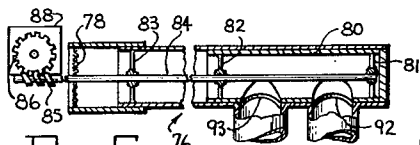


Fig. 6.

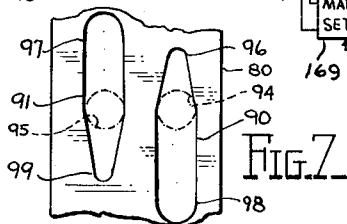
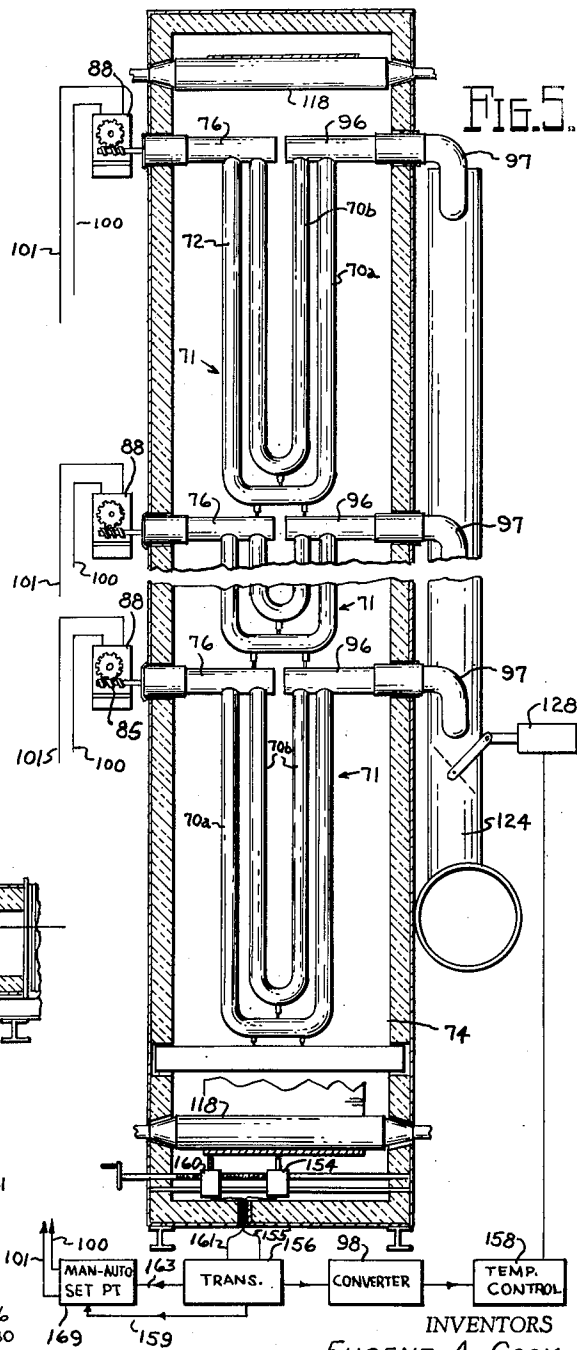


FIG. 7



INVENTORS
EUGENE A. COOK
CARROLL CONE

BY *Charles S. Haughey*
ATTORNEY

1

2

3,033,539 HEAT TRANSFER APPARATUS FOR CONTINUOUSLY MOVING STRIP

Eugene A. Cook and Carroll Cone, Toledo, Ohio, assignors, by mesne assignments, to Midland-Ross Corporation, Cleveland, Ohio, a corporation of Ohio
Filed Dec. 29, 1958, Ser. No. 783,465
3 Claims. (Cl. 257—306)

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 produces 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 within 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. Furthermore, 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.

Still another object of our invention is to provide a novel arrangement of a bank of cooling tubes which eliminates the necessity of individual control means for each tube in order to effect a preferred distribution of the cooling medium transversely across the strip.

