Sept. 5, 1944. P. H. WILLIAMS 2,357,440

SWITCH

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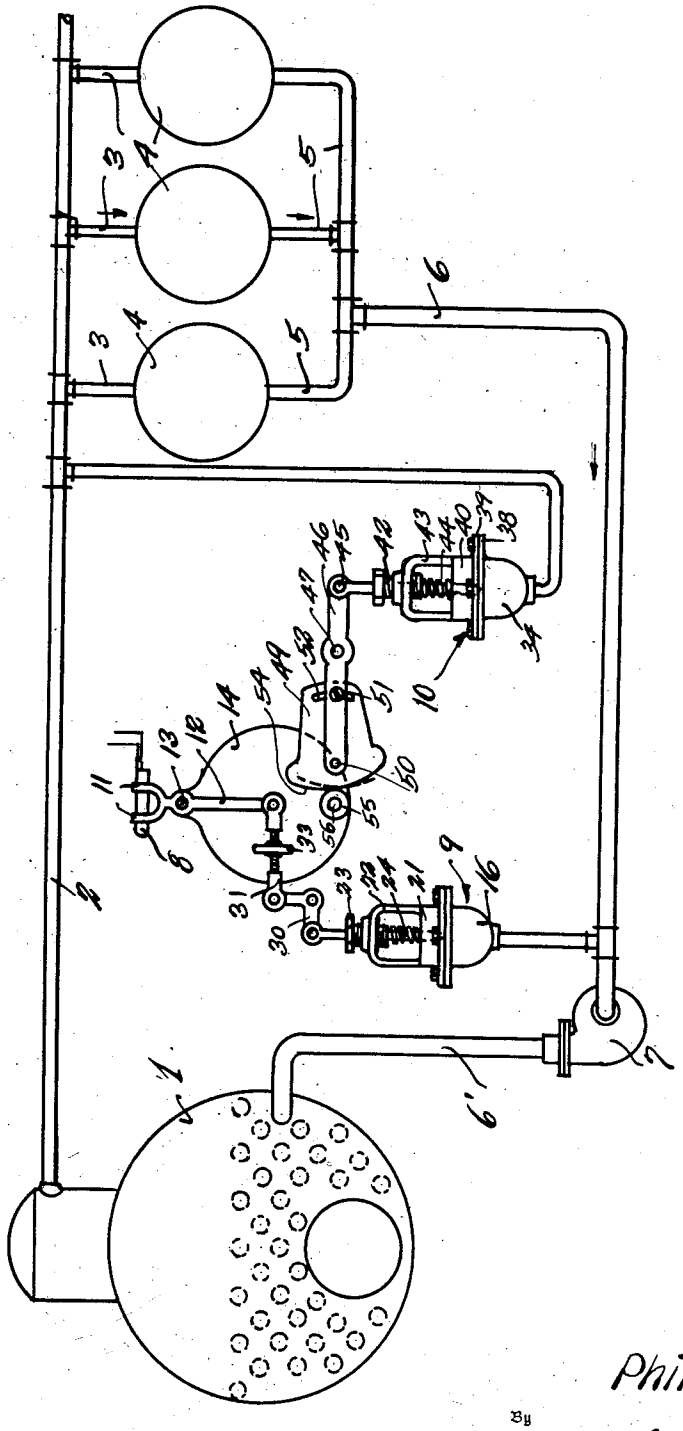


