

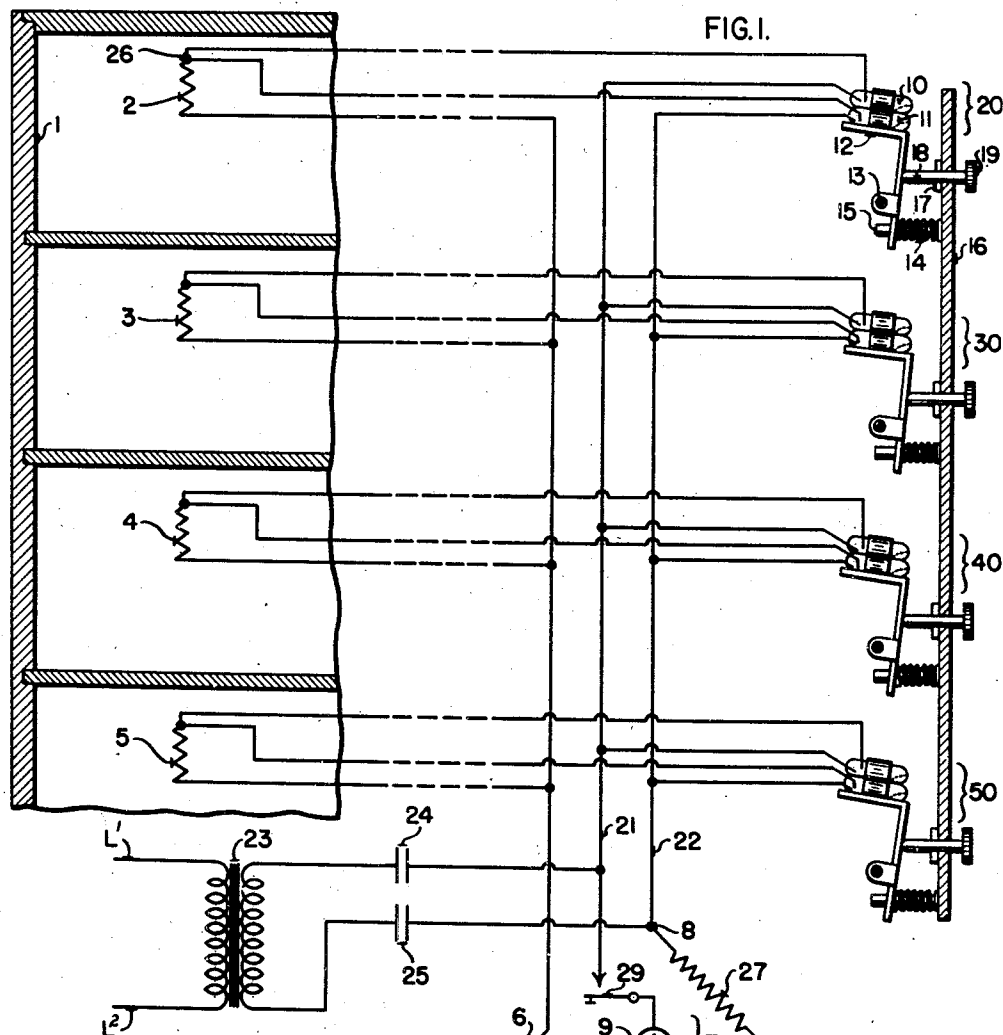
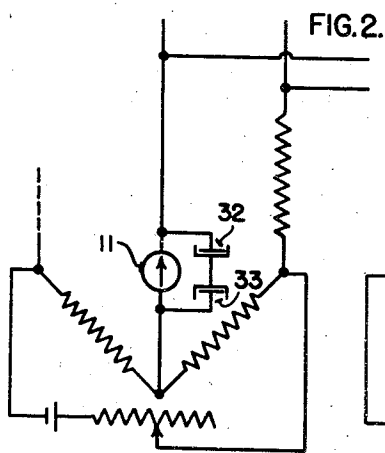
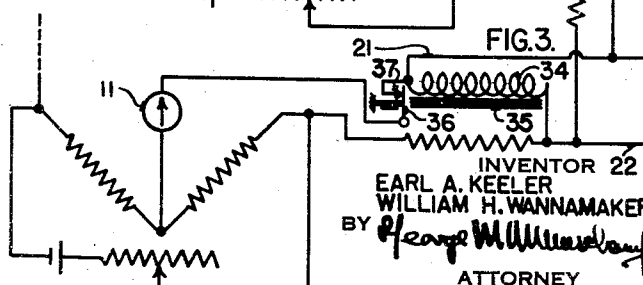
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MEASURING APPARATUS

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The present invention relates to the reduction or elimination of contact resistance in mercury switches.