The foregoing objects and others ancillary 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 measuring the temperature of the center portion of the strip and a second temperature measuring device for measuring the temperature of 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 one 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.

In another embodiment of our invention, the cooling fluid distributor comprises a manifold for a bank of hair-pin tubes and a positionable valve member within said manifold for selectively proportioning the flow through the individual tubes of the bank. Such arrangement not only provides a single control for an entire bank of tubes which is automatically adjustable according to the temperature differential between certain sections of the strip but also requires less openings in the chamber wall for the inlets and outlets of the cooling tubes. There is but one inlet and one outlet required for each bank of tubes as compared to an inlet and outlet for each tube of a bank in prior apparatus.

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 embodiments 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;

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

FIG. 4 is a diagrammatic and fragmentary elevational view of a cooling chamber illustrating a different type of heat exchange means;

FIG. 5 is a diagrammatic and fragmentary elevational view of the cooling chamber as seen from line 5—5 of FIG. 4 and a schematic illustration of the controls for the heat exchange means;

FIG. 6 is an enlarged sectional view of the valve mechanism for proportioning the flow through the individual heat exchange means; and

FIG. 7 is a developed fragmentary view of the valve of FIG. 6 illustrating the arrangement of the valve openings.

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, wherein 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

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. Through-bolts 44 attach the first clamping ring 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 journaled 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 61 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 55. 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 differential 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.

In the embodiment as illustrated in FIGS. 4-7 controlled cooling of the strip from portion to portion is attained by selectively proportioning the volume flow of coolant through the individual U or hairpin tubes 70 forming a bank 71 of tubes. The banks 71 of tubes are arranged in a series. Usually one more series than there are strip passes in the chamber 74 are provided so that each strip pass is exposed to two series of tubes.

The tubes 70 are arranged in the banks 71 with the vertical legs 72 of the U in alignment with the longitudinal direction of the strip. Two tubes 70a and 70b are shown in FIG. 5 as comprising a bank 71; however, more may be employed if desired. The outside tube 70a is placed in a position which corresponds to the width of the strip most frequently treated in the chamber 74, or one which is considered standard for the apparatus. Thus when wider strip than standard is being treated it is necessary to direct more of the coolant medium through the outside tube 70a. Conversely, when relatively narrow strip is being treated, it is preferred to direct more of the coolant to the inside tube 70b.

As shown in FIGS. 5 and 6, the coolant air enters the manifold entry section 76 through filter screen 78. The entry section 76 is provided with a rotatable sleeve valve

member 80. Valve 80 has spider members 81 and 82 for supporting turning rod 84. The entry section 76 is also provided with a spider member 83 for supporting and aligning the rod 84.

The end of rod 84 extending out of section 76 is provided with a toothed portion 85 for engagement with driving gear 86 of reversible driving motor 88. The operation of motor 88, illustrated as being electrical, is similar to and is responsive to the same conditions as motor 65 of the previously described embodiment, except that the electric impulse from the temperature sensing means need not be converted to a fluid impulse.

Valve 80 is provided with openings 90 and 91 which are registerable with port opening 92 and 93, respectively, of entry section 76. It will be understood, of course, that the number of openings in valve 80 will correspond to the number of U-tubes employed in a single bank of tubes.

In normal or neutral position, the portions 94 and 95 (indicated by discontinuous lines) of openings 90 and 91 respectively are in registry with ports 92 and 93. However, if the temperature of one selected portion of the strip deviates more than a preselected amount from the temperature of another selected portion, the valve 80 will be rotated to preferentially direct more of the coolant to the warmer portion of the strip.

Thermocouple 154 is positioned to measure the temperature of the center of the strip. An electrical impulse through line 155 representing the temperature is transmitted by the transmitter 156 to converter 98 which in turn transmits a fluid impulse to temperature control 158. Controller 158 actuates valve 128 according to a deviation from the set point on controller 158.

