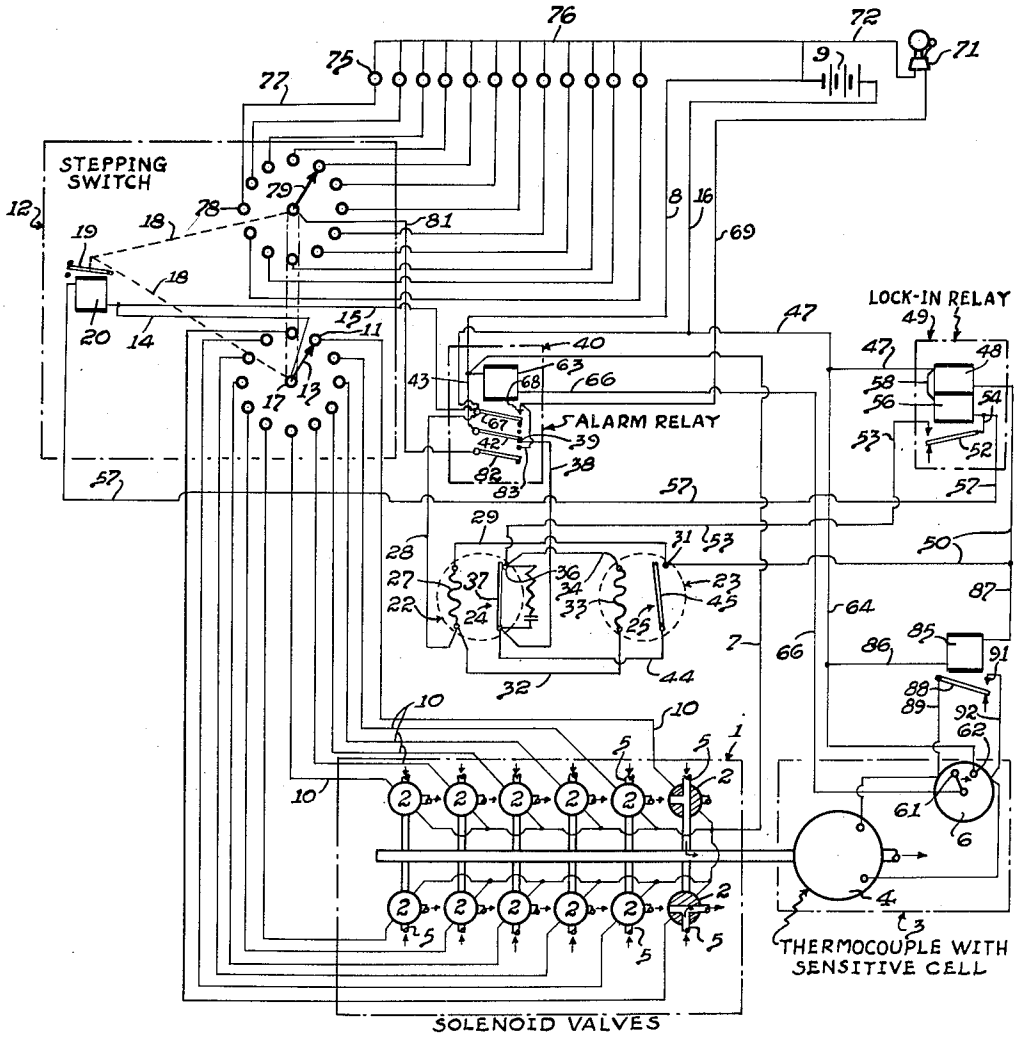
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MULTIPLE SAMPLING VALVE CIRCUIT

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## MULTIPLE SAMPLING VALVE CIRCUIT

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This invention relates to multiple sampling valves, and more particularly to an electrical system by which the operation of such valves can be controlled.