An object of the invention is to reduce the contact resistance to the flow of electric current present in a mercury switch so that such switches may be used in measuring circuits wherein the currents are very small.

Another object of the invention is to permit the use of an inexpensive switch in a measuring circuit requiring a switch of negligible contact resistance.

In measuring circuits carrying currents of a low order of magnitude, it is necessary that switches connected in said circuits have a very low contact resistance in order to insure accuracy in the measurements obtained. Switches designed for this use have in the past been of the mechanical type employing wiping contacts and have necessarily been expensive, because of the careful machine work required, or because of the special parts or materials needed to insure accurate performance. Mercury switches of conventional construction have been considered unsuitable for such uses, because of their relatively high and unstable contact resistance to small values of current. In certain applications, it is desirable to use mercury switches containing a small amount of oil, to reduce the adhesion between mercury and glass so that the mercury will move to make or break contact upon movement of the switch through a very small angle. Such mercury switches have particularly unstable contact resistance characteristics when used in low current circuits.

In accordance with the present invention the difficulties encountered in the past with mercury switches in such applications have been surmounted by applying a potential of suitable value across the switch contacts, so that, upon closure, the switch carries a current superposed upon the current being measured. The contact resistance of mercury switches to the flow of current once a flow of current has been initiated is known to be negligible, and it has been found that the arrangement described effectively reduces and stabilizes the contact resistance of the switch. In accordance with our invention, any suitable current source, either direct or alternating, may be superposed on the measuring current to obtain this desirable effect.

The present invention also includes provisions for preventing such superposed current from flowing through parts of the circuit where its effect

would be undesirable. Several means for achieving this effect have been disclosed herein.

The potential applied across the switch in accordance with our invention must be sufficient so that the voltage gradient which is established at the contact surfaces will be sufficient to break down any film or other condition existing there and causing high resistance. Furthermore, the potential must not be so large that the current caused thereby will exceed the switch capacity. For example, a range of from 8 to 12 volts is suitable for certain applications.

The various features of novelty which characterize our invention are set forth in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its advantages, and the specific objects attained with its use, however, reference should be made to the accompanying drawing and descriptive matter, wherein we have illustrated and described several embodiments of our invention.

Of the drawing:

Fig. 1 is a diagrammatic representation of a multiple unit resistance thermometer system embodying our invention;

Fig. 2 is a wiring diagram of a bridge circuit for the resistance thermometer where in the superposed current is obtained from an alternating current source and illustrates a preferred means of filtering the superposed alternating current from the circuit of the galvanometer used therein; and

Fig. 3 is a wiring diagram of another bridge circuit wherein the superposed current is obtained from a direct current source and illustrates a different means of preventing the superposed current from adversely affecting the galvanometer operation.

In Figure 1 we have illustrated, more or less diagrammatically, the use of our invention in a measuring instrument employed to measure the temperature at various locations in a building 1, having resistance units 2, 3, 4, and 5 in different rooms thereof. Each of the said resistance units has an appreciable temperature coefficient of resistance so that the resistance thereof varies in accordance with the variations of the temperature to which they are subjected. The lower terminal of each of these resistances, as seen in the drawing, is connected to the terminal 6 of a bridge circuit designated generally by the reference numeral 7. The upper terminal of each resistance unit is connected to two lead wires, one of which goes to the terminal 8 of the

bridge 7, and the other to one terminal of a galvanometer 9 which is adapted to indicate on a suitable calibrated scale (not shown) the state of balance of the bridge 7 and thereby the temperature to which the resistance units 2, 3, 4 and 5 are subjected.

