

Dec. 26, 1950

G. W. KUNTNY
CONTROL INSTRUMENT

2,535,429

Filed Oct. 31, 1945

4 Sheets-Sheet 1

FIG. 2

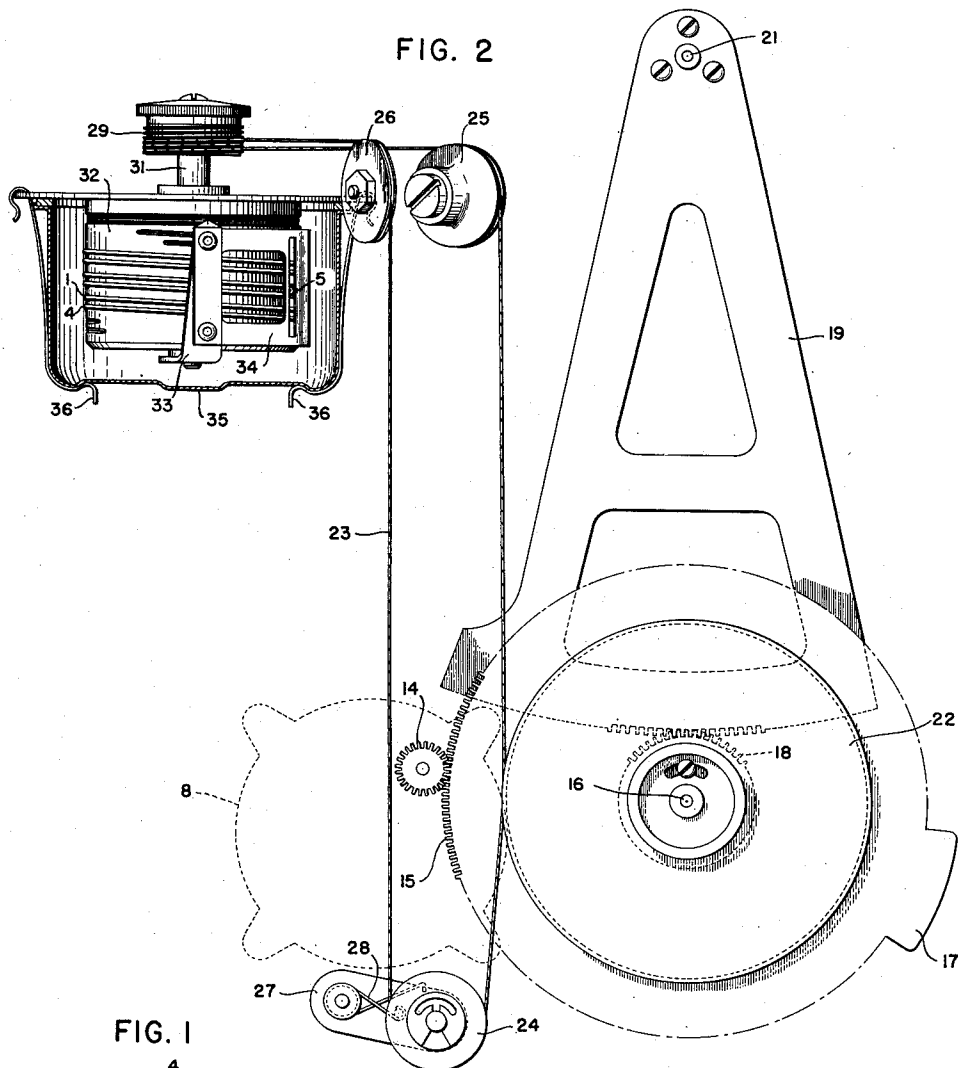
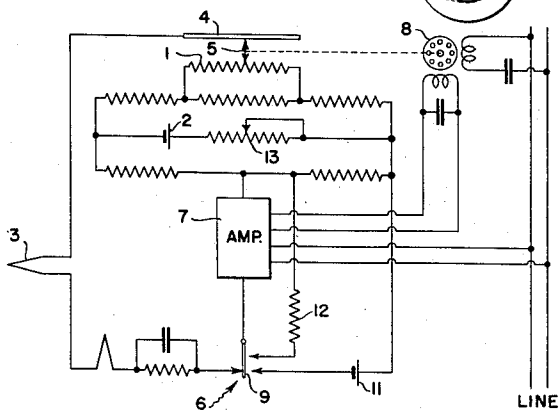