Fig. 1

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Fig. 2

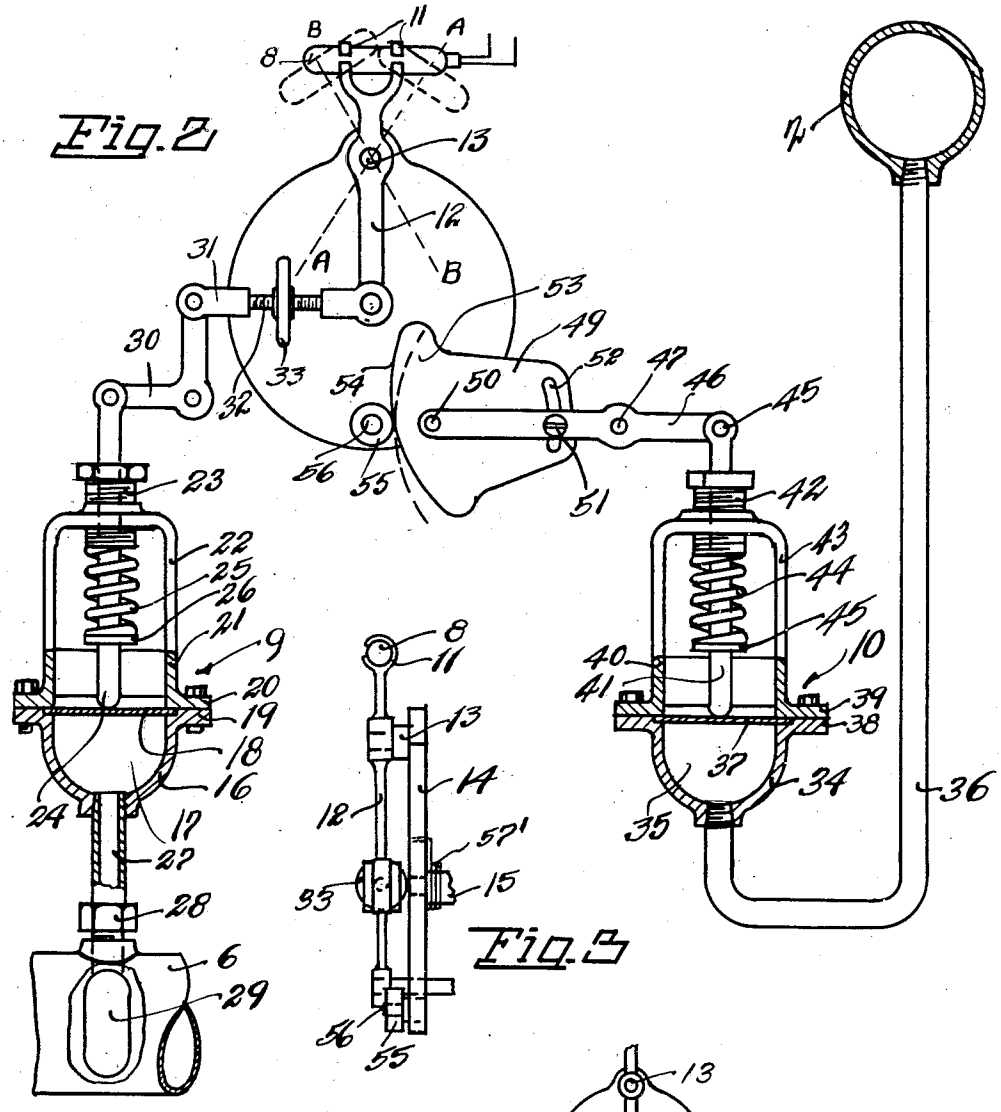


Fig. 3

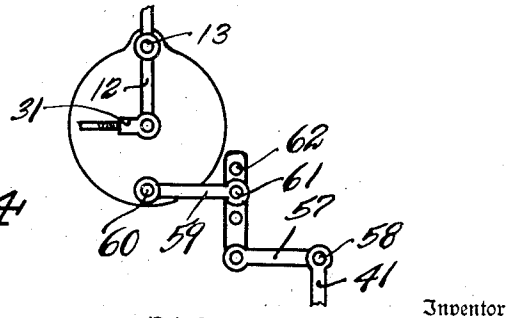


Fig. 4

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SWITCH

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8 Claims. (Cl. 200—81.5)

This invention relates to a system or apparatus wherein steam is employed for driving or otherwise operating elements of the apparatus, said apparatus being provided with means for returning condensate to a boiler instead of discharging steam to atmosphere and filling the boiler with water when necessary.

In steam processing plants where steam is used to heat the machines, it is desirable, in the interest of economy, to return the condensate to the boiler at the highest possible temperature. This prevents excessive heat losses and effects a marked saving in fuel consumption. In many cases, a saving of 15% to 20% in fuel costs has been accomplished by returning the condensate to the boiler at an increased temperature.

To accomplish this it is necessary to pump condensate at temperatures greatly in excess of the atmospheric boiling point. This can be done only with the so-called closed systems as to expose the high temperature condensate to the atmosphere would result in its flashing into steam and being lost with the heat it contained. This would necessitate its replacement with cold water at a marked increase in fuel consumption. Such conditions would also greatly reduce the net power output of the boiler as a larger percentage of the fuel heat would be used to bring the cold raw water up to the temperature of the returning condensate.

