

June 9, 1959

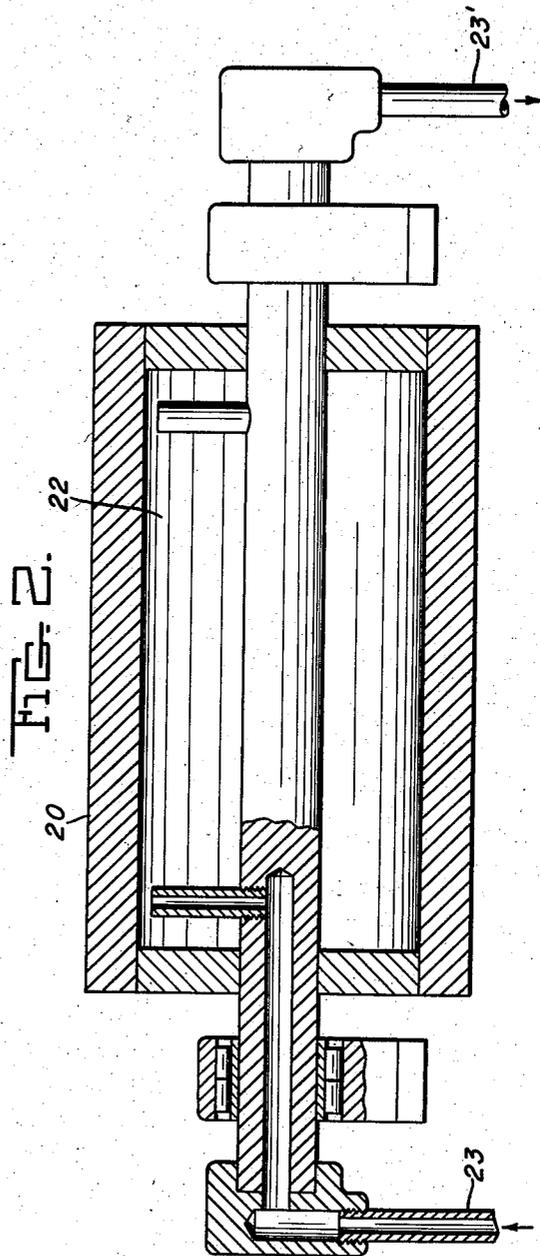
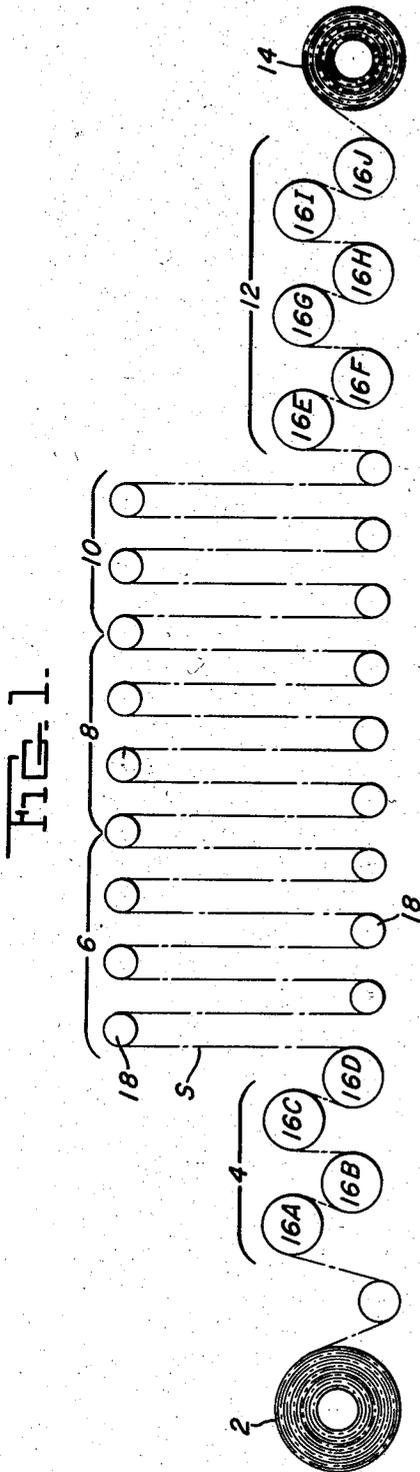
G. H. RENDEL

2,890,037

METHOD AND APPARATUS FOR CONTINUOUSLY COOLING METAL STRIPS

Filed Nov. 10, 1954

3 Sheets-Sheet 1



INVENTOR:  
GEORGE H. RENDEL,

BY: *Donald G. Dalton*  
his Attorney.