FIG. 1



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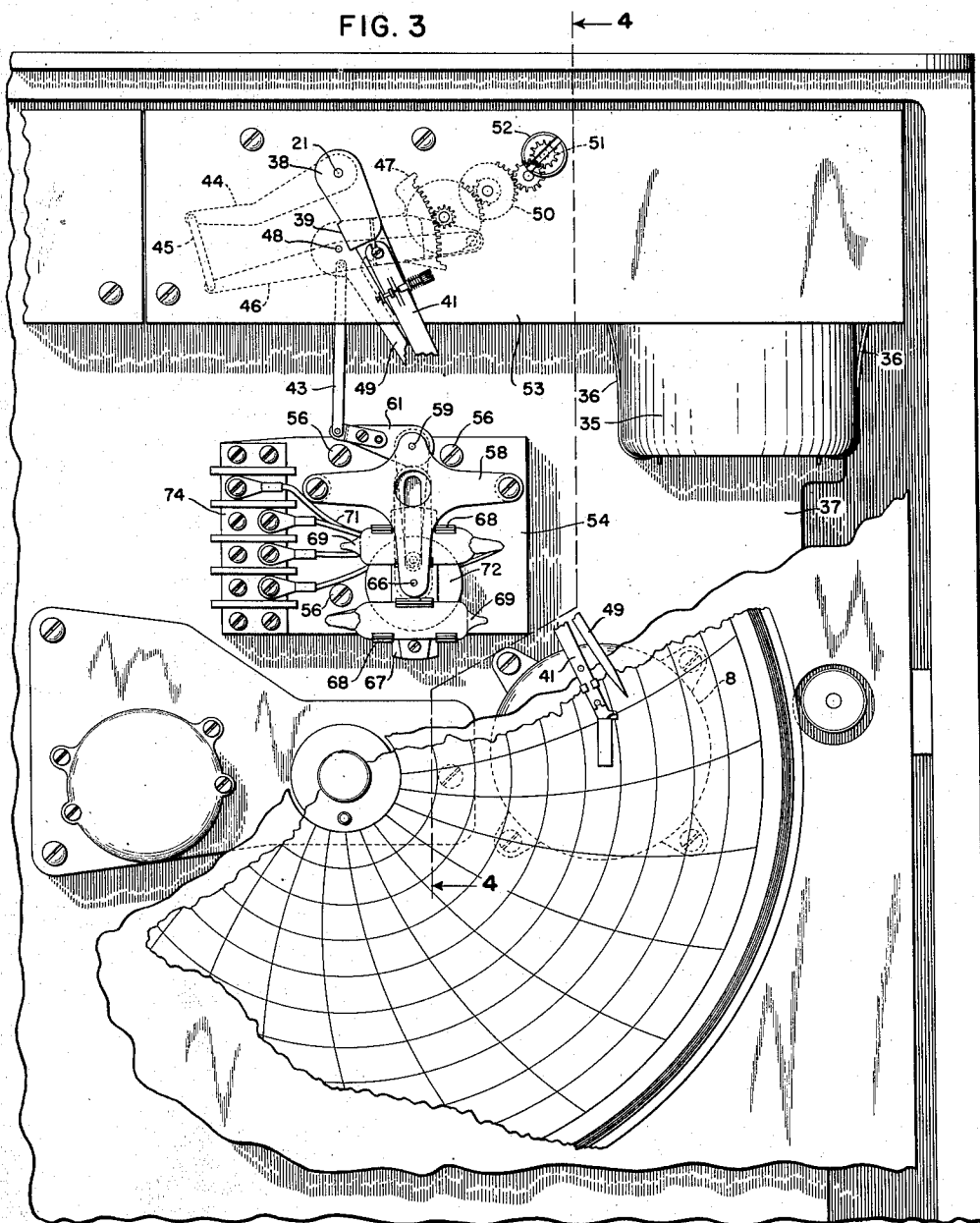
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2,535,429

