In the manufacture of sheet material such as linoleum, asphalt tile, or other plastic floor and wall coverings, it has been common practice to form the sheet from a mass of composition disposed in the nip of a pair of calender rolls. To obtain the proper surface characteristics on the sheet produced from the mass of material, it is essential that the calender roll forming the face of the sheet be maintained at a specific predetermined temperature. In order to insure that the calender roll will always be maintained at the proper predetermined temperature, regardless of whether the sheet is being formed from a mass of composition processed at a temperature in excess of the desired roll temperature or at a temperature less than the desired roll temperature, it is necessary to equip the calender roll with a heat transfer fluid circulating system, which system can be operated either with heating fluid or cooling fluid and can be changed from one to the other while the roll is in operation to take care of certain changes in the condition of the material passing through the calender, which would ordinarily have an effect on the temperature of the working surface of the roll.

For example, in the manufacture of asphalt tile sheet material from a mass of asphalt tile composition, the composition is processed at a temperature substantially in excess of the desired calender roll temperature and is fed to the calender roll at this high temperature. It has been found through experience that in order to maintain the face forming calender roll at the desired temperature it is necessary to circulate cold brine through the roll. In order to maintain the working surface of the roll at the desired temperature while working composition at a substantially higher temperature, it is necessary to circulate cooling fluid through the roll. This cooling fluid is at a temperature substantially less than the temperature at which the working surface of the roll is maintained. The internal structure of the roll is such as to provide a uniform quantity of fluid across the roll so as to get a uniform heat transfer effect from end to end of the entire roll. A roll structure suitable for accomplishing this purpose is illustrated and described in U.S. Patent No. 2,498,662, issued February 28, 1950.

In processing certain of the plastic materials which do not have as high a residual heat as asphalt tile composition, it may be found desirable at times to supply heating fluid to the calender roll during the calendering operation in order to maintain the surface of the roll at the desired temperature. At other times it may be found necessary to supply cooling fluid to the roll while processing the same type raw material.

The above examples are given to illustrate the temperature control of calender rolls during normal continuous operation. However, in the first example, in which the mass of material is at a temperature substantially in excess of the temperature at which the calender roll is maintained, the system will work satisfactorily so long as the mill is in continuous operation and hot material is passing therethrough. During commercial production runs it is necessary at times to have the mill operating with no heated composition passing therethrough. During these brief periods the cooling fluid circulating through the roll causes the temperature of the roll to drop rapidly until the roll surface is the same temperature as the temperature of the cooling fluid. When this condition exists and the material is subsequently fed to the calender the composition itself must heat the calender roll to the proper temperature before the desired surface characteristics can be produced on the finished product. This means that considerable composition must pass through the calender and a relatively large quantity of imperfect material is produced until satisfactory temperature conditions are obtained.

To overcome the disadvantages of the system set forth above, we have developed a system whereby either hot or cold fluid can be conducted through the roll, depending on the requirements. While the mill is in constant operation and a continuous sheet of material is being calendered, heating fluid can be conducted through the roll or cooling fluid can be conducted through the roll to maintain the roll at the proper temperature regardless of the temperature condition of the material passing through the calender. Any major temperature variation on the surface of the roll will cause the system to change from the transfer of heating fluid to the transfer of cooling fluid, or vice versa.

An object of this invention is to provide a calender roll comprizing a closed loop for the circulation of cooling fluid or heating fluid through the roll and automatic means for transferring from cooling fluid to heating fluid or vice versa, upon a corresponding decrease or increase in temperature on the surface of the roll caused by the material passing through the calender.

In order that our invention may be more readily understood, it will be described in connection with the attached drawings, in which:

Figure 1 shows a diagram of the system for transferring automatically from cooling fluid to heating fluid when the roll is not processing any material; and

Figure 2 is a diagram of a system for transferring from cooling fluid to heating fluid or vice versa while the roll is in continuous operation.

