April 25, 1933. A. G. S. SANDISON 1,906,105

ELECTRICAL RECORDING INSTRUMENT OF THE RELAY TYPE

Filed March 18, 1929 2 Sheets-Sheet 1

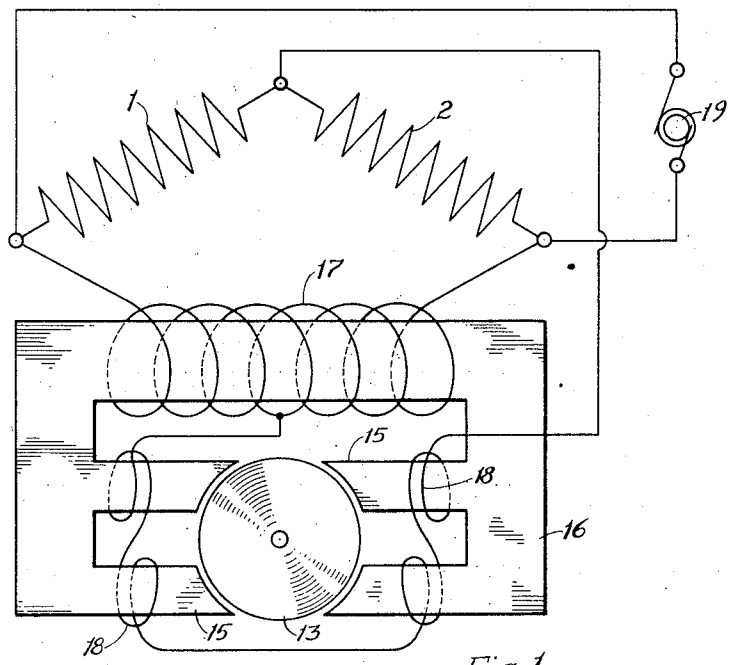


Fig. 1.

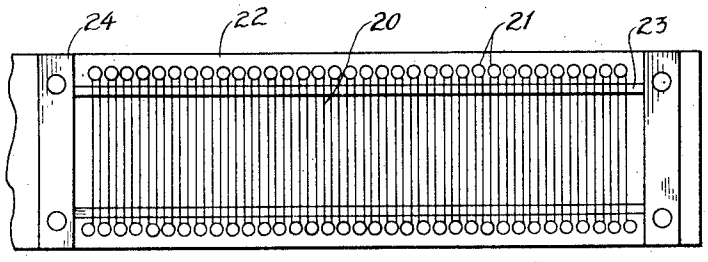


Fig. 4.

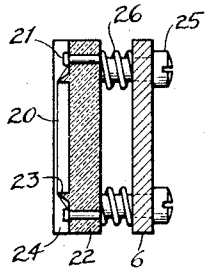


Fig. 5.