Filed Oct. 31, 1945

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FIG. 3



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Filed Oct. 31, 1945

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FIG. 4

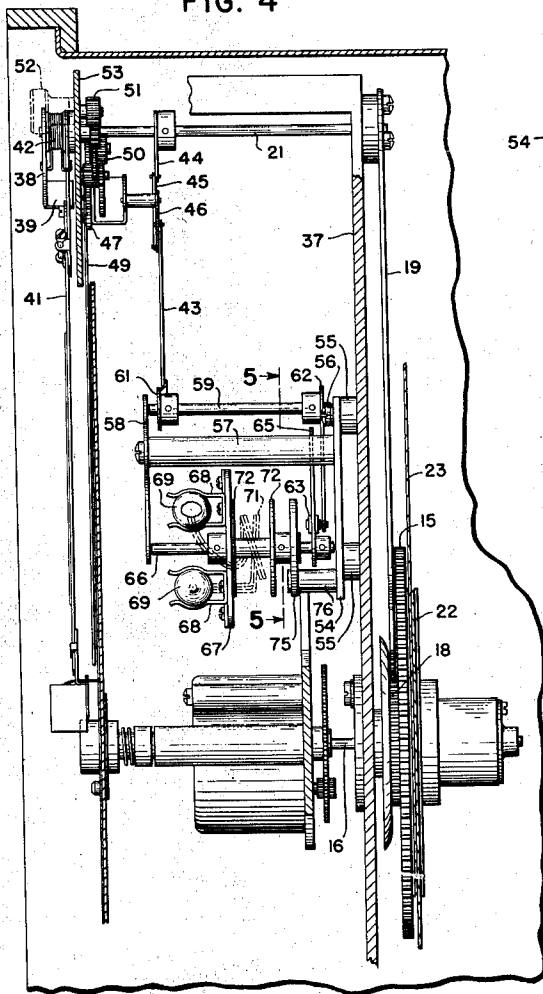


FIG. 5

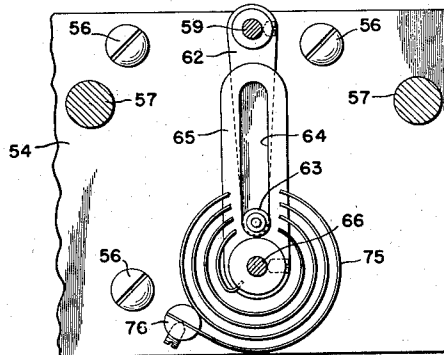


FIG. 6

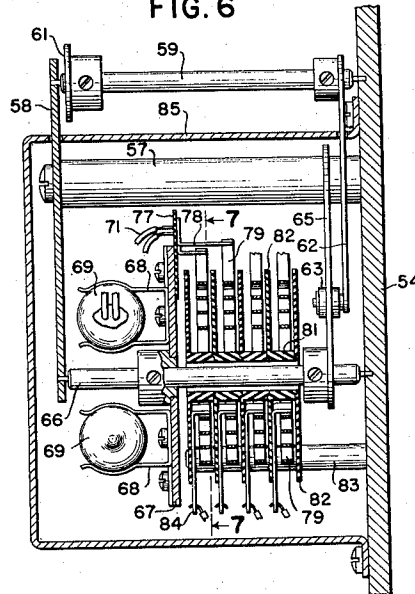
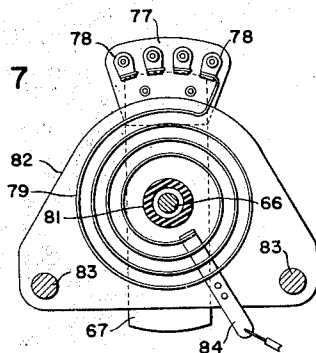


FIG. 7



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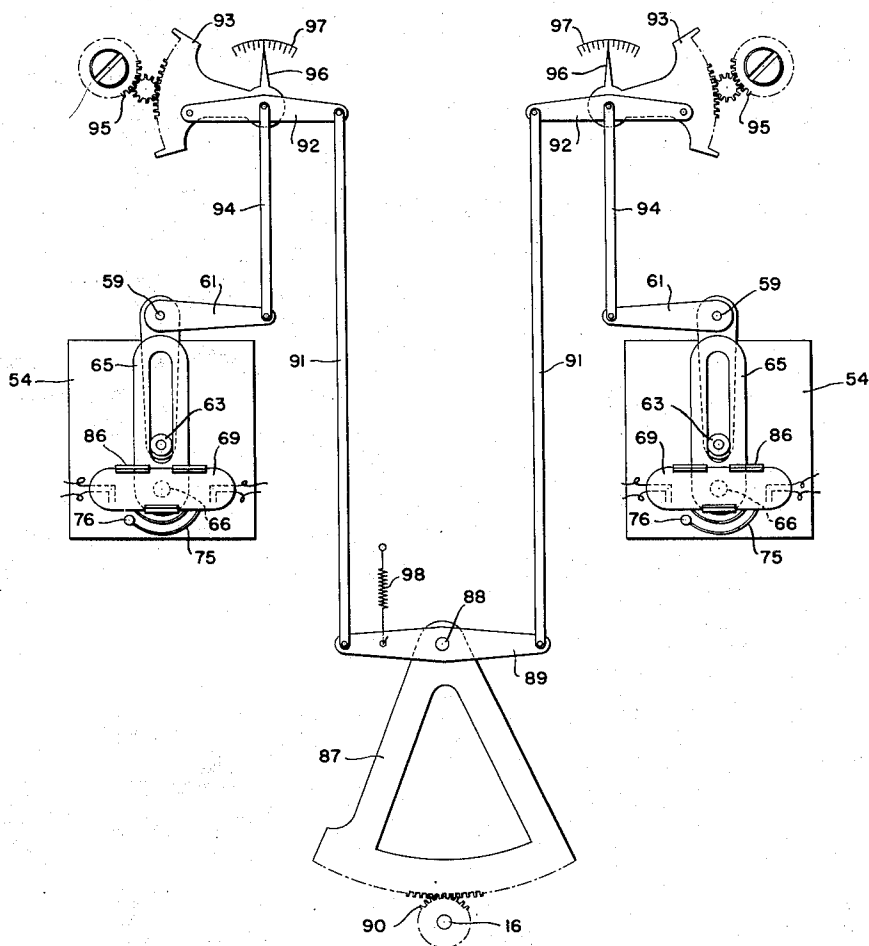
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FIG. 8