Referring to Figure 1, there is shown a calender roll 2 provided with a fluid inlet pipe 3 and a fluid outlet pipe 4. A pump 5 is provided to maintain circulation of the fluid through the circuit. The temperature of the surface of the roll 2 is measured by means of a thermocouple 6 in engagement with the surface of the roll. This thermocouple 6 is in engagement with the surface of the roll. This thermocouple 6 is connected to a standard electronic potentiometer recorder 7 equipped with a standard 100% proportional pneumatic throttling controller. The arrangement is such that the strength of the pneumatic signal put out by the controller can be measured by the potentiometer recording, which is in turn determined by the temperature of the roll surface. For example, the potentiometer may have a temperature range of from 0°F to 400°F, and the pneumatic controller may have a range from three to fifteen pounds air pressure. If it be desired to maintain the roll temperature at 100°F, the set point of the potentiometer is placed at the 100°F mark and the pneumatic controller is adjusted so that the center of its range, or nine pounds, is set to correspond with the 100°F setting of the potentiometer. With this arrangement, when the roll temperature is 100°F, the potentiometer will show a reading of 100°F and the pneumatic controller will put out a null signal. If the temperature of the roll increases, the potentiometer reading increases correspondingly and the signal from the pneumatic controller increases in pressure. If the temperature of the roll surface drops, the potenti-
eter recording drops and the pneumatic controller signal decreases in pressure. This increase and decrease in the pressure of the controller signal is proportional to the temperature fluctuation from the set point within the minimum and maximum of the controller range, namely three pounds to fifteen pounds. This electronic potentiometer with the 100% proportional pneumatic controller in combination therewith is a standard commercially available piece of equipment.

The pneumatic signal from the pneumatic proportional controller is supplied to a stack type pneumatic controller 8, which is additionally connected to an outside source of air supply at constant pressure. This air flow from the outside source is supplied to the pneumatic controller 8 through a reducing valve 9 to reduce the pressure from the outside source to equal the pressure of the signal put out by the pneumatic controller when the temperature on the surface of the calender roll corresponds to the predetermined set point on the potentiometer. The pneumatic controller 8 serves to control the amount of air supplied from the air line 10 through the pneumatic controller 8 to the valve 11 which controls the amount of cooling fluid permitted to enter the system. The valve 11 is a spring-actuated throttling valve and responds to the signals from the pneumatic controller 8. When the pneumatic controller 8 is in balance, the pressure supplied from the outside line and a nine pound pressure signal supplied from the proportional controller, the signal from the pneumatic controller 8 will be sufficient to hold the valve open a sufficient degree to permit enough cooling fluid into the system to maintain the desired temperature condition on the surface of the roll. If the load on the roll increases, causing a resulting increase in temperature of the roll surface, the potentiometer will move away from the set point and the proportional controller will increase the pressure of its signal supplied to the pneumatic controller 8, which will in turn increase the pressure on the line 12 to the valve 11. This increased signal opens the valve farther, permitting more cooling fluid to enter the system. If the roll surface temperature drops below that desired, the signals from the proportional controller and the pneumatic controller 8 are both decreased and the valve 11 is closed to the extent that a lesser amount of fluid is allowed to enter the system.

The output signal from the proportional pneumatic controller is also fed to the pneumatic relay 13, controlling the supply of air to a plurality of air-actuated valves 14, 15, 16, and 17 positioned on the lines supplying hot and cold temperature control fluid to the rolls. The relay 13 is so set that if air pressure supplied to the actuating chamber thereof from the pneumatic throttling controller is equal to or greater than a predetermined set amount the relay remains open and the air supply is conducted to the valves 14, 15, 16, and 17. As the air signal pressure supplied to the relay 13 from the pneumatic throttling controller falls below the predetermined set amount, the relay 13 closes, shutting off the air supply and venting the valves to atmosphere.