Inventor
Alexander G. S. Sandison,
per James B. Lewis
Attorney

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ELECTRICAL RECORDING INSTRUMENT OF THE RELAY TYPE

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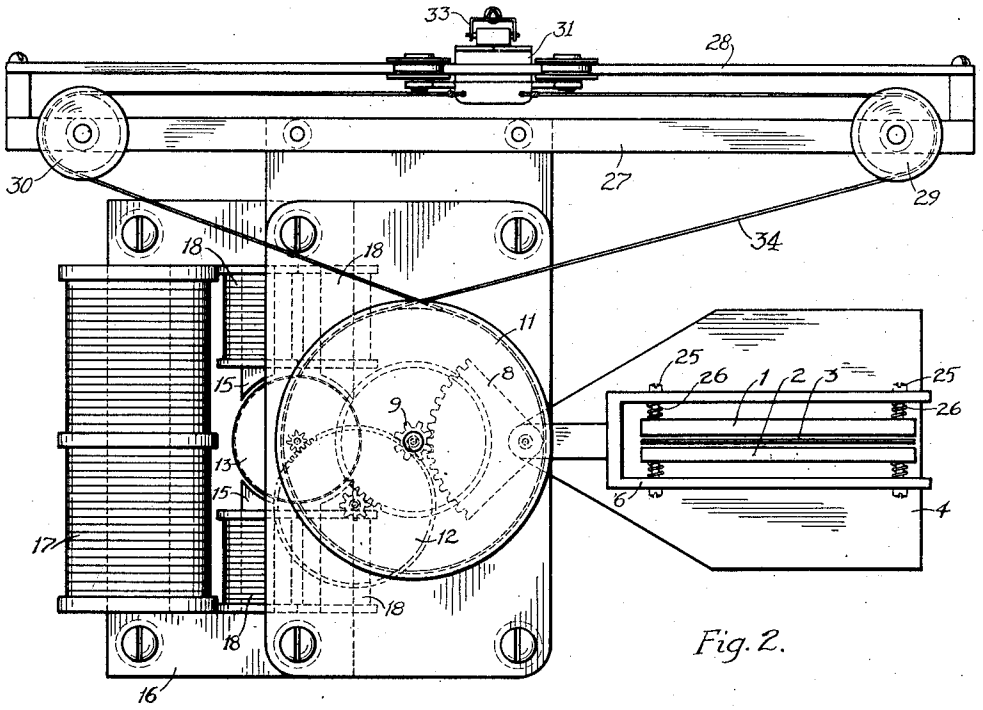


Fig. 2.

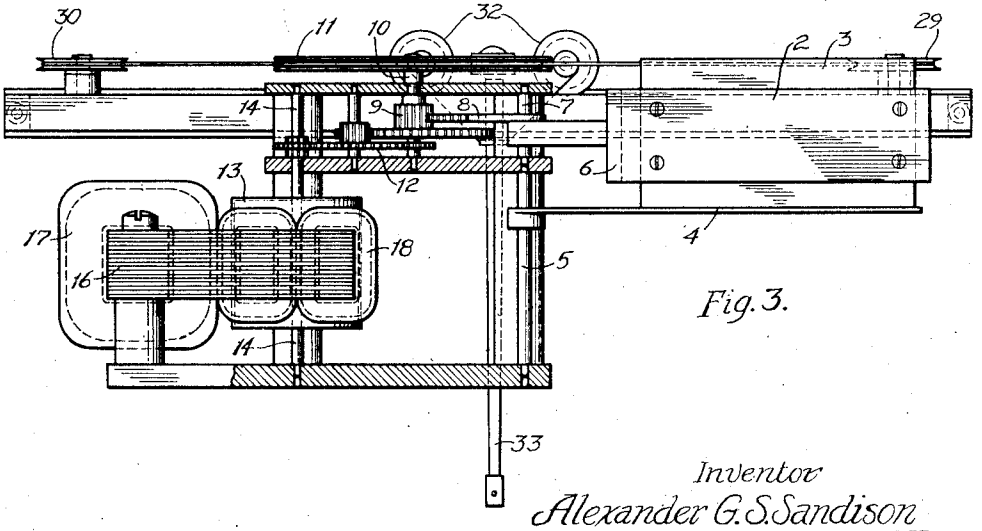


Fig. 3.

Inventor
Alexander G. S. Sandison
per James B. Lewis
Attorney

Patented Apr. 25, 1933 1,906,105

UNITED STATES PATENT OFFICE

ALEXANDER G. S. SANDISON, OF KELDA, BALTA SOUND, SHETLAND ISLANDS, ASSIGNOR TO REPUBLIC FLOW METERS COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS

ELECTRICAL RECORDING INSTRUMENT OF THE RELAY TYPE

Application filed March 18, 1929, Serial No. 348,048, and in Great Britain May 3, 1928.