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UNITED STATES PATENT OFFICE

2,535,429

CONTROL INSTRUMENT

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Application October 31, 1945, Serial No. 625,853

6 Claims. (Cl. 200—56)

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The present invention relates to control instruments and more particularly to a mechanism for operating mercury switches that are used to control either directly or through a relay some condition changing medium.

In general, the two types of control switches used in electrical control instruments are the open contact type, and the closed contact or mercury switch type. Both have their advantages, but in general mercury switches are more frequently used in control instruments, since their use reduces the danger of sparks and obviates the necessity of periodically cleaning the contacts. Another advantage of mercury switches is that for a given size they have greater current carrying capacity than open contact switches. At the present time mercury switches are accurately manufactured so that each switch will always close its contacts at the same angular position. Similar switches will close their contacts at almost exactly the same angular position so that only a negligible adjustment of an apparatus using them is necessary when one switch is substituted for another.

It is an object of this invention to provide a mechanism that may be operated by a control instrument to adjust mercury switches between contact open and contact closed positions. This mechanism is so constructed that the switch will be moved rapidly through the angle required to open or close its contacts, and will be moved slowly a small amount on either side of this position. The construction is such that the contact opening or closing movement of the switch may take place at any point in the range of the instrument.

It is a further object of the invention to provide a mercury switch control mechanism by means of which a mercury switch may be moved between its open and closed positions by the application of a very small amount of power. This means that the condition responsive mechanism may be very sensitive and move in response to each small variation of the condition under control while the control mechanism is being operated.

It is a further object of the invention to provide an accurate and inexpensive mercury switch operating mechanism. The instrument with which the operating mechanism is disclosed in the present case is a potentiometer. The switch moving parts are operated by the same drive means which moves the recording pen and in synchronism therewith. Adjustable connections are provided between the drive means and the switch moving parts, however, so that the switch may be opened or closed at any point in the pen travel.

While the control mechanism is disclosed herein as being used in combination with a potentiometer type instrument and is designed particularly therefor, it will be readily apparent that other

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types of instruments such as thermometers, pressure gauges, and flow meters may also be used. It is only required that the instrument have a part that is moved proportionally with the changes in the value of the condition being measured.

The various features of novelty which characterize this invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects obtained with its use, reference should be had to the accompanying drawings and descriptive matter in which is illustrated and described a preferred embodiment of the invention.

In the drawings:

Figure 1 is a wiring diagram of a potentiometer circuit,

Figure 2 is a diagrammatic view of various of the moving parts of a potentiometer,

Figure 3 is a partial front view of the instrument showing the switches and the switch actuating mechanism,

Figure 4 is a view taken on line 4—4 of Figure 3,

Figure 5 is a view taken on line 5—5 of Figure 4,

Figure 6 is a view of a different embodiment of switch supporting structure,

Figure 7 is a view taken on line 7—7 of Figure 6, and

Figure 8 is a view of a still different switch actuating mechanism.

Referring first to Figure 1 there is shown a wiring diagram of a potentiometer circuit. In an instrument of this type there is provided a slidewire 1 across which a potential is placed by a battery 2. A portion of this potential is opposed by the E. M. F. developed by a thermocouple 3, and to this end the thermocouple is connected in the potentiometer circuit by means of a collector 4 that is attached to one of the thermocouple terminals. This collector is connected electrically with the slidewire 1 by means of a movable contact 5. The other thermocouple terminal is connected to the circuit through a switch 6 and an amplifier 7. When the contact 5 is so positioned along the slidewire 1 and collector 4 that there is no current flow in the circuit, the instrument is in balance. If, however, the thermocouple should be subjected to a change in temperature, the voltage produced thereby would change and a current flow would take place through the potentiometer circuit. This current flow is detected and amplified by the amplifier 7 to produce an energization of a rebalancing motor 8 in a direction depending upon the current flow in the circuit. The motor is mechanically connected to contact 5 to move this contact along slidewire 1 in such a direction that the thermocouple voltage is exactly opposed by the voltage drop across the slidewire. When contact 5