It is well-known practice to operate a multiple sampling valve by means of an electric stepping switch so that each sampling line in turn will be connected by the valve to an instrument by which the presence of a predetermined element in any sample can be detected. The stepping switch may be actuated by a thermal relay containing an electric heating element and a normally closed bimetallic switch electrically connected to the stepping switch. In such a case the current for the heating element flows through the bimetallic switch, heats the element, and thereby causes the bimetallic switch to open. This interrupts the current to the heater, which cools off and permits the bimetallic switch to close. The cycle then is repeated. The difficulty with such a system is that only very short recycle time can be obtained, while for some instruments two minutes or more may be required between sampling valve changes. In the operation just described, a long delay may be obtained for the first opening of the bimetallic switch by having a low heat input and a high heat capacity in the contact strip, but the recycle time will be short and will continue to get shorter during the following operations. This is because the circuit is broken just as soon as the switch contacts are separated a fraction of an inch and, as soon as the heater cools a small amount, the circuit is remade. This leaves a lot of residual heat in the strip so that only a short time is required to reopen the contacts. Contacts which move slowly toward or away from each other, as they do when moved by a bimetallic element and when a long delay is required, are subject to vibration and shock and will stutter under such conditions. This will cause the valve to step when it should not do so. Another disadvantage is that when a sampling valve shifts from one sampling line to another, the last of the first sample may not reach the detecting instrument, or may not cause it to register, until the valve has shifted to the next sampling line, whereby the instrument will indicate for the second sample what it should have indicated for the preceding one.

It is among the objects of this invention to provide a multiple sampling valve system which is fully automatic, which is free of motors, gears and other mechanical arrangements that require lubrication, which permits any desired timing to be used for the sampling periods, which will not allow false stepping of the valve, which prevents the tail end of any sample from producing a false indication at the detecting instrument, which may use signal lights synchronized with the sampling lines, which stops stepping of the valve whenever a sample of a predetermined character is obtained, and in which the proper signal light is lit when such a sample appears.

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The invention is illustrated diagrammatically in the accompanying drawing which is predominantly a wiring diagram.

Referring to the drawing, the multiple sampling valve 1 is divided into two units each containing six solenoid operated three-way valves 2 connected to different sampling lines 5, and each solenoid valve is adapted to connect its sampling line in succession to a detecting instrument 3. The valves are shown diagrammatically, and two of them are in diagrammatic section to illustrate how one connects its sampling line with instrument 3 while all of the others connect their respective sampling lines to atmosphere. The detecting instrument shown only for the purpose of illustration includes a thermocouple 4 provided with a sensitive cell of known character containing hopcalite which generates heat when carbon monoxide flows across it. This heat produces electromotive force that operates a combined electric switch and meter 6 which can be calibrated to show the concentration of carbon monoxide in the gas being sampled. Each solenoid valve 2 has one end of its coil connected by wires 7 and 8 to one pole of a battery 9. The other ends of the coils are connected by separate wires 10 to a series of electric contacts 11 which may be arranged in a circle. These contacts form part of a stepping switch 12 of conventional form and are adapted to be engaged in succession by a rotating contact arm 13 that is connected by wires 14, 15, and 16 to the other pole of the battery. The contact arm is mounted on a shaft 17 which periodically is turned a few degrees to move the arm from one contact to the next one. The shaft rotating mechanism is well known in this art and is indicated in the drawing by broken lines 18 that connect the shaft with the reciprocable core 19 of a solenoid coil 20. One end of the coil is connected to wire 15, while the other end is connected through switches, about to be described, to wire 8 to complete a circuit through the coil. Every time the core moves in and out of the coil, the shaft of the stepping switch is turned one step to connect the next solenoid valve into the circuit.

In order to energize stepping coil 20 periodically, so as to control the movements of the stepping switch, a pair of thermal delay relays 22 and 23 are provided. These preferably are the well-known type in which the parts are sealed in a glass bulb or tube provided with a pronged base for plugging into an electric socket. The relays are shown diagrammatically, and each includes an electric resistance heating element and a bimetallic switch. Relay 22 has a normally closed switch 24 and the other has a normally open switch 25. One end of the heating element 27 in the first relay is connected by a wire 28 to main circuit wire 16. The other end of this element is connected by a wire 29 to the stationary contact 31 of switch 25 in the other relay. Wire 28 also is connected by a wire 32 to one end of the heating element 33 in relay 23, while the opposite end of element 33 is connected by a wire 34 to the stationary contact 36 of switch 24 in the other relay. The bimetallic strip 37, which carries the movable contact of this switch, is connected by a wire 38 to a contact 39 of an alarm relay 40. The movable contact 42, normally engaging contact 39, is connected by a wire 43 to main circuit wire 8.