The pumping of condensate, or fluid, at high temperatures, introduces peculiar difficulties not met with in the pumping of low temperature fluids. Under saturation conditions of steam and water the flash point or steam forming point, that is, the temperature point at which the water, or a portion thereof, will flash into steam, is a function of both the temperature and the pressure. To illustrate: at atmospheric pressure, water boils and steam forms at 212° F., while at 100 pounds gauge pressure, steam forms at 338° F., (approximately). Now, if with water at 338° F., a pressure of 110 pounds is maintained, steam will not be formed. However, if the pressure drops to 100 pounds or less, steam forms and greatly alters the pumping conditions.

Now in the case of a condensate pumping system, any given temperature will have a corresponding safe pumping pressure. As an illustration: we may pump water at 300° F. without trouble so long as we maintain at the pump intake a pressure of approximately 63 pounds gauge or more. If, however, we permit the pressure to fall to say 52 pounds gauge, we are at the steam forming or flash point and will have steam instead of condensate. Again, if we carry 110 pounds gauge pressure on the boiler, we may return the condensate to the boiler at 326° F., if and provided we maintain at the pump intake a pressure of 93 pounds gauge or more. If we permit the pressure at pump intake to drop a few pounds below 93 pounds gauge, we will have steam instead of condensate.

A displacement pump will not pump steam because steam is an elastic fluid and will not permit additional fluid to enter the pump chamber. Also, a centrifugal pump will not pump steam because steam is much lighter than water and does not set up the centrifugal action which is the principle involved in the centrifugal pump. In either case, if steam is permitted to enter or form within the pump, a steam or vapor lock is formed and the system becomes cold and waterlogged and rendered inoperative until the temperature falls below, or the pressure rises above, the flash point of the fluid in question.

To remedy this condition and to prevent steam forming in the pump and system, due to the pressure falling below the flash point for the temperature of the condensate, it has previously been the practice to control the starting relay of the condensate pump by means of a thermally responsive control set somewhat below the flash point corresponding to the lowest pressure at which the pump was desired to operate. Under this arrangement, the control will stop the pump before the pressure in the lines drops to the flash point for the temperature set as a maximum and will again start the pump after a fall of temperature determined by the setting of the control device. This system of controls is faulty and has been found unsatisfactory when used.

One object of the invention is to provide a highly efficient and thoroughly satisfactory and dependable system of controls for the pumping of high temperature condensate by using a temperature responsive control actuated by the temperature of the condensate as discharged from the pump, such temperature responsive control being mechanically, not electrically, controlled by the pressure in the boiler or main steam line. The system controls the pump motor relay by a temperature responsive control but uses the pressure of the boiler or main steam line to automatically adjust the cut-out point of the temperature responsive control through mechanical means.

Another object of the invention is to provide an apparatus wherein condensate can be returned to the boiler at a temperature within 15° F. to

18° F. of the temperature corresponding to the initial steam pressure. This is done by means of a temperature responsive control set to open its circuit and stop the motor at a point 15° F. to 18° F. below the initial boiler steam pressure, the boiler or steam line pressure then being used to shift the contact points on the temperature responsive control forward or backward, according to whether the steam pressure rises or falls. Thus, using the smooth action of the temperature responsive control and the constant or slowly changing pressure of the boiler, and the additional non-shock range of the temperature actuated control, I eliminate all shocks to pump or system, provide a means which will control the pump perfectly over a wide range of pressure and temperature, and still insure safe pumping conditions at the pump intake at all times.

In addition, I find I can handle much higher temperatures and provide closer regulation than is possible by any other arrangement. With this arrangement, the drop from boiler to machines may be as little as 3° F. to 4° F., and from machines to return pump discharge 12° F. to 14° F. Even closer regulation is possible while maintaining high differential pressures and rapid drainage of condensate from all lines and machines.

Another object of the invention is to provide means for the control of condensate pumps and the like which will permit the pumping of liquids at high temperatures without steam binding or vapor lock occurring at the pump.

Another object of the invention is to provide an apparatus which is efficient and effective over a very wide range of pressures and temperatures.

Another object of the invention is to provide an apparatus of this character which is automatic in action.

Another object of the invention is to provide apparatus which makes possible the coordination of a temperature responsive means and a pressure responsive means for the purposes described.