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reaches this point along the slidewire 1, current will cease to flow in the circuit and the motor will again be deenergized so that the contact will remain still until a further change in thermocouple voltage takes place. At times it is necessary to recalibrate or standardize the potentiometer circuit. This is accomplished by moving a contact 9 of switch 6 to the right to disconnect the thermocouple from the circuit and to connect a standard cell 11 in its place. This standard cell is connected in the circuit and a suitable resistance 12 is simultaneously connected in the circuit around the amplifier 7. The standard cell produces a given voltage drop across a portion of the potentiometer circuit so that if this voltage is not exactly opposed by the voltage of the battery 2, a resistance 13 may be adjusted in suitable manner until the voltages are equal. Thereafter the contact 9 is moved to the left to again connect the thermocouple in the circuit. For further details of the potentiometer circuit and the amplifier, attention is called to the copending application of Walter P. Wills, Serial No. 421,173, filed December 1, 1941, now Patent No. 2,423,540, issued July 8, 1947.

The mechanism of the instrument, or at least that which is necessary for an understanding of the invention, is shown in Figures 2 to 5. It will be seen in Figure 2 that the motor 8 is provided with a pinion 14 which meshes with the teeth of a large gear 15 that is mounted upon a shaft 16. The gear is provided with a stop or enlarged portion 17 that bears against one side or the other of pinion 14 to limit the rotation thereof in both directions. Also mounted on the shaft 16 is a small gear 18 that meshes with teeth which are formed in the lower edge of a segment member 19. This segment is movable with a pivoted shaft 21 that has attached to it in a manner to be described later a pen arm. The shaft 21 is also used to operate the control mechanism to which the invention is more particularly related.

Rotation of shaft 16 also serves to adjust the contact 5 along the slidewire 1 and the conductor 4. To this end there is provided a pulley 22 that is also attached to the shaft 16. This pulley has wrapped around it a cable 23 which passes over a series of guide pulleys 24, 25, and 26. The first of these pulleys is mounted for movement on a lever arm 27 that is biased in a downward direction by means of a spring 28. This mounting for the pulley 24 serves to take up any slack which may occur in the cable and thus prevent undesirable play between the drive motor 8 and the contact 5. As is shown in Figure 2 the cable 23 also passes around a drive pulley 29 that is mounted upon a shaft 31. This shaft is suitably journaled in a supporting member 32 made of insulating material upon which the slidewire 1 and the collector 4 are helically wound side by side. The contact 5 travels in a helical path around member 32 and is held in engagement with the slidewire and collector by means of a spring member 34. This spring has a slot in it extending in a direction parallel to the axis of shaft 31. Spring 34 is attached to a vertically extending arm of a part 33, the other arm of which extends across the bottom of support 32 and is fastened to the shaft 31.

From the above description it will be seen that as the motor 8 is energized in response to potentiometer unbalance, it will rotate the pulley 22, and through the cable 23, the pulley 29. When this pulley moves, shaft 31 will be rotated to

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move part 33 around the supporting member 32. During this movement contact 5 which engages the slidewire and collector bar will move up and down in the slot formed in spring 34 as the latter is moved around the outside of the supporting member 32. Therefore, the contact 5 moves in a helical path along the slidewire 1 and collector 4 to the proper position so that the motor 8 is deenergized when the potentiometer circuit is again balanced. The slidewire and collector are protected by a cover 35 that is placed around them and held in position by clips 36.

The parts of the potentiometer which have just been described are mounted on a frame member or casting 37, on the front of which is disposed the recording and control mechanism. It will be seen from Figures 3 and 4 that the shaft 21, which is moved by segment 19, extends through this casting and has attached to its front end a driving arm 38 which is formed with a rearwardly extending tongue 39. Rotatably mounted on the shaft 21 is a pen arm 41 that is held in engagement with the tongue 39 by means of a spring 42. Because of this construction the pen arm 41 will be moved across a suitable chart as the shaft 21 is rotated but that this pen arm may be manually moved to the right in Figure 3 without disturbing the position of shaft 21.

As the shaft 21 moves the pen arm, it also serves to operate the control mechanism. This is accomplished by moving a connecting link 43 in response to movements of the pen arm due to variations in the condition being controlled. The upper end of link 43 is connected to a differential lever mechanism that is operated by either the pen shaft 21 or a control point setting device, while the lower end of link 43 is connected directly to the switch operating mechanism.