June 9, 1959

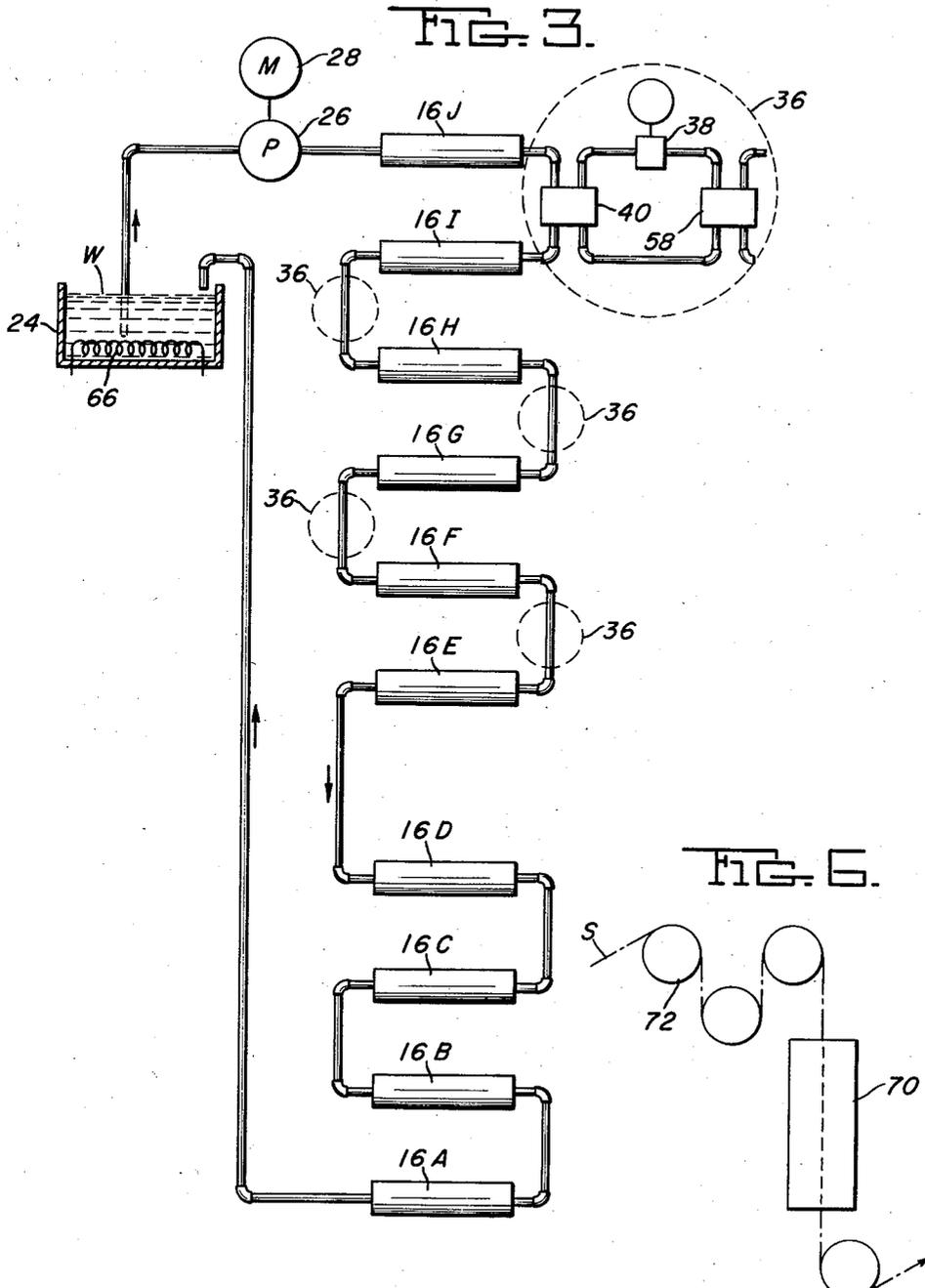
G. H. RENDEL

2,890,037

METHOD AND APPARATUS FOR CONTINUOUSLY COOLING METAL STRIPS

Filed Nov. 10, 1954

3 Sheets-Sheet 2



INVENTOR:  
GEORGE H. RENDEL,

BY: *Donald G. Dalton*  
his Attorney.

June 9, 1959

G. H. RENDEL

2,890,037

METHOD AND APPARATUS FOR CONTINUOUSLY COOLING METAL STRIPS

Filed Nov. 10, 1954

3 Sheets-Sheet 3

FIG. 4.

