

UNITED STATES PATENT OFFICE.

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CONTROL APPARATUS.

1,356,804.

Specification of Letters Patent.

Patented Oct. 26, 1920.

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To all whom it may concern:

Be it known that I, HENRY BREWER, a citizen of the United States, residing in the city and county of Philadelphia, State of Pennsylvania, have invented certain new and useful Improvements in Control Apparatus, of which the following is a specification.

My invention relates to a system of or apparatus for effecting any suitable control, as temperature control, for producing indications of the effect produced by the control, and for recording the variations, as of temperature, effected by the control.

My invention resides in apparatus, which may be in the nature of recording apparatus or with which a recorder may be co-operatively associated, which controls a circuit or circuits for effecting any suitable or desirable operation, as the control of one or more translating devices, and preferably such as may be employed for controlling temperature, the apparatus comprising structure which is in turn responsive to or controlled by the change in temperature or other condition effected by the translating device or devices, and particularly when a Wheatstone bridge, potentiometer, or any other equivalent or suitable arrangement is employed in association with a galvanometer to effect the control.

My invention resides in apparatus, comprising similar structure, which controls indicating or signaling means, especially when responsive to a change in temperature or other condition effected by the aforementioned control apparatus.

My invention resides also in apparatus of the character referred to in which the galvanometer which effects the controls or indications also controls mechanism for recording the variation or change with time of the temperature or condition effected by the aforementioned control apparatus.

My invention resides in apparatus of the character hereinafter described.

For an illustration of one of numerous forms my invention may take, reference may be had to the accompanying drawing, in which:

Figure 1 is a perspective view of structure embodying my invention.

Fig. 2 is a diagrammatic view illustrating

part of the structure shown in Fig. 1, together with indicating means, controlling means, and associated electrical circuits.

In the illustrated example of my apparatus parts thereof and their mode of operation are similar to those disclosed in prior Letters Patent of the United States to Leeds No. 1,125,699, January 19, 1915, my invention comprehending but not being limited to their employment.

Referring to the drawing, M is an electric motor, or any other suitable source of power, which rotates the shaft 1, preferably at substantially constant speed, which in turn drives the worm 2 meshing with and driving the worm gear 3 secured upon the shaft 4. Pivoted near its upper end is a lever 5 back of which and pivoted upon lever 5 on a horizontal axis is the arm 6 on each end of which is a shoe 7 of cork or other suitable material frictionally engaging the rim 8 of the clutch disk or wheel 9 secured upon the shaft 10. Secured upon the shaft 4 is a cam 11 which periodically engages the lever or member 5 and moves it outwardly away from the disk 9 in opposition to a spring, not shown, thereby lifting the shoes 7 free from the rim 8 of clutch disk 9, the said spring returning the shoes 7 into engagement with the rim 8 after predetermined rotation of the cam 11. Upon the shaft 4 is secured a second cam 12 which, after the cam 11 has lifted the shoes 7 from rim 8, actuates the end of finger 13 on the lower end of the arm 14 secured at its upper end to the member 15 pivoted at 16. Upon the frame or member 15 is secured the member 17, whose upper edge 18 is inclined and increases in height from the center toward each side. Disposed immediately above the edge 18 is the needle or pointer 19 of any suitable measuring or indicating instrument, as for example, a galvanometer of which is the movable coil or element which swings or deflects the needle or pointer 19. At opposite ends of the member 17 are the abutments 21 for limiting the deflection or swing of needle 19. Directly above the needle and beneath which it normally freely swings are the edges 22, preferably straight and horizontal, upon members 23, 23 pivoted at 24, 24, and extending toward each other,

leaving a gap of sufficient width between their inner ends to allow the free entry of the needle 19 when in balanced, zero or mid-position, the needle 19 normally swinging freely between the edge 18 of member 17 and the lower edges of the members 23, 23 which have the downwardly extending arms 25, 25 drawn toward each other by the spring 26. Attached to the lower end of the arm or lever 5 is the triangular plate 27 carrying the pins 28, 28 cooperating with the lower ends of members 25, 25. At opposite ends of the arm 6 are the ears or lugs 29, 29 adapted to be engaged by the cams 30, 30 similar in shape and similarly positioned and secured upon the shaft 4.