The differential lever mechanism consists of an arm 44 that is attached to and projects from the shaft 21. This arm is connected by means of a link 45 to one end of a floating lever 46, the other end of which is pivoted to a segment 47. This segment is pivoted at 48 and has either attached to it or forming a part of it an index arm 49 that cooperates with the chart to indicate the position at which the control point is adjusted. Segment 47 is also provided on its outer edge with gear teeth, as shown, that mesh with a pinion of a gear train 50 which is in turn driven by a pinion 51. The latter pinion may be rotated by a knob 52 which is adjusted manually in order to change the control point of the instrument. It is noted that the segment and the gears are mounted on the back of a plate 53 which is suitably attached to the casing 37 and which serves as a bearing for the front end of the pen shaft 21. It will be apparent from the construction that has been described that a movement of the pen arm in response to changes in the temperature being measured, will cause the left end of lever 46 to be raised or lowered depending upon the direction of the change. In normal operation the right end of lever 46 is stationary, but this right end may be adjusted to different positions in order to change the normal position thereof and thereby change the control point or the point at which the instrument will tend to maintain the temperature.

The mercury switch supporting mechanism is assembled as a unit upon a plate 54. This plate is attached to the casting 37 and is spaced therefrom a proper distance by means of bosses 55. Screws 56 extend through suitable openings in the plate and into the bosses to hold the unit

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rigidly in place. A pair of posts 57 extend from plate 54 and have attached to their front ends the cross pieces of a member 58 that serves as the front bearing for a pair of shafts. A shaft 59 is journaled in the plate 54 and in the member 58 and has attached to its front end and extending toward the left therefrom in Figure 3 an arm 61 whose outer end is fastened to the lower end of link 43. The rear end of shaft 59 has attached to it and extending downwardly therefrom another arm 62 which supports in its lower end a roller 63. This roller is received by a slot 64 in a third arm 65 which projects upwardly from a second shaft 66 that is also journaled for movement in the plate 54 and the member 58. It will be seen that longitudinal movements of link 43 will act through the arms attached to shaft 59 to rotate that shaft and rotate the shaft 66.

The support for the mercury control switches consists of a disc 67 which is attached to the shaft 66 so that it will rotate with that shaft. This disc has mounted upon it a pair of clips 68 which serve to hold mercury switches 69. For purposes of this disclosure the disc is shown as having two clips 68 on it so that two mercury switches may be held in place. It will be obvious that only a single switch or more than two mercury switches may be used if desired or necessary. The lead wires from the switches, which are indicated at 71, extend therefrom and are wrapped around the shaft 66 from which they pass to a suitable terminal block 74. In order to maintain these leads in their proper position and to prevent them from becoming entangled with the various actuating levers, there are provided on the shaft a pair of insulating discs 72 which in effect form a spool that receives the lead wires. Since the wires are very flexible and are wrapped around the spool before extending to the terminal block, it will be seen that they do not offer any resistance to rotative movements of shaft 66.

It is probable that there might ordinarily be some play between the roller 63 and the edges of slot 64, so there is provided a spiral spring 75 which tends to keep the roller 63 against one side of the slot at all times. To this end, one end of the spring is attached to the shaft 66 while the other end is attached to a pin 76 which projects forwardly from the base plate 54.

The operation of the controller should be apparent from the above description. A short résumé of the operation will, however, be given. When a temperature being controlled deviates from the desired value, current will flow through the potentiometer network and will produce unbalance thereof which is detected by the amplifier 7. This amplifier causes energization of motor 8 in the proper direction to act through the mechanism shown in Figure 2 to rotate slide-wire contact 5 around the slidewire and collector until the potentiometer network is again balanced. Simultaneously the pen shaft 21 is rotated to move the pen across the chart and indicate the value of the temperature. As the pen is moved it operates through levers 44, 45, and 46 to raise or lower link 43, as the case may be. If for example the temperature has increased, the lever system would produce a downward movement of link 43 to rotate shaft 59 in a counter-clockwise direction in Figure 5 thereby moving shaft 66 and the parts carried thereby in a clockwise direction. From an inspection of Figure 3 it will be seen that in this case the upper mercury

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switch 69 will be closed while the lower mercury switch 69 will be opened. These switches can be connected directly or through suitable relays in any well-known manner to control a temperature influencing means to bring the temperature back to the control point.