This invention relates to electrical recording instruments of the relay type, and particularly to the type wherein deflectional movement of a primary moving system brings into operation driving mechanism which operates the recording apparatus and simultaneously operates mechanism engaging with the primary moving system and arranged to stop the driving mechanism when the recording apparatus has executed a movement proportional to the deflectional movement of the primary moving system. Hitherto such relay type recording instruments have involved the use of complex motor operated mechanical mechanism or of electrical contacts, which are liable to give trouble due to faulty contact or partial welding and are particularly unreliable when vibration, even to a very slight extent, is present, as generally occurs with alternating current instruments. Again, in such instruments there is lost motion between the making of contact for forward and reverse operation of the driving mechanism, which causes a difference in reading according to whether the quantity being recorded is increasing or decreasing. In the present invention means is provided whereby the driving mechanism may be brought into operation on deflection of the primary moving system without the use of contact mechanism, and lost motion is practically eliminated.

According to the present invention deflectual movement of a primary moving system is arranged to cause alteration of the temperature in portions of an electrical circuit, the resulting changes in resistance effecting change in the distribution of electrical current in the circuit, thereby causing the operation of suitable driving means for operating the recording means. Such alterations of temperature may be caused by arranging for deflection of the primary moving system to alter the relative positions of a cooling surface and a resistance element of suitable temperature coefficient located adjacent to the cooling surface and heated by the passage of an electrical current. As the total amount of heat produced in such a resistance element may be arranged to remain practically constant, the temperature of the resistance element is reduced when it is moved closer to the cooling surface, owing to the increased thermal conductivity of the decreased intervening air gap, and similarly the temperature is increased as the resistance element and cooling surface are moved further apart. It is preferred to use two such resistance elements connected as arms of a bridge system substantially equivalent to a Wheatstone bridge and to arrange the cooling surface so that deflection movement of the primary moving system increases the temperature of the one resistance element and reduces the temperature of the other. The electro-magnetic driving mechanism is connected in the bridge arm of the bridge system, and may consist of a small induction motor of the eddy current type where alternating current is used.

The preferred embodiment of the invention, as used with alternating current, is shown in the accompanying drawings whereof

Fig. 1 is a diagram of electrical connections.

Fig. 2 is a plan view of the relay mechanism.

Fig. 3 is a front elevation of the relay mechanism with certain parts broken away to expose the mechanism.

Fig. 4 is a front elevation of a resistance element.

Fig. 5 is a sectional end elevation of a resistance element.

Resistance elements 1 and 2, normally of substantially equal resistance value and having a resistance winding of platinum, nickel, or other substance having a considerable temperature coefficient of resistance, are located each adjacent to one side of a metallic plate 3 which is attached to a second plate 4 having an area which will dissipate heat to a sufficient extent to prevent undue rise of temperature. The plates 3 and 4 are mounted on a spindle 5, which is capable of angular movement. A primary electrical moving system (not shown) responsive to an electrical quantity to be recorded, and which may be of the moving coil, moving iron, induction, or other suitable type, is adapted to impart angular movement to the spindle 5 and attached plates

3 and 4 on any change of the electrical quantity. The resistances 1 and 2 are mounted on a forked arm 6 mounted on a spindle 7 located above and co-axial with the spindle 5. A toothed sector 8 is also mounted on the spindle 7 and meshes with a pinion 9 mounted on a rotatable spindle 10 which carries also a pulley wheel 11 adapted to move a pen or other registering means across the recorder chart by means of a cord or the like. The spindle 10 is adapted to be driven through reduction gearing 12 by the motor rotor 13. The rotor 13 consists of a cylinder of copper or other suitable electrically conducting material mounted on the spindle 14, and is under the influence of the poles 15 of the alternating current electro-magnet 16. The electro-magnet is excited by the magnetizing winding 17 while each pole carries an additional winding 18. The exciting winding is connected across the source of alternating E. M. F. 19, and the resistance elements 1 and 2 in series are connected in parallel with this winding, and are heated by the passage of current. Connection is made from the junction of the resistances 1 and 2 through the windings 18 to a tapping at the mid-point of the winding 17. The windings 18 are so connected that the alternating current induces a flux of opposite instantaneous polarity in adjacent pole-pieces.