Secured upon the shaft 10 is a disk or wheel 31 of insulating material carrying upon its periphery the resistance conductor R, which may be disposed in the form of a helix laid upon the wheel 31. Engaging the resistance R is the stationary contact 32. The disk 31 may be secured to the shaft 10 in any suitable angular relation with respect thereto by the set screw 33 threaded through the hub 34 through which the shaft 10 extends. Secured upon the shaft 10 is a second wheel or disk 35 carrying the arcuate contacts 36 and 37 insulated from each other and preferably from the remainder of the apparatus. The disk 35 is held in any suitable angular position upon the shaft 10 by the screw 38 threaded through the hub 39 through which the shaft 10 passes.

Upon the shaft 10 is similarly secured by screw 40 and hub 41 a third disk 42 carrying the arcuate contacts 43, 44 and 45, all insulated from each other and preferably from the remainder of the apparatus.

While separate disks 31, 35 and 42 are shown, it will be understood that these disks or any two of them may be one and the same unitary structure whereby the different groups of contacts mentioned may be rotated in unison by the shaft 10 and may be adjusted in unison with each other as to angular position upon the shaft 10, particularly with respect to the point of engagement between contact 32 and resistance R on disk 31.

Secured upon the shaft 10 is the grooved pulley or wheel 46 around which passes the cord 47 which passes over suitable pulleys 48 and is secured to the marker or recorder pen 49, movable transversely, on guides, not shown, with respect to the recorder paper P stored upon a roller or spool 50, and having the marginal perforations 51, engaging teeth or pins upon the periphery of the roller 52, secured upon the shaft 53 which is driven by the motor M through the worm 54, gear 55, shaft 56, worm 57 and gear 58.

In the particular electrical system of control of the galvanometer coil 20, a potential

circuit is employed, which, however, may be replaced by any other suitable circuit arrangement. For example, the galvanometer coil may be connected directly in simple circuit with a source of current and a resistance thermometer or other device, or directly in circuit with a thermo-couple.

In the potentiometer circuit the contact 32 is connected by conductor 59 with one terminal of the thermo-couple T, whose other terminal is connected by conductor 60 with a switch contact 61, with which is adapted to engage a movable switch element 62 connected to one terminal of the galvanometer coil 20, whose other terminal 80 connects by conductor 63 with one terminal of the resistance R and one terminal of the resistance 64, which connects through battery or suitable source of current 65, adjustable resistance 66 and conductor 67 with the remaining terminal of the resistance R. To a point between one terminal of the battery 65 and one terminal of the resistance 64 a connection is made through the standard cell S with a switch contact 68 into contact with which the switch lever 62 may be thrown, when it is desired to readjust or calibrate the potentiometer. In the normal operation of the apparatus, however, the switch lever 62 remains in engagement with contact 61.

Conductors 69 and 70 connect with any suitable source of current, the conductor 69 communicating with one terminal of each of the indicating lamps or any other suitable signal or indicating means *r*, *w* and *b*, which may be, respectively, red, white and blue incandescent lamps whose other terminals connect, respectively, with contacts 45, 44 and 43 upon the disk 42. The conductor 70 connects with two brushes 71 and 72, spaced from each other circumferentially of the disk 42 somewhat more than the distance between the contact 44 and the adjacent contacts 43 and 45.

F is a furnace or other structure which, according to one example of an embodiment of my invention, is to be controlled as to its temperature. In the example illustrated heat is supplied to the furnace by a main resistor 73 whose terminals are connected to the conductors 74 and 75, which in turn connect to any suitable source of current, which may be the same source of current to which the conductors 69 and 70 connect. The auxiliary resistor 76 has its one terminal connected to conductor 75 and its other terminal to conductor 77, which connects to the stationary contact 78 of relay structure having the actuating coils 79 and 80 which move the core structure 81 longitudinally, the structure 81 remaining in position to which last actuated by either coil upon deenergization of such coil. In the position shown contacts 78 and 82

are bridged by the contact 83 moved by the core structure 81. A second contact member 84, also moved by the core structure 81, is adapted to bridge and engage the contacts 85 and 86, of which 85 is connected with 82 to the supply conductor 74. Contact 86 connects to one terminal of the coil 79, which in turn is connected to the contact 37 on disk 35, the companion contact 36 being connected to one terminal of the coil 80, whose other terminal connects to the conductor 77. Associated with the contacts 36 and 37 is the brush or stationary contact 87, which connects with supply conductor 75.