From the construction of the lever system, as best shown in Figure 5, it will be seen that if the temperature is at the control point, the roller 63 will lie on a line drawn between shafts 59 and 66. As the temperature deviates in one direction or the other, this roller will be moved to rotate shaft 66 and the switches to open or close them. The lever system is such that a maximum movement of the switch shaft 66 will be obtained for a minimum movement of shaft 59 when the temperature is near the control point. This means that the switches are moving fastest when the roller 63 is passing through a line between shafts 59 and 66. After roller 63 passes to either side of the line the leverage between arms 62 and 65 will change so that movement of shaft 66 for a given angular movement of shaft 59 will get smaller. There is a particular advantage in having a lever system constructed in this manner. Ordinarily the temperature will remain at or substantially near the control point. Therefore small deviations of temperature will give a comparatively large and fast movement to the shaft 66 so that the switches will be closed or opened rapidly. This means that for a comparatively small movement of the lower end of lever 62, a comparatively large movement of shaft 66 will be obtained and this large movement will be fairly rapid. Therefore, the switches will be closed or opened rapidly and consequently a minimum of chattering of the relays will be obtained. Continued movement of the switches thereafter is immaterial and may be made as small as practical. Since the spring 75 tends to keep the roller 63 against one edge of slot 64, there will be no lost motion in the device and the switches will be opened or closed at exactly the same point in their operation each time they are moved.

There is shown in Figures 6 and 7 another form that a switch supporting unit may take. In this embodiment the switch is moved in response to movement of the pen shaft in exactly the same manner as the embodiment of the invention which was previously described. This figure differs in the manner in which the terminals of the mercury switches are attached to the support and are led from the movable switch support to the terminal block 74.

As is shown best in Figure 6, the rotatable disc 67 upon which the mercury switches are mounted has attached to it an insulating member 77 that is provided with four contacts 78 to each of which there is attached one of the leads from the two mercury switches 69. Each of the terminals 78 is connected on its rear side, or the right side shown in Figure 6, with one end of a helical spring 79, there being one spring for each of the terminals. There is provided a sleeve 81 made of insulating material concentric with shaft 66. This sleeve has placed upon it at spaced intervals insulating members 82. These members are attached to each other and to the base plate 54 by a pair of posts 83. It will be seen from the construction that the sleeve 81 and the spacers 82 are held in concentric relation with the shaft 66 upon which the mercury switches are mounted but that the shaft does not touch the tube 81. Each of the springs 79 is received between two of the spacers 82 and has

its inner end fastened by means of a terminal strap 84 to one of the spacers 82. Therefore each one of the springs serves the dual purpose of acting as an extension lead for one of the terminals in the mercury switch and also acts to bias slightly the switch support so that there will be no play between the roller 63 and the slot 64. It will be obvious that the springs 79 will be less strong than the spring 75 disclosed in Figure 4 since the four springs 79 are acting in the same direction, and if they were all strong, too much force would be required to rotate the switch supporting disc 67. Suitable leads will extend from the stationary terminal members 84 to the terminal block 74 that is attached to the instrument casting 37. As is shown in Figure 6, a cover 85 may be placed around the switches if it is desired. This cover, however, does not serve any function except to protect the switches against accidental damage.

In Figure 8 there is shown another embodiment of the invention in which two switch units are operated simultaneously. In the disclosure of Figure 8 there is shown only one switch on each of the switch supporting members. In this case each of the switches is supported directly by a clip 86 that is attached in a suitable manner to the front of shaft 66. Also as shown in this embodiment the switches are operated directly from a pinion 90 on the shaft 16 instead of being operated through the pen shaft as was the case in the previously described embodiments. As disclosed herein the pinion 90 meshes with a set of gear teeth that are formed on the periphery of a segment member 87 which is pivoted at 88. If this segment is rotated due to rotation of pinion 90, a cross bar or lever 89 which is movable therewith is also moved around the pivot 88. Each end of this bar is connected by means of a link 91 to one end of a floating lever 92. The floating levers and the switch mechanism which are operated by opposite ends of lever 89 are identical and have been given duplicate reference numerals for duplicate parts. The only difference between the two switch units is that the one actuated by the right hand end of lever 89 will be moved in an opposite direction from the unit which is operated by the left end of the lever 89. The other end of the floating lever 92 is supported upon a small segment lever 93, which in turn is pivoted for movement around an axis that is concentric with the center of the floating lever 92 when the parts are in the position shown. As the lever 92 is moved around its end which is pivoted upon the segment 93, arm 61 on the switch supporting unit will be moved by means of a link 94 that extends between this arm and the floating lever. Link 94 will also be moved when the control point of the instrument is changed by moving the floating lever 92 around the upper end of link 91 as a pivot. This latter movement is accomplished by rotating the segment 93 around its pivot by gearing 92. The gearing is normally provided so that a fine adjustment of the segment 93 may be obtained. Each of the segments 93 is provided with a pointer 96 which cooperates with a scale 97 to indicate the control point for which each of the switch units is adjusted. It is also noted that a spring 98 is used between one arm of the lever 89 and any suitable fixed point in order to place the lever mechanism under a bias in one direction. This serves to take up any slack or back play that might occur between the pinion 90 and the gear teeth formed on the segment 87.