In the preferred embodiment here under consideration, when the pneumatic throttling controller is set at nine pounds and the stack controller 8 is set at nine pounds, the relay 13 is set at eight and one-half pounds. Therefore, if the signal supplied by the pneumatic throttling controller is eight and one-half pounds or greater, the air line to the valve is open and air under pressure is supplied to the valves 14, 15, 16, and 17. If the signal from the pneumatic controller is less than eight and one-half pounds, the relay 13 closes and no air is supplied to the valves.

The valves 14, 15, 16, and 17 are pressure-actuated valves but they are selected so that 14 and 15 are held open by pressure and valves 16 and 17 are held in closed position by pressure. Thus, when relay 13 is open by reason of the pneumatic controller putting out a signal of eight and one-half pounds or greater, the pressure in the air line 18 will hold valves 14 and 15 open. These two valves are on lines 19 and 20, respectively, which are in turn connected to cold brine lines 21 and 22. Valves 16 and 17 are held in closed position by the pressure in line 18. When relay 13 is closed by reason of the signal from the pneumatic controller being less than eight and one-half pounds, the air pressure in line 18 is shut off and valves 14, 15, 16, and 17 are vented to atmosphere. This lack of pressure in line 18 opens valves 16 and 17 positioned on lines 24 and 25, respectively, which are in turn connected to lines 26 and 27 carrying heating fluid. It will be noted that when relay 13 is open the air pressure in line 18 holds valves 14 and 15 on the cold brine line open so that additional cold brine can be added to the closed loop supplying temperature control fluid to the roll.

In the operation of the device, when the calender is being used to consolidate the plastolic mix heated to a temperature in excess of the temperature at which the roll surface is maintained to obtain the desired surface grain characteristics, cold brine is continuously circulated through the roll 2 by means of the pump 5. The temperature of the surface of the roll 2 is measured by the thermocouple which acts on potentiometer 7. The potentiometer 7 is set for the temperature desired on the surface of the roll. Coupled with the potentiometer 7 is a pneumatic throttling controller adjusted so that the center of its range corresponds to the set point of the potentiometer. The output from the pneumatic throttling controller is fed to a stack type pneumatic controller 8 and a pneumatic relay 13. The pneumatic controller 8 is connected to a valve 11 in line 12 which is the cold brine return line. Pneumatic relay 13 controls the supply of air under pressure to pressure-sensitive valves 14, 15, 16, and 17, controlling the supply of hot and cold temperature control fluid to the closed loop in the roll.

Under normal conditions, when a heating load is being applied to the roll the temperature of the surface of the roll will be maintained at the desired point by cooling fluid circulating through the roll. Circulation of the cooling fluid by the pump 5 is possible due to the fact that under normal operating conditions when the roll surface is at the desired temperature pneumatic relay 13 is open, which in turn holds valves 14 and 15 open and closes valves 16 and 17. The pneumatic controller 8 is in balance, which holds valve 11 on the cold brine line in a position to permit sufficient cooling fluid to bleed into the system to maintain the temperature desired on the roll surface. This means that the cold brine is free to circulate through the entire system so long as the temperature on the surface of the roll is maintained at or close to the set point of the potentiometer. When the temperature of the roll surface decreases rapidly because of the removal of the heating load, the indicator on the electronic recorder of the potentiometer will move rapidly away from the set point. This will cause the pneumatic throttling controller to put out a diminishing signal proportional to the temperature drop. This means that as soon as the signal from the throttling controller drops below nine pounds, the pneumatic controller 8 will be thrown off balance and will adjust valve 11 to decrease the amount of cooling fluid entering the system. If the temperature drop is of sufficient magnitude valve 11 will be closed completely. When valve 11 closes the cold brine circulation system, the cold brine is held in the roll. If this condition persists for a length of time that the throttling controller signal pressure drops to eight and one-half pounds, pneumatic relay 13 will close, shutting off the supply of air under pressure to valves 14, 15, 16, and 17. This closes the cold brine line and opens the hot line, permitting heating fluid to circulate through the roll by means of the pump 5. The supply of hot brine replaces the cold brine in a roll and prevents the tem-
perature of the roll surface from dropping more than eight or ten degrees. The temperature of the hot brine should preferably be more than the normal operating temperature at the roll surface so that during this idle period when hot brine is being circulated through the roll, the roll temperature cannot attain the normal operating temperature; however, it should be only a few degrees less than normal operating temperature. As the hot brine circulates through the roll, the temperature increase on the surface of the roll will bring the potentiometer up toward the desired recording and along with this temperature increase the signal from the throttling controller will increase in pressure. When the signal increases to eight and one-half pounds, relay 13 will open, permitting air under pressure to the control valve 11, 14, 15, 16, and 17, closing the hot brine line and opening the valves on the cold brine line. However, cold brine cannot circulate through the system under these conditions because the temperature of the surface of the roll has not come up to the desired working temperature and, therefore, the signal from the throttling controller has not attained nine pounds pressure. This means that pneumatic controller 8 is still off balance and valve 11 is held in closed position. As soon as a work load is supplied to the roll, the temperature of the roll surface will be increased to the desired working temperature, at which time the throttling controller will put out its nine pound signal, balancing pneumatic controller 8 and opening valve 11.