The mode of operation is as follows:

Supposing the temperature of the furnace F to be above that desired, the thermo-couple T will produce an electro-motive force greater than that which produces balance in the potentiometer circuits, and the galvanometer coil 20 is therefore energized and deflects its needle 19 toward the right, Fig. 1, whereby due to the periodic vertical movement of the member 15 by cam 12 the needle 19 is clamped between the inclined edge 18 and the lower edge 22 of the right hand member 23, causing the arm 25 to be tilted in a clockwise direction about its pivot 24, thereby pushing on the right hand pin 28 on plate 27, and so tilting the movable or driving clutch member or arm 6 in a clockwise direction, while cam 11 is holding shoes 7, 7 from the rim 8 of clutch wheel 9, the angular movement of the member 6 being dependent upon the degree of deflection of the galvanometer needle 19. The cam 11 soon allows the shoes to again grip the rim 8 of the wheel 9 and soon thereafter the left hand cam 30 engages the ear 29, which has now been elevated, pushing it downwardly, due to rotation of shaft 4, restoring it to the horizontal position indicated, but in so moving back to normal position the clutch member 6 rotates the clutch disk 9 in a counter-clockwise direction, similarly rotating the disks 31, 35 and 42. The action is such as to move the potentiometer resistance R with respect to contact 32 in such direction as to tend to restore balance of the electro-motive-force in the potentiometer to or toward equality with the electro-motive-force produced by the thermo-couple T. But this counter-clockwise movement implies that contact 87 is in engagement with contact 36, thereby energizing relay coil 80, which moves the core structure 81 in such direction as to separate bridging contact 83 from contacts 82 and 78 and to bring bridging contact 84 into engagement with contacts 85 and 86. Due to separation of contact 83 from contact 78 the circuit of coil 80 is broken and the circuit of auxiliary heater 76 is also broken so that the temperature of the furnace will descend. During further

step movements of shaft 10, in a counter-clockwise direction, controlled by the galvanometer needle 19 under control of the so varied resistance of R, a condition will sooner or later be reached where the temperature of the furnace is at or near the desired temperature, in which case the electro-motive-force produced by the thermo-couple T will be less than before and such that it is substantially equal to the electro-motive-force fall in the potentiometer circuits, and accordingly there will be no deflection of the galvanometer needle 19, which then remains in the free space between the members 23, 23, and the periodic or successive upward movements of the frame 15 produce no effect as to setting the clutch member 6.

Should the temperature of the furnace fall too low for any reason, the electro-motive-force produced by the thermo-couple T will be still lower than before, with resultant deflection of galvanometer needle 19 toward the left, causing a clockwise movement of the disk 9 and shaft 10 by mode of operation similar to that above described. This will bring brush 87 into engagement with contact 37, whereby relay coil 79 will be energized, causing the core structure to return to the position illustrated, whereupon the auxiliary resistor 76 is again brought into circuit, tending again to raise the temperature of the furnace.

The lamps or other indicators *r*, *w* and *b* may be located at any desired point, either near the recorder structure or near the furnace, or both, in which latter case the lamps are duplicated and connected in parallel with each other.

When the temperature of the furnace is that desired, the lamp controlling contacts are in the position indicated in Fig. 2. In this case the white light *w* only is glowing, the same being energized from conductor 70 through either or both brushes 71 and 72, contact 44, lamp *w*, to conductor 69. This indicates that the furnace is at or quite near the desired temperature. Should the temperature of the furnace be only somewhat above the desired temperature, contact 71 will be in engagement with contact 45, while contact 72 is still in engagement with contact 44. This will cause both lamps *w* and *r* to glow, which will indicate, due to the fact that lamp *r* is glowing, that the temperature is too high, but the simultaneous glowing of lamp *w* will indicate that it is only slightly too high. However, if the disk 42 has been rotated by the automatic mechanism, due to still higher temperature, to a position where both brushes 71 and 72 engage contact 45, lamp *r* only will glow and so indicate that the temperature is far too high. Similarly, when the temperature is somewhat below normal or desired temperature, contact 72 will be in engagement

with contact 43, while contact 71 is still in engagement with contact 44. This will cause lamps *b* and *w* to glow, and so indicate that the temperature is below normal or desired temperature. If, however, the temperature is far below normal, the disk 42 is in such position that both brushes 71 and 72 are in engagement with contact 43, whereby blue lamp *b* only is glowing, indicating a temperature far below normal.