Another object of the invention is to provide an apparatus adapted to coordinate the pressure of water under saturated steam conditions and the expansion pressure of a heat responsive fluid confined in an expansion chamber.

Another object of the invention is to provide means for such purpose as will coordinate a pressure responsive means the action curve of which is a straight line with a thermally responsive means the action curve of which is not a straight line.

Another object of the invention is to provide an apparatus which is simple in construction, low in cost, and which may be easily installed in steam plants by workmen of ordinary skill.

A preferred embodiment of the invention is illustrated in the accompanying drawings, wherein:

Figure 1 is a diagrammatic view showing the apparatus installed.

Figure 2 is a view showing a portion of the apparatus partially in elevation and partially in section.

Figure 3 is a view in elevation, looking at one edge of the disc and elements carried thereby.

Fig. 4 is a fragmentary view showing a modified construction in elevation.

This improved apparatus is shown diagrammatically in Fig. 1, and referring to this figure, it will be seen that steam which is generated in the boiler 1, flows through the steam line 2 and its branches 3 to machines 4 which may be of any steam-driven type. The steam, after operating machines 4, flows through pipes 5 and, instead of being discharged to atmosphere as a steam cloud, passes into a pipe line 6 as a condensate which is delivered to the inlet of a pump 7. From this pump, the condensate is forced through pipe 6' back to the boiler. It will thus be seen that the hot condensate is delivered into the boiler where it is again converted into steam without the temperature of water in the boiler being materially reduced, as would be the case if it were necessary to replenish water in the boiler by periodically admitting water which would have to be heated before being converted into steam. Operation of the pump 7 is controlled by an electric switch 8 and opening and closing of the switch is controlled by combined action of a temperature responsive control 9 connected with the return pipe 6 and a pressure responsive control 10 connected with the steam line 2.

The switch 8 has been illustrated in the form of a mercury switch mounted horizontally in the forks 11 of an arm 12 which is disposed vertically and pivoted on a fulcrum pin 13 projecting laterally from the upper portion of a disc 14, and, from an inspection of Figure 2, it will be seen that when the arm 12 is tilted about pin 13 to shift the switch toward the position indicated by line A—A, the circuit for the motor of pump 7 will be closed and that when the switch is shifted toward the position indicated by line B—B, the circuit will be opened and operation of the pump stopped. The disc 14 is mounted on a fulcrum 15 shown in Fig. 3, for turning movement about the fulcrum to adjusted positions, adjustment of the disc being accomplished through the medium of the pressure responsive control 10 and tilting of the switch arm 12 being accomplished by action of the temperature responsive control 9. The mercury switch 8 merely represents one specific form of switch which may be used, it being understood that other forms of switches may be substituted and either carried by and moved with the switch arm or mounted stationary over the disc and opened or closed by movement of the switch arm.

The temperature responsive control 9 is of the construction shown in Fig. 2, and, referring to this figure, it will be seen that the casing 16 defines a chamber 17 closed at its top by a diaphragm 18. The diaphragm is clamped about its margins between the flange 19 of casing 16 and the flange 20 of a hood 21 carrying an upstanding yoke 22. At the top of the yoke is a sleeve nut 23 through which slidably passes a rod 24 having its lower end yieldably held against the diaphragm by a spring 25 which bears against the lower end of the sleeve nut and rests upon a collar 26 carried by the rod. A pipe or tube 27 extends downwardly from casing 16 with its lower end portion passing into the condensation pipe 6 where it is secured by a packing nut 28. At its lower end, the tube 27 carries a bulb 29 disposed within pipe 6 and variations of temperature within pipe 6 will cause gas or liquid with which the bulb and the tube and chamber 17 are filled to expand and contract. As the liquid expands, the diaphragm will be forced upwardly and rod 24 shifted upwardly through the sleeve nut. The upper end

of rod 24 is pivoted to one arm of a bell crank 30 having its other arm pivoted to a shackle or link 31 which extends horizontally and has its inner end pivoted to the lower end of arm 12 and it will be readily seen that when the rod 24 is shifted upwardly and the link 31 shifted toward the right of Fig. 2, arm 12 will be tilted about the pin or fulcrum 13 and its upper portion tilted toward the left in the direction of line B—B to open switch 8 and stop operation of the motor or pump 7. The link or shackle mid-section 32, in the form of a rod threaded in opposite directions from its ends so that when this section is turned through the medium of wheel 33, longitudinal adjustment of the link will be accomplished. When the temperature of condensate in pipe 6 is lowered, the rod 24 is shifted downwardly by spring 25 and arm 12 will be tilted to shift the switch toward the position indicated by dotted line A—A and closed to start the pump and force accumulated condensate through pipe 6' to the boiler. It will thus be seen that the switch will be automatically opened and closed in response to variations in the temperature of condensate flowing through pipe line 6.