Each of the said upper lead wires from resistance unit 2 is connected through an associated mercury switch 10, or 11, both of which switches are mounted on a bracket 12 which is pivotally supported on a rod 13. The bracket is biased for rotation in a clockwise direction into engagement with a rod 13 by a spring 14 coiled about a bolt 15 which is fastened to a panel 16 and passes through a suitable opening in the lower part of the bracket. The normal position to which the bracket is so biased is such that the mercury switches are held tilted an amount just sufficient to maintain their contacts open, as shown in Fig. 1. Further clockwise rotation of the bracket is prevented by a stop 17 which is rigid with a rod 18 and normally abuts against the panel 16. The rod 18 extends through the panel 16, and carries a pushbutton 19 at its outer end.

This switch assembly constitutes a selector device 20 for the unit 2, that is, a device for selectively connecting the unit 2 into and out of the circuit of bridge 7. When it is desired to measure the temperature in the room containing the resistance unit 2, the pushbutton 19 is depressed, causing the bracket 12 to move counter-clockwise and tilt the mercury switches 10 and 11 so as to close them. The resistance unit 2 is thereby placed in circuit with the bridge 7 and the temperature may be determined by noting the deflection of the pointer of galvanometer 9 over its associated scale which may be calibrated in temperature units as noted hereinbefore. Selector switches 30, 40 and 50 similar to the selector switch 20 just described are associated with each of the resistance units 3, 4, and 5, respectively, and are provided to permit the selective connection of each of these resistance units into circuit with the bridge 7.

After passing through the mercury switches, each of the upper leads from the various resistance units is connected through a common lead 21 or 22 to its respective destination. The potential which is used in accordance with the present invention to reduce the contact resistance in the mercury switches is applied across these leads 21 and 22. The potential may be obtained from any convenient source as, for example, from alternating current supply lines L¹ and L² through a suitable transformer 23. In order to isolate the direct current in the measuring circuit 7 from the transformer 23, condensers 24 and 25 may be connected in circuit between transformer 23 and the bridge conductors 21 and 22 as shown.

When the selector button 19 is depressed, alternating current flows through a circuit from one terminal of the secondary winding of transformer 23, through condenser 24, lead 21, switch 10, junction 26, switch 11, lead 22 and condenser 25 to the other terminal of the transformer secondary winding. When any other selector button is depressed alternating current flows through the corresponding mercury switches in a similar circuit.

When all the selector switches are open, a relatively large current would flow from one terminal of the transformer secondary winding through branches 27 and 28 of the bridge, thence through the galvanometer 9 and back to the other side of

the transformer winding if means were not provided to prevent such flow. The flow of such a large current in this circuit would cause an undesirable deflection of the galvanometer needle, and might damage the instrument. In Figure 1, such flow is prevented by the switch 29, which is normally open, but may be held closed when a reading is desired.

As illustrated, the bridge 7 consists of three arms having fixed resistances 27, 28 and 31 and a fourth arm in which any of the variable resistances 2, 3, 4 or 5 may be inserted by the use of its corresponding selector switch 20, 30, 40 or 50. If an additional current were not applied across the mercury switches, the deflection of the galvanometer would be affected not only by the magnitude of the selected resistance, but by the contact resistance of the mercury switches. Since this is an appreciable and a variable factor, the accuracy of the measurement would be impaired. However, when an additional current is impressed across the mercury switches as described, their contact resistance is reduced and stabilized, and the effect, if any, of the stabilized resistance value upon the measurement may be eliminated by a proper calibration of the galvanometer.

In Figure 2 we have illustrated a modification of the arrangement described in connection with Fig. 1 wherein the switch 29 may be dispensed with in preventing the flow of alternating current through the galvanometer 9 and this end is obtained by the use of a pair of electrolytic condensers, 32 and 33, connected back to back across the galvanometer terminals. The condensers 32 and 33 shunt the galvanometer, so that any alternating potential impressed across its terminals will be shunted through the condensers.

In Figure 3 we have illustrated a modification wherein the superposed current is obtained from a direct current source, and wherein a different means is used for preventing the flow of the added current through the galvanometer. The solenoid 34 of a relay 35 is connected between the lines 21 and 22. When any one of the selector switches is operated, the solenoid is shunted through the mercury switches and is effectively deenergized whereupon its armature 36 being biased for engagement with the contact 37 closes the galvanometer circuit. However, when all of the mercury switches are open, the solenoid is again energized and picks up its armature 36, opening the galvanometer circuit, thus preventing the flow of current through the galvanometer.