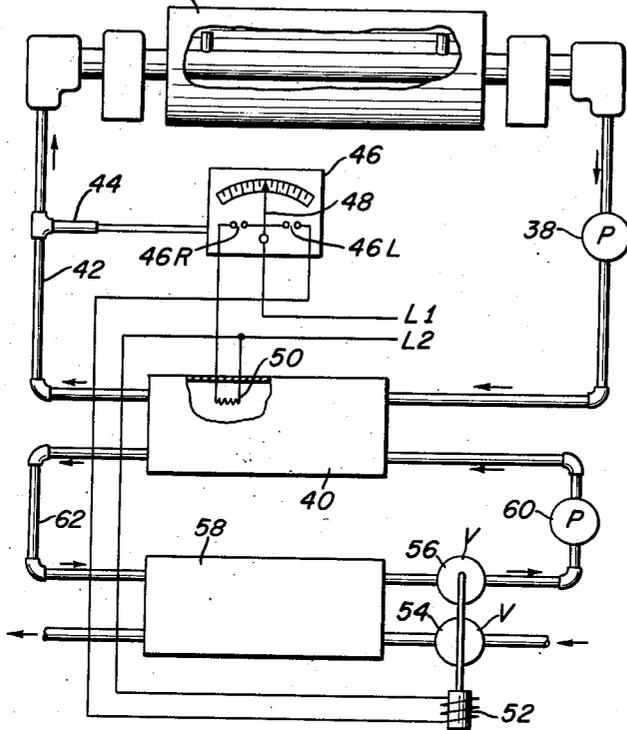
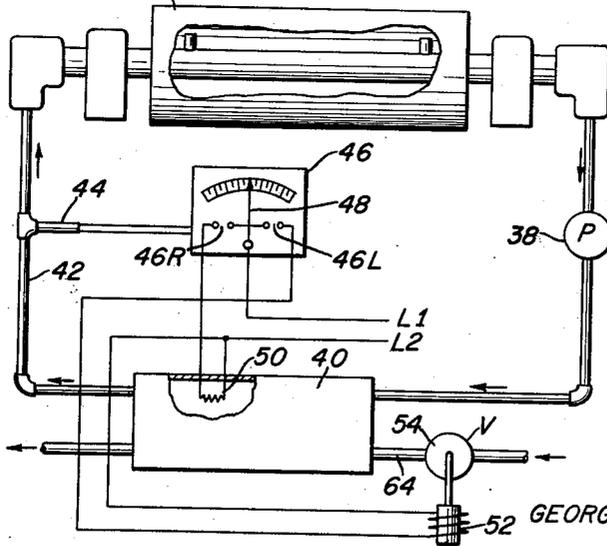


FIG. 5.



INVENTOR:  
GEORGE H. RENDEL,

BY: *Donald G. Dalton*  
his Attorney.

1

2,890,037

**METHOD AND APPARATUS FOR CONTINUOUSLY COOLING METAL STRIPS**

George H. Rendel, Pittsburgh, Pa., assignor to United States Steel Corporation, a corporation of New Jersey

Application November 10, 1954, Serial No. 468,005

3 Claims. (Cl. 266—3)

This invention relates to a strip temperature control and more particularly to a control for cooling or heating steel strip as it passes over a plurality of rolls. One specific application for which my control is well adapted is in the continuous annealing of steel strip. In such processes the strip is heated to the annealing temperature and is held at that temperature for a predetermined time interval after which it is cooled and recoiled. Before recoiling the temperature of the strip should be below 200° F. The cooling of the strip to this low temperature is one of the major problems in the continuous strip annealing process. It has been proposed to cool the strip by blowing a cooling medium thereover and by lengthening the cooling zone, but neither of these solutions have been satisfactory and, in many instances, it has been necessary to decrease the speed of the line in order to obtain proper cooling.

It is therefore an object of my invention to provide a control for regulating the temperature of strip passing over rolls.

Another object is to provide a continuous strip annealing line having means for cooling the strip rapidly and uniformly.

These and other objects will be more apparent after referring to the following specification and attached drawings, in which:

Figure 1 is a schematic view of an annealing line incorporating my invention therein;

Figure 2 is an enlarged sectional view of a roll used in the control of strip temperature;

Figure 3 is a schematic view of the control of roll temperatures as utilized in the line of Figure 1;

Figure 4 is a schematic view of one form of control for regulating the temperature of a single roll;

Figure 5 is a schematic view, similar to Figure 4, showing another embodiment of my invention; and

Figure 6 is a schematic view of my invention as applied to an electrostatic oiler.