The pressure responsive control 10 for regulating the action of the switch is similar in construction to the temperature responsive control and has a casing 34 defining a chamber 35 which is connected with the steam pipe 2 by a pipe 36. The top of the chamber is closed by a diaphragm 37 clamped between the flange 38 of the casing and the clamp 39 of a hood 40 and upon the diaphragm rests the lower end of a rod 41 which is slidable vertically through a sleeve nut 42. This sleeve nut is threaded through the top of a yoke 43 and about the rod is a spring 44 having its upper end bearing against the sleeve nut and its lower end abutting a collar 45 carried by the rod. The spring urges the rod downwardly and, by turning the sleeve nut, tension of the spring may be adjusted. When pressure rises in the steam line 2 and in pipe 36, the diaphragm will be flexed upwardly and the rod shifted upwardly with it and when the pressure is reduced, the spring 44 forces the rod and the diaphragm downwardly. Therefore, the rod is shifted vertically in response to variations in pressure.

The disc 14 is to be turned about its fulcrum pin in response to variations in pressure in the steam line and, in order to do so, there has been provided an arm 46 pivoted on a fulcrum pin 47 and having its outer end pivotally connected with the upper end of rod 41 by a pin 48. This arm 46 carries a cam 49 which is pivotally connected with the inner end of the arm by a pin 50 and extends longitudinally of the arm with its inner end secured by a screw or bolt 51 carried by the arm and passing through an arcuate slot 52 formed in the cam. The outer end or front end of the cam is widened to provide a head 53 formed with a curved edge 54 constituting a cam surface and bearing against a roller 55 which is rotatably carried by a pin 56 projecting laterally from the lower portion of the disc 14. When the arm 46 is tilted about its fulcrum pin 47, the cam 49 is swung vertically and its cam surface 54 acts on the roller to turn the disc 14 about the fulcrum pin 15 and angularly adjust the position of arm 12. The extent of movement required of arm 12 to open or close the switch may thus be controlled. A spring 57' yieldably resists turning of the disc in one direction and thus causes the roller 55 to be held in engagement with the cam surface 54 of the cam 49. The roller is thus caused to move with the cam and the disc and the arm 12 carried thereby will be automatically adjusted in response to variations in pressure. It will thus be seen that opening and closing of the switch is effected in timed relation to variations in pressure of steam passing through the pipe line 2 as well as in timed relation to variations in the temperature of condensate flowing through pipe 6 to the pump.

In Figure 4, there has been disclosed a modified construction wherein turning adjustment is directly imparted to the disc instead of by means of a cam. In this embodiment of the invention, a bell crank 57 is provided and has its horizontally extending arm pivoted to the upper end of rod 41 by a pin 58 and the disc is connected with the vertical arm of the bell crank by a link 59 which has one end connected to the disc by a pin 60 and its other end connected with the bell crank by a pin 61 passing through a selected one of the openings 62 formed in the bell crank arm. Since the bell crank is formed with a plurality of openings 62, movement imparted to the disc by movement of the rod 41 may be regulated. This is similar to the manner in which movement of the disc is controlled by loosening the fastener 51 and tilting the cam 49 about pin 50 to an adjusted position.

Having thus described my invention, what I claim is:

1. In an electric circuit control device, the combination with a temperature responsive control means, a pressure responsive control means, and an electric contact switch; of a disc rotatably mounted, a pin positioned intermediate the center and periphery of said disc, a switch control arm mounted pivotally upon said pin, means for moving one end of said arm in response to the action of the temperature responsive control means, means for operating an electric circuit opening and closing device with the other end of said arm, another pin positioned intermediate the center and periphery of said disc, a roller mounted upon the second mentioned pin, a cam bearing against said roller, means for varying and adjusting the throw of said cam, means for causing said cam to vary the position of the roller and pin and said disc in response to the action of the pressure responsive control means, and means for adjusting the various parts to temperature and pressure ranges.