It will be apparent to those skilled in the art that other means may be used to prevent too great a current from flowing through the galvanometer. For instance, a switching arrangement might be provided, such that one resistance unit would always be connected to the bridge, or an extra set of contacts and a low resistance might be provided for the off, or normal, condition of the selector units 20, 30, 40 and 50.

While in accordance with the provisions of the statutes, we have illustrated and described the best forms of embodiment of our invention now known to us, 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 our invention as set forth in the appended claims and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

Having now described our invention, what we

claim as new and desire to secure by Letters Patent, is:

1. In combination, a measuring circuit including a mercury switch, means for impressing a current to be measured on said circuit, a source of alternating potential, means for impressing a potential from said source across the terminals of said switch, and means for preventing the flow of direct current to said source.

2. The combination of claim 1, wherein said last-mentioned impressing means comprises conducting leads between the terminals of said source and the terminals of said switch, and said preventing means comprises a condenser in each of said leads.

3. In a circuit including a mercury switch and a direct current measuring instrument, means for impressing a direct current to be measured on said circuit, means for impressing an alternating potential across said switch, and means for preventing the flow of alternating current through said instrument.

4. The combination of claim 3 wherein said last named means comprises a normally open, manually closable switch in series with said instrument.

5. A device as described in claim 3 wherein said last named means comprises a condenser in shunt with said instrument.

6. A device as described in claim 3 wherein said last named means comprises a relay having its winding in shunt with said switch, and having its contacts in series with said instrument, said contacts being normally closed, but being opened upon energization of said relay when said switch is opened.

7. Measuring apparatus including in combination, an electrical bridge circuit, an impedance variable in magnitude in accordance with the magnitude of a condition to be measured, means for connecting said impedance to said bridge circuit, said connecting means including a mercury switch, and means for applying a potential across the terminals of said mercury switch to control the contact resistance thereof.

8. Measuring apparatus including in combination, an electrical bridge circuit, a source of direct current for said bridge circuit, a resistance variable in magnitude in accordance with the magnitude of a condition to be measured, means for connecting said resistance to said bridge circuit, said connecting means including a mercury switch, and means for applying an alternating potential across the terminals of said switch to reduce and stabilize the contact resistance thereof.

9. Measuring apparatus including in combination, an electrical network, an electrical device variable in characteristic in accordance with the magnitude of a condition to be measured, means for connecting said device to said network, said

connecting means including a mercury switch, and means for applying a fluctuating potential across the terminals of said mercury switch to control the contact resistance thereof.

10. Measuring apparatus including in combination, an electrical network, a measuring instrument in said network, an electrical device variable in characteristic in accordance with the magnitude of a condition to be measured, means for connecting said device to said network, said connecting means including a mercury switch, means for applying a fluctuating potential across the terminals of said switch to control the contact resistance thereof, and means for preventing the flow of fluctuating current through said instrument.

11. Measuring apparatus including in combination, an electrical network, an electrical device variable in characteristic in accordance with the magnitude of a condition to be measured, means for connecting said device to said network, said connecting means including a mercury switch, and means for applying a potential across the terminals of said mercury switch to control the contact resistance thereof.

12. The method of substantially eliminating contact resistance to the flow of electric current of a low order of magnitude in a switch connected in a circuit including said electric current which switch when closed presents abnormal and unstable contact resistance to the flow of such electric current which consists of impressing a potential directly across the terminals of said switch so that when said switch is closed the portion of said potential which is impressed on said circuit is due only to the potential drop across said switch, said potential being of sufficient magnitude to overcome the condition causing the switch to present abnormal and unstable contact resistance, whereby upon closure of the switch a current is superposed on the electric current normally carried by the switch.

13. In combination, a measuring circuit including a switch having the characteristic of presenting abnormal and unstable contact resistance to the flow of electric current of a low order of magnitude, means for impressing a current of a low order of magnitude to be measured on said circuit, and means for impressing a potential directly across the terminals of said switch so that when said switch is closed the portion of said potential which is impressed on said circuit is due only to the potential drop across said switch, said potential being of sufficient magnitude to overcome the condition causing the switch to present abnormal and unstable contact resistance, so as to control the contact resistance of said switch.

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