The resistance elements 1 and 2 each comprise a winding of wire 20 of high temperature coefficient of resistance wound backwards and forwards round pins 21 driven into a former 22 of insulating material. The wire should be sufficiently thin to respond in temperature rapidly to the influence of an adjacent cooling surface. The former 22 carries projections or ridges 23 on its face, and the wire 20 is stretched across the intervening gap, forming a series of parallel wires lying in one plane and adapted to lie adjacent to the surface of the metal plate 3. Blocks 24, of metal or other suitable material insulated from the wire 20 project slightly above the plane of the wire, and prevent electrical contact being made between the wire and the metal plate 3. As an additional precaution the plate 3 may be coated with enamel or other suitable insulating material. Screws 25 passing through the fork of the arm 6 and screwed into the blocks 24 hold the resistance element in position against the pressure of the springs 26, and adjustment of the position may be made by tightening or slackening the screws.

The bar 27 conveniently supported from the mechanism frame, guide or rail 28 carried by said bar and pulleys 29 and 30, constitute a frame for supporting the pointer mechanism. A carriage or slide 31, provided with rollers 32 traveling upon the guide or rail 28 provides a convenient support for the pointer or pen 33 which cooperates with a scale or chart, not shown. The rotary movement of pulley wheel 11 is transmitted to the pen through the cord 34 which passes one or more times around said wheel thence over pulleys 29 and 30 and has its ends secured to the slide 31. While this mechanism forms a convenient means of translating the rotary movement of the wheel into a straight line movement of the pointer it is obvious that other mechanism may be substituted therefor and in some cases the pen can be operated directly from the spindle 10.

In operation, on deflection of the primary electrical moving system, the vane 3 moves towards and, if the deflection is considerable, against one of the resistance elements and away from the other. As a result the temperature of the one resistance element increases and that of the other decreases, and therefore their resistance values become unequal. The resistances 1 and 2 and the two halves of the magnetizing winding 17 are substantially equivalent to the four outer arms of a Wheatstone bridge system of connections, and on departure from the balanced condition a current passes through the windings 18, which are equivalent to the bridge arm of a Wheatstone bridge. By keeping the inductance of these windings relatively low it may be arranged that this bridge current is substantially in phase with the applied E. M. F., as the circuit is completed in opposite directions through the two halves of the magnetizing winding 17, which is thus practically non-inductive with respect to this current. On the other hand the winding 17 is highly inductive with respect to the magnetizing current, and it may easily be arranged that this magnetizing current is substantially in quadrature with the applied E. M. F. Thus the rotor 13 is inductively acted upon in the manner well known in bipolar induction watt-hour meters and the like so as to produce rotation, and by means of the reduction gearing 12 it moves the pulley wheel 11 and thus also the pen or other recording means and, at the same time, by means of the pinion 9 and toothed sector 8 moves the forked arm 6 carrying the resistance elements 1 and 2. When the forked arm 6 has moved through an angle such that the vane 3 is allowed to come to its free stable position and becomes central between the resistance elements the temperature of these elements again becomes normal and electrical balance of the bridge system occurs, whereupon rotation of the rotor 13 ceases. Thus, on deflection of the primary moving system, movement of the resistance elements takes place in the same direction until the plate 3 is again between them, and the recording pen executes a proportional movement. The speed of the rotor is limited by the braking action of the magnetic field, and the movement may thus be arranged to be

dead-beat and not to over-shoot its reading without the necessity of providing further damping means.