From the above description it will be seen that I have devised a simple and positive operating mercury switch controller. This device has few parts and a minimum number of adjustments. Emphasis is also placed upon the fact that in the operation of the switch unit in response to changes in the value of the condition being measured, that the switches will be moved quickly from open to closed position and vice versa as the condition changes through a very small amount.

While in accordance with the provisions of the statutes, I have illustrated and described the best forms of the invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention as set forth in the appended claims, and that in some cases certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a control instrument, the combination of a member moved in response to variations in the value of a condition, a mercury switch having leads extending therefrom, means to support said switch for movement about an axis including a rotating shaft, a part attached to and extending radially of said shaft, supports for said switch on said part, a second radially extending part extending from said shaft and forming with said first part a spool around which the leads from said switch may be wrapped as they extend between said switch and suitable terminals, means to bias said shaft in one direction, and connecting means extending between said member and part to rotate said shaft against the force of said biasing means as said member moves.

2. In a control instrument, a member movable in response to variations in a condition, a mercury switch having leads extending therefrom, means to mount said mercury switch comprising a rotatable shaft, a part extending radially from said shaft, a support for said mercury switch on said part, terminals on said part to which the leads extending from said mercury switch are attached, a plurality of spiral springs, one for each terminal, surrounding said shaft and insulated therefrom, means to attach an end of each spring to one of said terminals, means to attach the other end of each of said springs to a stationary support, said springs acting to bias said shaft in one direction and as extension leads for said switch, and connecting means between said member and said shaft to rotate the latter as said member moves.

3. In a control instrument, the combination of a member movable in response to variations in the value of a condition, a mercury switch having leads extending therefrom, means to support said mercury switch including a rotatable shaft, a part extending radially from said shaft and having terminals attached thereto, there being one terminal for each lead extending from the mercury switch, means to support said mercury switch on said part with its leads attached to said terminals respectively, a plurality of resilient means surrounding said shaft and being insulated therefrom, means to connect electrically one end of each of said resilient means to one of said terminals whereby each of said resilient means acts as a lead for said mercury switch as

said mercury switch is moved due to rotation of said shaft, and connecting means between said member and shaft operable to rotate said shaft as said member moves.

4. In a control instrument, the combination of a support, a shaft pivoted in said support, a part attached to said shaft and extending radially therefrom, a mercury switch mounted on said part whereby as said shaft is rotated said switch will be tilted between open and closed positions, means to bias said shaft for rotation in one direction, an arm extending radially from said shaft, a second pivotally mounted arm having a portion thereof engaging said first arm in opposition to the action of said biasing means, and means to move said second arm in accordance with variations in the value of a measurable condition to rotate said first arm or let said first arm be rotated by said biasing means.

5. In a control instrument, a measuring element responsive to a variable under control, a manually operable knob forming means for adjusting the set point of the instrument, a differential lever mechanism one input to which is formed by the movements of said measuring element and another input to which is formed by the movements of said knob, a link pivotally secured to said differential mechanism so as to form the output therefrom, a first pivotally mounted shaft having one arm pivotally secured to said link and having a second arm fast on said shaft, a second pivotally mounted shaft, at least one mercury switch mounted on said shaft for pivotal movement, a spring biasing said first shaft in one direction, and a toggle formed of an interfitting pin and slot forming a driving connection between said second arm and said second shaft whereby said mercury switch is moved

at maximum speed at an intermediate point in its travel when said mercury switch is making or breaking an electric circuit.

6. A mercury switch operating mechanism including, a mercury switch, a pivotal mounting for said mercury switch, a spring tending to turn said mounting in one direction about its pivot, a pair of arms one of which is secured to said pivotal mounting and one of which has a slot therein, an anti-friction roller pivotally mounted on the other of said arms and rolling in said slot so as to rotate the slotted arm, a driving link pivotally secured to that arm which is not secured to said pivotal support, a differential lever mechanism to which the opposite end of said link is pivotally secured, a manually operable knob secured to said mechanism so as to adjust said link, and a measuring instrument responsive to the movements of a variable to which it is desired to have the mercury switch respond and connected to said mechanism so as to move said link.

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