Referring more particularly to the drawings, reference numeral 2 indicates an uncoiler from which strip to be annealed is uncoiled. After passing through various conventional equipment (not shown) the strip passes through a preheating zone 4 and then successively through a heating zone 6, holding zone 8, slow cooling zone 10 and a fast cooling zone 12 from which it passes to a coiler 14. In the preheating zone the strip passes successively around rolls 16A, 16B, 16C and 16D and in the fast cooling zone 12 the strip S passes successively around rolls 16E, 16F, 16G, 16H, 16I and 16J. In zones 6, 8 and 10 the strip passes around rolls 18. It will be understood that the number of rolls may be either greater or less than shown. As shown in Figure 2 the rolls 16 are hollow and have a wall 20 surrounding a chamber 22 which receives a heat exchange medium through a conduit 23 and exhausts it through conduit 23'. The heat exchange medium may be a non-flammable oil, liquid silicone or other suitable fluid which will withstand relatively high temperatures. As shown in Figure

2

3 the heat exchange medium W is delivered from a storage tank 24 by means of a pump 26 driven by a motor 28 to the roll 16J at the exit end of the series of rolls and then successively through rolls 16I, 16H, 16G, 16F and 16E and hence through rolls 16D, 16C, 16B and 16A back to the storage tank 24. This arrangement causes the surface temperature of the rolls to increase from the roll 16J to roll 16E and to decrease from the roll 16D to the roll 16A. For the purpose of illustration only it may be assumed that the surface temperatures of rolls 16J, 16I, 16H, 16G, 16F and 16E are 125° F., 200° F., 300° F., 400° F., 500° F. and 600° F., respectively, and that the temperature of the strip S as it first contacts the roll 16E is 850° F. As the strip S it passes around the roll 16E it will be cooled to a temperature of 725° F. As it passes around the rolls 16F, 16G, 16H, 16I and 16J it will be cooled still further to temperatures of 600°, 475°, 375°, 275° and 200° F., respectively. In order to utilize the heat in the heat exchange medium W it is passed to the rolls 16D, 16C, 16B and 16A. The surface temperatures of rolls 16D, 16C, 16B and 16A may be assumed as 500°, 400°, 300° and 200° F., respectively. The strip temperature as it passes successively over rolls 16A, 16B, 16C and 16D will increase from atmospheric to 100°, 200°, 300° and 400° F., respectively. The amount of wrap around the rolls should be as great as possible to increase the amount of heat transferred to or from the strip S. In order to obtain the desired differential in surface temperature of the cooling rolls the thickness of the wall 20 may be varied so as to be of decreasing thickness from the first to the last roll contacted by the strip. This arrangement of wall thickness can also be used to provide the desired surface temperature of the rolls when utilizing a heat exchange medium having a constant temperature as it enters each roll. For some installations it may be necessary to utilize a temperature control system 36 to regulate the temperature of the heat exchange medium W as it enters one or more of the conductor rolls. The temperature regulating system 36 may be as shown in Figures 4 or 5. In Figure 4 the heat exchange medium is pumped by means of a pump 38 to a heat exchanger 40 and then through a conduit 42 to the next succeeding roll 16 or if it is desired to maintain the temperature of a single roll constant the conduit 42 will lead back to the original roll. Located in the conduit 42 is a thermocouple 44 which is connected to a thermal-sensitive instrument 46 having contacts 46R and 46L and a moving arm 48. Power line L1 is connected to contact arm 48 and contact 46R is connected to one terminal of a heating element 50. The other terminal of the heating element 50 is connected to power line L2. A solenoid 52 has one terminal connected to power line L2 and the other to contact 46L. Solenoid 52 operates valves 54 and 56 connected to an auxiliary heat exchanger 58. Valve 54 controls the flow of cold water to heat exchanger 58 and valve 56 controls flow of fluid from the heat exchanger 58 to heat exchanger 40 by means of a pump 60. Conduit 62 returns the fluid from the heat exchanger 40 to the heat exchanger 58.

The operation of this control is as follows:

When the temperature of the heat exchange medium in conduit 42 becomes cooler than desired, contact arm 48 will move to the left completing a circuit through contact 46R to energize heating element 50. When the fluid in conduit 42 becomes warmer than desired contact arm 48 will move to the right closing contact 46L and completing a circuit to solenoid 52, thus energizing solenoid 52 and opening valves 54 and 56. This permits cold water to flow through valve 54 to heat exchanger 58 to remove heat from the system and the cool fluid to flow through valve 56 to the heat exchanger 40 to

3  
lower the temperature of the heat exchange medium. Valves 54 and 56 may be provided with suitable by-passes to permit a relatively small quantity of fluid and water to flow through auxiliary heat exchanger continuously. By properly selecting the sizes of pumps 38 and 60 the heat exchangers 40 and 58 and valves 54 and 56, the temperature regulating system may be so designed that the water temperature in auxiliary heat exchanger 58 will not exceed about 170° even when the temperature of roll 16 is being maintained at 700°.