It is evident that numerous variations in the details of construction and operation may be made without departing from the spirit or scope of the invention. Thus instead of the cooling surface being mechanically connected to the primary moving system the resistance elements may be so connected. Again, other systems of electrical connections may be employed to give equivalent results, and the invention may be operated either with a plurality of resistance elements or with a single resistance element only. Further, it is not essential to the operation of the invention to use the induction type of driving mechanism described, and other types of driving mechanism may be used, the modifications necessary for operation with direct current being readily apparent to those skilled in the art. Again, while the invention has been described as applied to a relay recorder of the deflectional type, it may equally be applied to a relay recorder of the zero reading or null type wherein the driving mechanism actuates the recording means and simultaneously alters the conditions determining the deflection of the primary moving system so as to restore this system to its zero position.

Having now particularly described and ascertained the nature of my invention and in what manner the same is to be performed what I claim is:

1. A recording instrument of the relay type comprising a primary moving system, a circuit including resistance elements, an electro-motive device in circuit with said resistances and adapted to be operated in one direction by the current through one resistance and in the opposite direction by current through the other resistance, means operable by the primary moving system to vary the resistance of one or the other resistance elements to operate the electro-motive device, a recording element and means whereby said element is operated by said electro-motive device.

2. A recording instrument comprising a primary moving element responsive to the condition to be measured, resistance elements, an electro-motive device in circuit with said elements and adapted to be operated on variation in the distribution of current therein, means operated by the primary element for varying the resistance of one of said elements to vary the current therein to operate said device and recording means operable by said device.

3. A recording instrument of the relay type comprising an element actuable in accordance with the condition to be measured, a circuit including a pair of resistance elements, an electro-motive mechanism in circuit with said elements adapted to be operated on variation in the distribution of current in the resistance elements, means operated by the primary element to vary the distribution of the current and recording means operated by the electro-motive mechanism as an incident to the unequal distribution of current.

4. In a recording mechanism, an element actuable in accordance with the condition to be measured, a circuit including two resistance elements, driving mechanism in circuit with the resistances adapted to be driven on variation in the distribution of current in the resistances, means operated by the element for causing an unequal flow of current in said resistances, and means operated by the driving mechanism for restoring an equal distribution of current in said resistances.

5. A recording instrument of the relay type, a primary element operable in accordance with variations of the condition to be measured, two resistance elements arranged parallel one to the other, a cooling element intermediate said resistances, an electro-motive device in circuit with said resistances adapted to be operated on variation of the distribution of current in the resistances, means operable by deflection of the primary element for causing relative displacement of the resistance elements and the cooling element to vary the resistance of one of the resistance elements, means operated by the device incident to an unequal distribution of current due to variation in resistance of one resistance element for restoring said resistance and cooling elements to normal position and recording means operated by the last named means.

6. A recording instrument comprising a movable member responsive to the condition to be measured, two resistance elements, cooling means adapted to be moved toward and from said elements to vary the temperature thereof, an electro-motive device in circuit with said elements operable on unequal distribution of current in the elements incident to variations in temperature thereof, means operated by said member for moving the cooling means toward one element to vary the temperature thereof, means operable by the device for restoring the elements and cooling means to normal position and recording means operated by the last named means.

7. In a recording instrument, a swinging member operable in accordance with variations of a physical phenomenon, resistance elements pivotally supported and located on opposite sides of said member whereby when there is relative movement therebetween the member is brought into juxtaposition to one or the other of said elements to vary the resistance thereof, a motor in circuit with said elements adapted to be rotated in one direc-

tion or the other depending upon variation in distribution of current through said elements, connecting means between the motor and resistance elements whereby the motor swings said elements to normal position when the swinging member approaches one or the other of said elements.

8. In a recording instrument of the relay type, an oscillatable member actuable in accordance with the condition to be measured, a pair of resistance elements pivotally supported to lie on opposite sides of said member so that when the member is oscillated it moves toward one and away from the other resistance, a reversible motor in circuit with said elements adapted to be driven by unequal distribution of current in said elements, and means between said resistance elements and motor whereby when the member is moved adjacent one resistance element the resistance thereof is varied causing an unequal distribution of current whereupon the motor operates to swing said resistance elements to a position where they are equidistant from the member to equalize the flow of current through said elements.