Thus, a control circuit extends from wire 16 through heating element 33, switch 24, alarm relay 40, and back to wire 8. Heating of element 33 will cause the bimetallic strip of switch 25 to engage contact 31 so that a circuit will be completed through heating element 27, wire 29, switch 25, and a wire 44 connecting bimetallic strip 45 with the wire 38 leading to the alarm relay and wire 8. When the heat from element 22 opens switch 24, the circuit through heating element 33 will be opened so that strip 45 will cool and move away from contact 31.

When switch 25 closed, it also completed a control circuit from wire 16 through a wire 47 and one solenoid coil 48 of a two coil lock-in relay 49 connected by a wire 50 to contact 31 of switch 25, and then by wires 44 and 38 and the alarm relay to wire 8. The energized relay coil 48 closes a switch 52, one side of which is connected by a wire 53 to contact 36 of switch 24. The other side of switch 52 is connected by a wire 54 to one end of the second solenoid coil 56 of the lock-in relay from which a wire 57 extends to stepping relay coil 20. Every time switch 52 is closed, coil 20 is energized and the stepping switch indexes one contact. When switch 52 closes, it also closes a circuit which leads from wire 47 through a wire 58 and coil 56 and wire 54 to the switch. Thus, even if the circuit through the first lock-in coil 48 is broken accidentally at switch 25, switch 52 will be held closed by the other coil 56 until bimetallic switch 24 opens and breaks the circuit through the second coil.

It will be noted that element 33 remains in circuit after switch 25 closes until contact strip 37 in the other thermal relay is heated enough to open switch 24. This stores heat in relay 23 so that switch 25 remains closed a short period after switch 24 opens. Therefore, contact strip 37 continues to move away from contact 36 after the initial break, because switch 25 holds element 27 in circuit a short time after switch 24 opens. Switch 24 is designed to operate relatively quickly and to open after a delay of only about three seconds. Due to the fact that it makes a fast break, which also is wide because of the "overshooting" of switch 25, there is no danger of the contacts of switch 24 stuttering because of vibration. While switch 24 is open it makes no difference whether switch 25 stutters, because the circuit containing switch 52 is broken at switch 24 anyway. While switch 24 is closed, stuttering of the contacts of switch 25, which operate more slowly, is rendered ineffective by the lock-in relay 49 wherein coil 56 holds switch 52 closed even if coil 48 is deenergized by opening of switch 25. This prevents double or false stepping of the multiple sampling valve. A slowly acting relay having a single coil could be substituted for the lock-in relay, but the latter is preferred because it is more positive in operation.



By using two thermal delay relays interconnected as disclosed herein, the delay obtained with one relay is used to permit dissipation of heat from the other. This allows a long period of time for the complete cycle to be obtained. Variations in total time can be obtained simply by substituting relays of different heat capacities and heat input. With the type of thermal relay preferred, changing relays is as simple as changing radio tubes.

In order to call attention to dangerous samples, or samples of predetermined character which may not be dangerous, meter 6 includes a movable contact 61 which will engage a stationary contact 62 when the concentration of a predetermined element in any fluid sample reaches a certain value. This meter switch controls the solenoid coil 63 of alarm relay 40. Thus, contact 62 of the meter switch may be connected by a wire 64 to wire 47 leading to main line 16, while the movable contact is connected by a wire 65 to one end of coil 63, the other end of which is connected to wire 8. Therefore, when the meter switch closes, coil 63 is energized and draws three contact members, which are linked together, upwardly toward it. One of these, contact 42, is in the thermal delay relay circuit, so that circuit is broken the moment a sample causes the meter switch to close, and therefore stepping of the multiple valve ceases. At the same time the upper movable contact 67 engages contact 68 which is connected by a wire 69 to one side of an alarm bell 71. The other side of the bell is connected by a wire 72 to the battery and by wire 16 to switch contact 67.

In order to indicate the sampling line from which the sample in question has issued, a series of electric lamps 75 is provided, each of which is synchronized with a different sampling valve 2. The lamps may be numbered or labeled to show which valve they indicate. The lamps are connected by a wire 76 to wire 8, and are connected by wires 77 to groups of contact members 78 arranged in a circle and forming part of stepping switch 12. These contacts are engaged in succession by a movable contact arm 79 mounted on shaft 17. Consequently, every time relay coil 20 indexes the shaft, the latter moves arms 13 and 79 in unison to the next contacts. The contact arm 79 is connected by a wire 81 to a normally open switch 82 in the alarm relay. However, when the meter switch closes the circuit through the alarm relay coil 63 so that switch 82 is closed, wire 81 is electrically connected by a wire 83 leading to contacts 68 and 69 and wire 16. This completes the circuit through the lamp that happens to be connected to the contact 78 engaged by the movable arm 79 at the time the meter switch closes in response to a sample of a certain character. As the lamps are synchronized with the valves, the lighted lamp will indicate the valve through which the sample is

flowing. It will be seen that as long as no sample is of such a character as to close the meter switch, the lamps will remain unlighted, thus avoiding constantly flashing lamps which occurs when the lamps are connected in parallel with the valves.