2. In an electric circuit control device, the combination with a temperature responsive control means, a pressure responsive control means, and an electric contact switch; of a rotatably mounted member, a fulcrum carried by said member, a vertically disposed switch arm pivotally mounted on said fulcrum and carrying said switch at its upper end, means for causing said switch arm to tilt upon said fulcrum in response to the action of the temperature responsive control element and tilt the switch for opening and closing the switch, means actuated by the pressure responsive element for causing said rotatably mounted member to turn about its mounting in response to the action of the pressure responsive control element and affect adjustment of the switch, and means for adjusting the various parts to different ranges of temperature and pressure.

3. In an electric circuit control device, the combination with a temperature responsive control

means, a pressure responsive control means, and an electric contact switch; of a movable member rotatably mounted, a fulcrum intermediate the end and center of said member, an arm for controlling the electric switch pivotally mounted on said fulcrum and connected with the temperature responsive control means for movement in response to the action of the temperature responsive control means, and means to cause the first member to rotate in response to the action of the pressure responsive control means independent of said temperature responsive control means, including a movable member and a cam carried thereby for engaging the rotatable member, said cam being movable to adjusted positions for adjusting the position of the rotatable member and the arm carried thereby.

4. In an electric control device, the combination with a pressure responsive control element, a temperature responsive control element and an electric contact switch; of a rotatably mounted member, a fulcrum carried by said member, an arm for operating an electric switch mounted upon said fulcrum and connected with the temperature responsive control element for movement in response to action of the temperature responsive control element, a roller mounted on the rotatable member, a cam having an arcuate edge at one end bearing against said roller, an arm pivotally mounted and carrying said cam, said cam being movable to adjusted positions, and means for tilting said arm and thereby causing said cam to transmit motion to the rotatable member in response to the action of the pressure responsive control means.

5. In an apparatus of the character described, a rotatable disk, a switch holder pivotally carried by said disk, an arm pivotally mounted intermediate its length, a cam, a pin carried by said arm and mounting the cam for tilting adjustment at a point near its effective edge, an abutment carried by said disk and engaged by the effective edge of said cam, an extension for said cam extending longitudinally of the arm and formed with a slot extending transversely of the arm, a binding screw carried by said arm and passing through the slot of the cam extension, means for imparting tilting motion to said arm whereby the cam acts upon said abutment to rotate the disk to an adjusted position, and means for tilting said switch holder to open and close the switch.

6. In an electric circuit control switch, the combination with a temperature responsive control means including a longitudinally shiftable rod and a pressure responsive control means including a longitudinally shiftable rod; of a disc mounted for rotary adjustment between the rods, a switch-actuating arm pivoted to said disc for tilting movement in opposite directions to accomplish opening and closing of a switch, a bell crank having an arm pivoted to the rod of the temperature responsive control means and its other arm connected with said switch-actuating arm, and means actuated by movement of the rod of said pressure responsive control means for effecting turning movement of said disc to adjusted positions.

7. In an electric circuit control device, the combination with a temperature responsive control means including a longitudinally shiftable rod and a pressure responsive control means including a longitudinally shiftable rod; of a disc mounted for rotary adjustment between the rods, a switch-actuating arm pivoted to said disc for tilting movement in opposite directions to accomplish opening and closing of a switch, a bell crank having an arm pivoted to the rod of the temperature responsive control means and its other arm connected with said switch-actuating arm, a lever pivotally mounted and extending transversely of the switch arm and having one end pivoted to the upper end of the rod of the pressure responsive control means, a cam carried by the other end portion of said lever, and an abutment carried by said disc and bearing against the cam for effecting turning adjustment of the disc when the lever is moved.

8. In an electric circuit control device, the combination with a temperature responsive control means including a longitudinally shiftable rod and a pressure responsive control means including a longitudinally shiftable rod; of a disc mounted for rotary adjustment between the rods, a switch-actuating arm pivoted to said disc for tilting movement in opposite directions to accomplish opening and closing of a switch, a bell crank having an arm pivoted to the rod of the temperature responsive control means and its other arm connected with said switch-actuating arm, a lever pivotally mounted and extending transversely of the switch arm and having one end pivoted to the upper end of the rod of the pressure responsive control means, a cam pivoted to the other end of said lever and extending along the lever, a fastener carried by said lever and engaging the cam to hold the cam in set position, and an abutment carried by said disc and bearing against the cam for effecting turning adjustment of the disc when the lever is moved.

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