9. An improved recording instrument of the relay type comprising a primary moving system, a pivotally mounted cooling plate adapted to be moved on deflection of the primary moving system, resistance elements adjacent to the sides of the cooling plate and pivotally mounted co-axial to the cooling plate axis and adapted to be heated by the passage of an electrical current, electromagnetic driving mechanism adapted to be operated on variation in the distribution of current in the resistance elements, recording means, gearing connecting the driving mechanism and recording means, and means to impart angular movement to the resistance elements proportional to the movement of the recording means.

10. In a recording instrument of the relay type, the combination of a Wheatstone bridge having two legs adapted to be heated by the passage of current therethrough, means for altering the temperature of one of said legs in accordance with variations in the condition to be measured, an electro-motive device in the arm of said bridge adapted to be operated on variation in distribution of the current in said legs, and means operated by said device for equalizing the temperature of the legs to establish equilibrium in the flow of current in said legs.

11. In a recording instrument of the relay type, the combination of a Wheatstone bridge having two legs adapted to be heated by the passage of current therethrough, means for altering the temperature of one leg relative to the other, incident to variations in the condition to be measured, an electro-motive device in the arm of the bridge adapted to be operated on variation in the distribution of current in said legs and means operated by said device for equalizing the flow of current in said legs.

12. In a recording device of the type described, the combination of a Wheatstone bridge having two legs of high temperature coefficient, an electromagnet having its exciting winding consisting of the other two legs of said bridge and a second winding of the bi-polar induction type consisting of the arm of said bridge, a rotor of conducting material inductively acted upon by the field of said magnet, means responsive to the condition to be measured for altering the temperature of said two first named legs to operate the rotor and means actuated by said rotor for equalizing the temperature of said legs.

13. A recording instrument of the type described comprising a primary moving element responsive to the condition to be measured, resistance elements, means operable by said primary element for varying the relative resistance of said elements to cause an unequal distribution of current flow therethrough, a magnetic driving means including a rotor of conducting material inductively acted upon by the field of an electromagnet having an exciting winding connected to a source of alternating current and a second winding of the bi-polar induction type distributed on a plurality of poles carrying a current determined by the unequal resistance of said elements, means actuated by said driving means for equalizing the resistance of said elements and recording mechanism operated by said driving means.

14. An improved recording instrument as set forth in claim 13 wherein the said exciting winding has a tapping at an intermediate point, the resulting sections of the winding being connected in circuit with the resistance elements so as to form a bridge system substantially equivalent to a Wheatstone bridge, the bi-polar windings being connected in the bridge arm of the said system.

15. A recording instrument of the relay type comprising a primary member actuable in accordance with variations in the condition to be measured, a Wheatstone bridge system having two legs of high temperature coefficient of resistance, a pivotally supported furcated member for supporting said two legs parallel to each other, a cooling plate intermediate said legs adapted to oscillate from one leg to the other upon deflection of said primary member but normally occupying a position intermediate said legs, magnetic driving means including a rotor of conducting material, an electromagnet having an exciting winding composed of the other two legs of said bridge, the bridge arm being tapped at an intermediate point of the winding forming a second winding of the bi-polar induction type and distributed on a plurality of poles carrying current determined by

the unequal resistance of said elements, gearing between said driving means and the furcated member whereby when the primary member deflects the cooling plate adjacent one of the legs a current passes through the driving means to move the furcated member to such position that the legs are equidistant from the cooling plate and the bridge is balanced, a recording pen and means interposed between said pen and gearing whereby the pen executes a movement proportional to the deflection of the primary moving system.