In the operation of calender rolls in which it is necessary to change from hot to cold brine while the calender is under load conditions, the embodiment of this invention shown in Figure 2 is used. This system has the same type potentiometer 7, having in conjunction there with the proportional throttling controller. The signal from the proportional throttling controller is supplied to a pneumatic controller 8 and a pneumatic relay 13, the same as earlier described. However, the signal from the pneumatic controller 8 is supplied directly to a diverting relay 28 and also through an inverting relay 29, to the diverting relay 28. The inverting relay 29 reverses the signal from the pneumatic controller 8, and feeds the reverse signal to the diverting relay 28. The output from the pneumatic relay 13 is fed to the actuating chamber of the diverting relay 28. The output of relay 13 is also supplied to the pressure valves 14, 15, 16, and 17. When the signal from the pneumatic relay 13 reaches its preset amount the pneumatic relay will transmit air pressure through the diverting relay 28 and the pneumatic valves 14, 15, 16, and 17. This signal will actuate the diverting relay 28 in such manner that the signal from the temperature controller 8 will be fed directly through the diverting relay 28, and at the same time, the four valves 14, 15, 16, and 17 are actuated by the same air signal so that the circulating loop is connected to the cold brine supply. Under these conditions, the control valve 11 will proportion the amount of cold brine required to maintain the temperature of the roll surface at the proper degree for the heating load applied thereto.

If the load on the roll surface should change so that a cool load is applied and hot brine is required, the pressure of the signal from the throttling controller will decrease; and if it drops to a predetermined point, pneumatic relay 13 will close and will not supply air to the diverting relay 28 and the valves 14, 15, 16, and 17. When this occurs, the diverting relay 28 will connect control valve 11 to the temperature controller 8 through the inverting relay 29. Inasmuch as relay 13 is closed, valves 14 and 15 on the cold brine lines are closed due to lack of air and 16 and 17 on the hot brine lines are open due to lack of pressure. This means that the hot brine is connected with the circulating loop and the amount of hot brine is controlled through the same control valve 11, but the action of the valve is reversed so it is now controlling the amount of hot brine supplied to the roll. This condition will be maintained as long as the cooling load is applied to the roll.

The systems outlined above are particularly desirable for use in operating calenders in which the same calender is used at different times for processing different materials, each material requiring a different processing temperature. With the system outlined it is only necessary to set the throttling controller so that the center of its range corresponds to the potentiometer recording, which is the desired temperature on the surface of the roll. This is the only adjustment to make and the balance of the system functions in exactly the same manner regardless of the temperature setting on the potentiometer.