While these operations of automatically controlling the temperature of the furnace and of indicating its temperature are performed, an actual record of the temperature variations of the furnace *F* with time are produced by the marker 49 drawing an ink or pencil mark 88 upon the recorder paper *P*, which moves in the direction indicated by the arrow.

While in connection with the particular example of my invention described I prefer to employ a potentiometer in association with the thermo-couple *T*, it will be understood that the couple *T* may when suitable be connected directly in series with the galvanometer coil 20, independently of the potentiometer arrangement, though such connection of the couple and galvanometer does not effect so nice a control as may be desired, particularly when the apparatus is also employed as a recorder.

In lieu of the thermo-couple *T* any other suitable temperature responsive device, as a resistance thermometer, may be employed; and in case a resistance thermometer is used it may be associated as well understood in the art with the galvanometer coil 20 and resistance *R* in a Wheatstone bridge arrangement. The resistance thermometer may for some purposes be connected in circuit with a suitable source of current and the galvanometer in simple circuit arrangement.

It will therefore be understood that my invention is not limited to the particular circuit arrangements and devices employed, but comprehends any suitable means for controlling the deflecting member, either of the galvanometer or any other suitable deflection instrument, whether electrical or mechanical, in response not only to temperature, but any other changing condition which it is desired to control or of whose changes it is desired to give indications or a record.

While in the heating apparatus herein disclosed the heating agent is electrical energy, any other types of heater may be controlled, for example, those using fluid or gaseous fuel.

In lieu of operating as an auxiliary resistor or burner, the member 76 may be the main or sole resistor or burner of a furnace or the like.

While there is herein disclosed apparatus for performing the three functions of con-

trol, indication and recording, it will be understood that my invention is not limited to the use of all of them, but comprehends either of the controlling or indicating features solely or in combination, and either of the controlling or indicating features solely with the recording feature, or the controlling, indicating and recording features in combination.

What I claim is:

1. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device, and means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power.

2. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device effecting a change of condition to which said deflecting member is responsive, and means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power.

3. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater, and means for controlling said heater comprising a third member actuated by said source of power under the control of said deflecting member.

4. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater, and means for controlling the same comprising fixed and movable contacts, of which a movable contact is moved by said source of power under control of said deflecting member.

5. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater effecting a change of temperature to which said deflecting member is responsive, and means for controlling said heater com-

prising a third member actuated by said source of power under the control of said deflecting member.

6. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater effecting a change of temperature to which said deflecting member is responsive, and means for controlling the same comprising fixed and movable contacts, of which a movable contact is moved by said source of power under control of said deflecting member.

7. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device, means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power, indicating means, and means controlling the same comprising a third member actuated by said source of power under control of said deflecting member.

8. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device effecting a change of condition to which said deflecting member is responsive, means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power, means for indicating a condition of said translating device comprising an indicator, and means controlling the same actuated by said source of power under control of said deflecting member.

9. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater, means for controlling said heater comprising a third member actuated by said source of power under the control of said deflecting member, an indicator, and means for controlling the same actuated by said source of power under the control of said deflecting member.

10. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflect-

ing member controlling actuation of said second named member by said source of power, a heater, means for controlling the same comprising fixed and movable contacts, of which a movable contact is moved by said source of power under control of said deflecting member, an indicator circuit, and contacting means controlling the same actuated by said source of power under the control of said deflecting member.

11. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater effecting a change of temperature to which said deflecting member is responsive, means for controlling said heater comprising a third member actuated by said source of power under the control of said deflecting member, means for indicating a condition produced by said heater comprising an indicator, and means controlling the same actuated by said source of power under control of said deflecting member.

12. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater effecting a change of temperature to which said deflecting member is responsive, means for controlling the same comprising fixed and movable contacts, of which a movable contact is moved by said source of power under control of said deflecting member, an indicator and its circuit for indicating a condition produced by said heater, and means for controlling said circuit actuated by said source of power under control of said deflecting member.

13. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device, means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power, and a recorder having a marker actuated by said source of power under control of said deflecting member.

14. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device effecting a change of condition to which said deflecting member is re-

sponsive, means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power, and a recorder having a marker actuated by said source of power under control of said deflecting member.

15. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater, means for controlling said heater comprising a third member actuated by said source of power under the control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

16. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater effecting a change of temperature to which said deflecting member is responsive, means for controlling said heater comprising a third member actuated by said source of power under the control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

17. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device, means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power, indicating means, means controlling the same comprising a third member actuated by said source of power under control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

18. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a translating device effecting a change of condition to which said deflecting member is responsive, means for controlling the same comprising fixed and movable contacts of which a movable contact is moved with said second named member by said source of power, means for indicating a condition of said translating device comprising an indicator, means controlling the same actuated

by said source of power under control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

19. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater, means for controlling said heater comprising a third member actuated by said source of power under the control of said deflecting member, an indicator, means for controlling the same actuated by said source of power under the control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

20. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member, said deflecting member controlling actuation of said second named member by said source of power, a heater effecting a change of temperature to which said deflecting member is responsive, means for controlling said heater comprising a third member actuated by said source of power under the control of said deflecting member, means for indicating a condition produced by said heater comprising an indicator, means controlling the same actuated by said source of power under control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

21. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a translating device effecting a change of condition to which said galvanometer is responsive, and means for controlling said translating device actuated by said source of power under control of said deflecting member.

22. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a heater, means responsive to temperature changes produced by said heater controlling said galvanometer

ter, and means controlling said heater actuated by said source of power under control of said deflecting member.

23. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a translating device effecting a change of condition to which said galvanometer is responsive, means for controlling said translating device actuated by said source of power under control of said deflecting member, indicating means, and means controlling the same actuated by said source of power under control of said deflecting member.

24. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a heater, means responsive to temperature changes produced by said heater controlling said galvanometer, means controlling said heater actuated by said source of power under control of said deflecting member, indicating means, and means controlling the same actuated by said source of power under control of said deflecting member.

25. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a translating device effecting a change of condition to which said galvanometer is responsive, means for controlling said translating device actuated by said source of power under control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

26. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a heater, means responsive to temperature changes produced by said heater controlling said

galvanometer, means controlling said heater actuated by said source of power under control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

27. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a translating device effecting a change of condition to which said galvanometer is responsive, means for controlling said translating device actuated by said source of power under control of said deflecting member, indicating means, means controlling the same actuated by said source of power under control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

28. The combination with a galvanometer having a deflecting member, a source of power, a member adapted to produce a change in the deflection of said galvanometer, said deflecting member controlling actuation of said second named member in opposite directions by said source of power according as said deflecting member deflects in one direction or the other, a heater, means responsive to temperature changes produced by said heater controlling said galvanometer, means controlling said heater actuated by said source of power under control of said deflecting member, indicating means, means controlling the same actuated by said source of power under control of said deflecting member, and a recorder having a marker actuated by said source of power under control of said deflecting member.

29. The combination with a heating device, of means responsive to the temperature thereof, recording mechanism controlled by said means, and a controller for said heater comprising means actuated in unison with the marker of said recorder.

30. The combination with a heating device, of means responsive to the temperature thereof, recording mechanism controlled by said means, a controller for said heater comprising means actuated in unison with the marker of said recorder, means for indicating the temperature resulting from control of said heater comprising an indicator, and a controller therefor moving in unison with the marker of said recorder.

31. The combination with a member capable of deflecting in opposite directions, of a source of power, a member adapted to pro-

duce a change in the deflection of said deflecting member and actuated by said source of power under control of said deflecting member, means effecting a change of condition to which said deflecting member is responsive, a plurality of electro-magnetic windings, and fixed and movable contact structure controlling said windings, the movable structure of said contact structure actuated by said source of power under control of said deflecting member.

32. The combination with a member capable of deflecting in opposite directions, of a source of power, a member adapted to produce a change in the deflection of said deflecting member and actuated by said source of power under control of said deflecting member, means effecting a change of condition to which said deflecting member is responsive, a plurality of indicators, and contact structure controlling the same, the movable structure of said contact structure actuated by said source of power under control of said deflecting member.

33. The combination with a member capable of deflecting in opposite directions, of a source of power, a member adapted to produce a change in the deflection of said deflecting member and actuated by said source of power under control of said deflecting member, means effecting a change of condition to which said deflecting member is responsive, a plurality of indicators, and contact structure controlling the same actuated by said source of power under control of said deflecting member to indicate in which direction said deflecting member has deflected.