16. The combination with two movable members, of means for controlling relative movement of said members comprising a pair of thermal elements carried by one of said members, a thermal conducting element carried by the other one of said members, an electroresponsive means to which said pair of thermal elements are oppositely connected, the said conducting element serving to vary the current through said responsive means in one direction by thermally effecting one of said elements when brought into juxtaposition thereto by its supporting member and varying the current through said responsive means in the other direction upon displacement of the two members in the opposite direction.

17. The combination with two movable members, of means for controlling relative movement thereof comprising electroresponsive means for effecting movement of one of said members, two resistance elements carried by one of said members and oppositely connected to the electroresponsive means, and means carried by the other of said members for varying the resistance of one or the other of said two resistances as the relative positions of said two members vary.

18. The combination with two movable members, of means for controlling relative movement thereof comprising electroresponsive means for effecting movement of one of said members, two spaced electrical conductors carried by one of said members and oppositely connected to said responsive means, and current varying means carried by the other of said members and normally disposed intermediate of said two conductors, whereby the current through one or the other of said two conductors may be varied as the relative positions of the two members vary.

19. The combination with two movable members, of means for controlling relative movement thereof comprising electroresponsive means for effecting movement of one of said members, two spaced resistance elements adapted to be heated by the passage of an electric current therethrough carried by one of said members and oppositely connected to said responsive means, and a cooling plate carried by the other of said members and normally disposed in intermediate spaced relation to said two resistance elements, whereby the current through one or the other of said two elements may be varied by the cooling action of the plate as the relative positions of said two members vary.

20. The combination with two movable members, of means for controlling relative movement thereof comprising electroresponsive means for effecting movement of one of said members, two spaced parallel resistance elements, adapted to be heated by the passage of electrical current therethrough, carried by one of said members and oppositely connected to said responsive means, and a cooling fin carried by the other of said members adapted to swing back and forth between said elements but normally occupying a position intermediate said elements, said fin when deflected from its normal position exerting a cooling effect on the nearest resistance element thereby varying the resistance of that element whereupon the responsive means restores the two members to normal position.

21. The combination with two movable members, one of which has spaced parallel parts and the other of which carries a heat conducting plate positioned between said parts, of means for controlling relative movement of said members comprising an electroresponsive device for effecting movement of one of said members, two resistance elements one carried by each of said parts adjacent said plate and oppositely connected to said device, whereby when the plate is moved adjacent one of said elements the current therethrough due to the cooling action of the plate thereon is varied and the responsive device operated to restore the members to normal position.

22. The combination of two movable members, one of which is positionable in accordance with variations in a value, of means for operating the other member to maintain a predetermined relationship between said members comprising electroresponsive means, two electrical conductors carried by one of said members and oppositely connected to said responsive means, circuit varying means carried by the other of said members adapted to cooperate with one or the other of said conductors upon relative movement between said members to vary the current in the cooperating conductor whereby to operate the responsive means to restore said members to normal position.

23. In a device of the type described, the combination of a deflecting member positionable in accordance with a value to be measured, a movably supported heated means, means operable by the deflecting member for exerting a cooling effect on the heated means, said heated means normally uneffected by the cooling means, and means for restoring said two means to normal po-

sition upon departure therefrom due to movement of the deflecting member.

24. Apparatus of the type described, comprising two relatively movable normally spaced apart members, means for moving one member relative to the other and means including a part on said other member actuable upon departure of said members from said spaced apart relation to restore said members to normal position.

25. In a recording instrument, the combination of a deflecting member responsive to variations in a condition, movable means comprising two spaced apart thermal elements and a third element intermediate said first elements and movable by said deflecting member to and from said thermal elements and adapted to vary the temperature thereof when in proximity thereto, and means responsive to the differential heating of said elements due to the cooling of one of said elements by the third element for moving said first means to restore the balance of heat between said elements and recording means actuated by said responsive means commensurately with the movement of the movable means.

In testimony whereof I affix my signature.

ALEXANDER G. S. SANDISON.