We claim:

1. In a device for controlling the temperature of the working surface of a calender roll, the elements comprising a system for circulating fluid through the interior of said roll, said circulating system being connected to a closed circulating loop carrying cooling fluid and a closed circulating loop carrying heating fluid; a thermocouple in engagement with the working surface of the calender roll; a potentiometer connected to said thermocouple; a pneumatic controller in combination with said potentiometer, the arrangement of the pneumatic controller and the potentiometer being such that the set point of the potentiometer corresponds to the center of the range of the pneumatic controller so that a variance of the temperature on the surface of the roll recorded on the potentiometer changes the strength of the pneumatic signal put out by the pneumatic controller; a pneumatic throttling controller, said pneumatic throttling controller controlling the flow of air through a pressure line; a valve on the cold fluid circulating system to control the amount of cooling fluid supplied to the circulating loop in the calender roll, the adjustment of said valve being controlled by the throttling controller which is in turn controlled by the signal from the pneumatic controller; and a pair of valves on the hot fluid loop and a pair of valves on the hot fluid loop, said valves being controlled by the pneumatic controller to close the one loop and open the other loop upon a temperature drop on the surface of the roll within a predetermined limit.

2. In a device for controlling the temperature of the working surface on a calender roll, the elements comprising a system for circulating fluid through the interior of said roll, said circulating system being connected to a closed circulating loop carrying cooling fluid and a closed circulating loop carrying heating fluid; a thermocouple in engagement with the working surface of the calender roll; a potentiometer connected to said thermocouple; a pneumatic controller in combination with said potentiometer, the arrangement of the pneumatic controller and the potentiometer being such that the set point of the potentiometer corresponds to the center of the range of the pneumatic controller so that a variance of the temperature on the surface of the roll recorded on the potentiometer changes the strength of the pneumatic signal put out by the pneumatic controller; a pneumatic throttling controller, said pneumatic throttling controller controlling the flow of air through a pressure line; a valve on the cold fluid circulating system to control the amount of cooling fluid supplied to the circulating loop in the calender roll, the adjustment of said valve being controlled by the throttling controller which is in turn controlled by the signal from the pneumatic controller; and a pair of valves on the cold fluid loop and a pair of valves on the hot fluid loop; an air line for supplying air to actuate said valves; and a valve on said air line, said valve on said air line being operated by the signal from the pneumatic controller to close one loop and open the other loop upon a temperature drop on the surface of the roll within a predetermined limit.

3. In a device for controlling the temperature of the working surface of a calender roll, the elements compris-
ing a system for circulating fluid through the interior of said roll, said circulating system being connected to a closed circulating loop carrying cooling fluid and a closed circulating loop carrying heating fluid; a thermocouple in engagement with the working surface of the calender roll; a potentiometer connected to said thermocouple; a pneumatic controller in combination with said potentiometer, the arrangement of the pneumatic controller and the potentiometer being such that the set point of the potentiometer corresponds to the center of the range of the pneumatic controller so that a variance of the temperature on the roll surface recorded on the potentiometer changes the strength of the pneumatic signal put out by the pneumatic controller; a pair of valves on the cold loop and a pair of valves on the hot loop; an air line for supplying air to actuate said valves; a valve on said air line operated by the signal from the pneumatic controller to close the valves on the cold loop upon a pre-determined drop in temperature on the surface of the roll and to open the valves in the hot loop; a valve located between the group of cold and hot loops and the circulating system in the calender roll; a pneumatic throttling controller actuated by the signal from the pneumatic controller for controlling the amount of air supplied to said valve so that the opening of the valve will be increased upon an increase in temperature on the roll surface while the cold brine line is open and the opening of the valve will be decreased if there is a corresponding drop in temperature on the surface of the roll when the cold brine line is open; and an inverting relay located between the throttling controller and the pneumatic valve to supply a reverse signal to the pneumatic valve in the event the hot fluid loop is open and the cold fluid loop is closed so that a continuing drop in temperature on the surface of the roll will increase the quantity of hot fluid supplied to the system.

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