The header duct 124 is connected to suitable suction means (not shown). Depending upon the parameters of the system, one header duct 124 may service one or more series of tubes. The duct 124 is connected to the exit manifold sections 96 through branch pipes 97. In operation if the temperature of the strip is above the preselected point on the control 158, the valve 128 will be opened to increase the total suction in header 124 and consequently through the banks of tubes 71.

Thermocouple 160 is adjustably mounted in the same manner as thermocouple 60 in the previously described embodiment to measure the temperature at a selected portion of the strip.

Impulses representing the temperatures as sensed by thermocouples 154 and 160 are transmitted by transmitter 156 to manual-automatic set point instrument 169 through lines 159 and 163 respectively. When the temperature of the strip portion measured by thermocouple 160 is higher than the temperature of the center portion as measured by thermocouple 160 by a degree greater than that set on instrument 169, the instrument 169 will transmit a signal to the reversible drive motor 88 through line 100. The motors 88 in response to this signal will rotate the driving gears 86 in a direction which causes the valve 80 to partially close port 92 and maintain port 93 fully open. Thus a greater portion of the coolant will flow through port 93, and consequently tube 70b, until a temperature equilibrium is reached and then the valve 80 will resume its normal position with portions 94 and 95 in registry with ports 92 and 93.

When the temperature of the strip center is higher than the strip portion measured by thermocouple 160, then instrument 169 will transmit a signal to the reversible drive motors 88 through line 101. The motors 88 in response to this signal will rotate the driving gear 86 in a direction which causes the valve 80 to partially close port 93 and maintain port 92 fully open. Thus a greater portion of the coolant will flow through port 92 and consequently tube 70a.

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.

We claim:

1. Apparatus for cooling a continuously moving metal strip comprising, in combination: wall means forming an elongate chamber; means for advancing the strip through said chamber; a first hair-pin cooling tube having its legs extending generally parallel to said strip; a second hair-pin cooling tube having its legs extending generally parallel to said strip and to the legs of said first hair-pin tube, said second cooling tube having its legs disposed closer to each other than the legs of said first cooling tube and being disposed generally intermediate the legs of said first hair-pin tube; an inlet manifold connected to one leg of each of said first and second hair-pin cooling tubes; an exhaust manifold connected to the other leg of each of said first and second cooling tubes; circulating means for causing cooling medium to flow from said inlet manifold to said exhaust manifold through said first and second hair-pin cooling tubes; and cooling medium flow control means for controlling the relative quantity of cooling medium which flows through each of said first and second cooling tubes to thereby control the heat absorbing capacity of each of said tubes.

2. The combination, as described in claim 1 wherein said cooling medium flow control means is adjustable to vary the relative quantity of cooling medium which flows through each of said first and second cooling tubes, which further comprises: a plurality of temperature measuring means for measuring the temperature along selected portion of said 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 automatically adjusting said cooling medium flow control means.

3. Apparatus according to claim 1 wherein one of said manifolds is ported and wherein said cooling medium flow control means comprises a rotatable sleeve member having a plurality of openings corresponding to the number of and for alignment with the ports in said ported manifold, each of said openings having a first portion which substantially corresponds to the size of its corresponding port, each of said openings also having a second portion, leading away in opposite directions from said first portion and progressively diminishing in size therefrom, said openings being spaced about said sleeve in a predetermined manner whereby cooling medium flows through each of the cooling tubes from the inlet manifold to the outlet manifold in a predetermined ratio for a given position of the sleeve member.

References Cited in the file of this patent

UNITED STATES PATENTS

1,090,934	Metcalf et al.	Mar. 24, 1914
1,717,004	Buck	June 11, 1929
2,205,915	Wean	June 25, 1940
2,666,994	Dungler	Jan. 26, 1954
2,825,979	Verwayen	Mar. 11, 1958
2,876,335	Rendel	Mar. 3, 1959