The temperature regulating system shown in Figure 5 is essentially the same as that shown in Figure 4 except that the auxiliary heat exchanger 58 is omitted and the solenoid 52 operates valve 54 in the conduit 64 leading from the cold water line to the heat exchanger 40. Thus when the temperature of the heat exchange medium is too high in the roll 16 the valve 54 opens permitting cool water to pass through heat exchanger 40 and lowering the temperature of the water leading to the roll 16.

If desired, the heat exchange medium from roll 16E can be returned directly to tank 24 without passing through rolls 16A, 16B, 16C and 16D. However, it is desired to cool the heat exchange medium from roll 16E by the method disclosed so that the heat therein will be utilized to heat the strip. This also is desirable because the temperature of the heat exchange medium returning to the storage tank 24 will be reduced thus decreasing the amount of heat which must be removed by means of cooling coils 66.

The temperature control unit shown in Figures 4 and 5 may also be used with conductor rolls such as shown in my prior Patent No. 2,658,982. It has been found that the strip shown therein had a temperature of 240° F. before contact with the conductor roll 12 of the patent but that after its contact it had a temperature of only 165°. Such heat loss is undesirable and by providing a temperature control unit for the roll its temperature may be maintained close to the temperature of the strip so that such heat loss will not result.

Another installation in which my invention may be utilized is in conjunction with an electrostatic oiler such as disclosed in my co-pending application, Serial No. 394,033, filed November 24, 1953, now Patent No. 2,796,845, dated June 25, 1957. It has been demonstrated that better results are obtained when the strip is thoroughly dry on entering an electrostatic oiler 70. When the strip is wet as it enters the oiler evaporation of water occurs in the oiler enclosure and frequently raises the moisture content to the extent that flashovers occur between the ionizing electrodes and the strip. Also, oil electrostatically deposited on moist strip forms an emulsion and does not adhere as well as when the strip is dry. As shown in Figure 6 the strip S passes around one or more hollow rolls 72 prior to its entry into the electrostatic oiler 70. The temperature of the roll 72 is controlled by means of the control shown in either Figure 4 or 5 so that the strip temperature is raised sufficiently to in-

sure complete dryness of the strip prior to its entry into the enclosure of the electrostatic oiler.

While several embodiments of my invention have 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. Apparatus for continuously cooling strip comprising a plurality of hollow rolls around which the strip passes successively, the walls of said rolls being of varying thickness with the thickness decreasing from the first to the last roll contacted by the strip, and means for passing a heat exchange medium through said rolls.

2. The method of continuously cooling hot strip comprising passing the hot strip successively around a substantial arc of each of a series of hollow rolls arranged in staggered relationship with opposite sides of the strip contacting successive rolls, passing a cooling medium serially through said rolls, regulating the rate of flow of cooling medium into said rolls, regulating the temperature of the cooling medium introduced into successive rolls by providing a maximum temperature in the cooling medium introduced into the first roll contacted by the strip and gradually decreasing the temperature of the cooling medium introduced into succeeding rolls to a minimum temperature in the last roll contacted by the strip.

3. Apparatus for continuously cooling a moving strip comprising a series of spaced apart hollow rolls arranged in staggered relationship so that the strip is wrapped around substantial arcs of said rolls with opposite sides of the strip contacting successive rolls, means for passing heat exchange medium into the first roll contacted by the strip, means for regulating the rate of flow of heat exchange medium into said first roll, connection means for delivering the heat exchange medium from each of said rolls to the next succeeding roll in said series of rolls, and means operatively associated with each of said connection means for regulating the temperature of the heat exchange medium introduced into said next succeeding roll.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

1,268,155	Rowland	June 4, 1918
1,937,382	Cone	Nov. 28, 1933
1,950,669	Gleason	Mar. 13, 1934
2,431,473	Flynn	Nov. 25, 1947
2,435,959	Eaby	Feb. 17, 1948
2,463,412	Nachtman	Mar. 1, 1949
2,661,669	Friedrick	Dec. 8, 1953
2,693,353	Vaughan	Nov. 2, 1954
2,797,899	Funk et al.	July 2, 1957

##### FOREIGN PATENTS

371,080	Great Britain	Apr. 21, 1932
481,379	Great Britain	Mar. 10, 1938
736,751	Germany	June 26, 1943
624,545	Great Britain	June 10, 1949