34. The combination with a member capable of deflecting in opposite directions, of a source of power, a member adapted to produce a change in the deflection of said deflecting member and actuated by said source of power under control of said deflecting member, means effecting a change of condition to which said deflecting member is responsive, a plurality of indicators, and contact structure controlling the same actuated by said source of power under control of said deflecting member to indicate when said deflecting member is in normal position and when slightly deflected.

35. The combination with a galvanometer having a member deflecting in opposite directions, of a source of power, electrical means controlling said galvanometer, said means comprising means variable by said source of power under control of said deflecting member of said galvanometer, means cooperating with said second named means in controlling said galvanometer, and means for controlling said last named means actuated by said source of power under control of said deflecting member.

36. The combination with a galvanometer

having a member deflecting in opposite directions, of a source of power, electrical means controlling said galvanometer, said means comprising means variable by said source of power under control of said deflecting member of said galvanometer, means cooperating with said second named means in controlling said galvanometer, a plurality of indicators for indicating when said deflecting member is in normal position or to either side thereof, and a plurality of contacts for controlling said indicators, controlled by said source of power under control of said deflecting member.

37. The combination with a galvanometer having a member deflecting in opposite directions, of a source of power, electrical means controlling said galvanometer, said means comprising means variable by said source of power under control of said deflecting member of said galvanometer, means cooperating with said second named means in controlling said galvanometer, means for controlling said last named means actuated by said source of power under control of said deflecting member, and a marker actuated by said source of power under control of said deflecting member.

38. The combination with a galvanometer having a member deflecting in opposite directions, of a source of power, electrical means controlling said galvanometer, said means comprising means variable by said source of power under control of said deflecting member of said galvanometer, means cooperating with said second named means in controlling said galvanometer, a plurality of indicators for indicating when said deflecting member is in normal position or to either side thereof, a plurality of contacts for controlling said indicators controlled by said source of power under control of said deflecting member, and a marker actuated by said source of power under control of said deflecting member.

39. The combination with a deflecting member, of a source of power, a member adapted to produce a change in the deflection of said deflecting member actuated by said source of power under control of said deflecting member, a translating device, means responsive to changes in condition of said translating device controlling said deflecting member, indicating means, means actuated by said source of power under control of said deflecting member operating said indicating means, and means actuated by said source of power under control of said deflecting means effecting changes in condition of said translating device.

40. The combination with a deflecting member, of a source of power, a translating device, said deflecting member responsive to changes in condition of said translating device, an indicator, and means operated by

said source of power under control of said deflecting member controlling said indicator.

41. The combination with a deflecting member, of a source of power, a translating device, said deflecting member responsive to changes in condition of said translating device, an indicator, means actuated by said source of power under control of said deflecting member controlling said indicator, and means actuated by said source of power under control of said deflecting member controlling said translating device.

42. The combination with a deflecting member, of a motor, a translating device effecting changes of condition to which said deflecting device is responsive, means for controlling said translating device comprising fixed and movable contacts, and motion transmitting mechanism under control of said deflecting member for moving said movable contact by said motor.

43. The combination with a device responsive to changes in a condition, of a structure movable under control of said device, means for indicating the condition to which said device is responsive, and means controlling said last named means comprising a fixed contact and a plurality of movable contacts, said movable contacts carried by said structure.

44. The combination with a temperature responsive device, of a structure movable under control of said device, contacts carried by said structure comprising two long contact members and an intermediate short contact member, indicating devices connect-

ed to each of said contact members, and a fixed contact connected with said indicating means and in cooperative relation with said movable contact members, said fixed contact engaging said intermediate contact member or one or the other of said long contact members when the temperature is normal or above or below normal, respectively.

45. The combination with a temperature responsive device, of a structure movable under control of said device, a series of contact members carried by said structure, a fixed contact adapted to engage one of said contact members or two of said contact members, a series of electrical circuits each of which includes said fixed contacts and one of said contact members, and a lamp in each electrical circuit.

46. The combination with a galvanometer having a deflecting member, of a source of power, a movable structure actuated by said source of power under control of said deflecting member, an electrical circuit including a variable resistance controlling deflection of said deflecting member, said variable resistance carried by said movable structure, a second electrical circuit electrically independent of said first named electrical circuit, and switching means carried by said movable structure controlling said second electrical circuit.

In testimony whereof I have hereunto affixed my signature this 11th day of February, 1919.

HENRY BREWER.