When a shift is made from any sampling line to the next one in succession, the last part of the first sample may not reach or influence thermocouple **4** until the multiple sampling valve has been stepped. If the last part of the first sample happens to be of a character that will give an alarm, the lamps would indicate that the sample came from the succeeding line to which the valve had just been stepped, if provision was not made to prevent such a false indication. Accordingly, means is provided for rendering meter **6** inoperative for a few moments after the sampling valves have been stepped. This can be done by short circuiting the meter. For this purpose a solenoid coil **85** is connected by a wire **86** to wire **64**, and by another wire **87** to wire **50**. Thus, every time the bimetallic switch **25** closes and causes the valves to step, shorting coil **85** is energized. When energized, the coil lifts a movable contact member **88**, connected by a wire **89** to one side of the meter, into engagement with a stationary contact **91** connected by a wire **92** to the other side of the meter, thereby short circuiting the meter. As soon as switch **25** opens again, the circuit through the shorting coil is broken and the meter resumes functioning. As all of the old fluid sample has left the thermocouple by this time, it cannot influence the reading for the new sample.

According to the provisions of the patent statutes, I have explained the principle and construction of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. In an electrical system for operating a multiple sampling valve, an electric circuit adapted to be connected to the valve, a stepping switch connected in said circuit for controlling the operation of the valve, a pair of thermal delay relays electrically connected to the stepping switch for operating it, each relay including a heating element and a bimetallic switch, one bimetallic switch being normally open and the other being normally closed, the switch in each relay being connected in series with the heating element in the other relay, means for connecting said relays into said circuit to heat said heating elements, means responsive to successive fluid samples flowing thereto from said valves for indicating the presence of undesired elements therein, and means controlled by the relays for rendering said indicating means ineffective for a short time after each sample starts to flow to the indicating means.

2. In an electrical system for operating a plurality of sampling valves, an electric circuit adapted to be connected to the valves, a stepping switch connected in said circuit for controlling the operation of the valves, a pair of thermal delay relays electrically connected to the stepping switch for operating it, each relay including a



heating element and a bimetallic switch, one bimetallic switch being normally open and the other being normally closed, the switch in each relay being connected in series with the heating element in the other relay, means for connecting said relays into said circuit to heat said heating elements, electrically operated means for indicating the presence of a predetermined element in successive fluid samples flowing from said valves, and means controlled by the relays for short circuiting said indicating means for a short time every time the switch is stepped.

3. In an electrical system for operating a plurality of sampling valves, an electric circuit adapted to be connected to the valves, a stepping switch connected in said circuit for controlling the operation of the valves, a pair of thermal delay relays electrically connected to the stepping switch for operating it, each relay including a heating element and a bimetallic switch, one bimetallic switch being normally open and the other being normally closed, the switch in each relay being connected in series with the heating element in the other relay, means for connecting said relays into said circuit to heat said heating elements, electrically operated means for indicating the presence of a predetermined element in successive fluid samples flowing from said valves, a normally open shorting switch connected around said indicating means, and means controlled by said relays for closing the shorting switch every time the switch is stepped.

4. In an electrical system for operating a plurality of sampling valves, an electric circuit adapted to be connected to the valves, a stepping switch connected in said circuit for controlling the operation of the valves, a pair of thermal delay relays electrically connected to the stepping switch for operating it, each relay including a heating element and a bimetallic switch, one bimetallic switch being normally open and the other being normally closed, the switch in each relay being connected in series with the heating element in the other relay, means for connecting said relays into said circuit to heat said heating elements, electrically operated means for indicating the presence of a predetermined element in successive fluid samples flowing from said valves, a normally open shorting switch connected around said indicating means, a solenoid coil for closing the shorting switch, and means electrically connecting said coil in series with said normally open switch.

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