

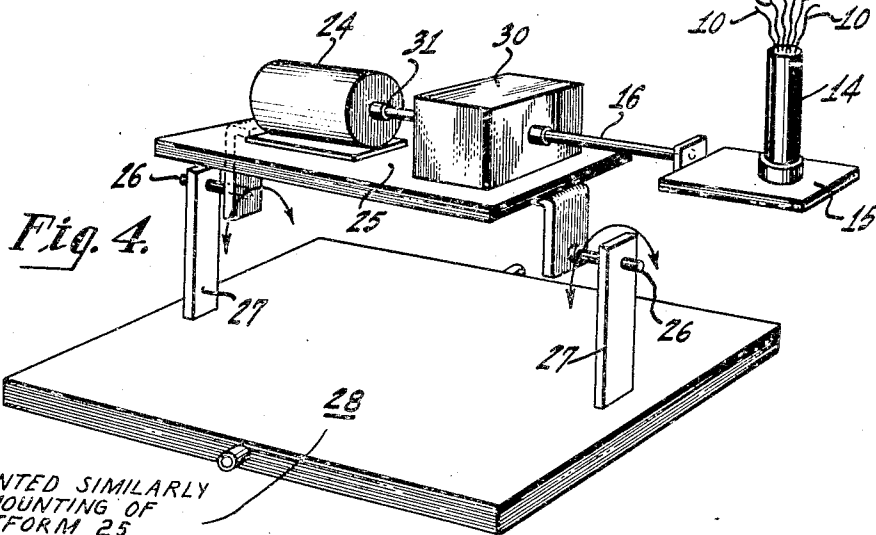
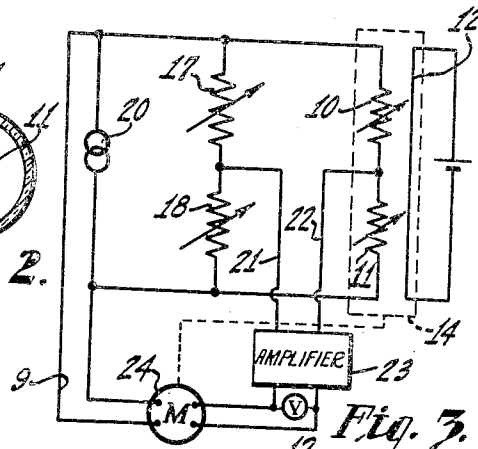
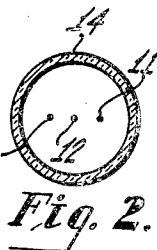
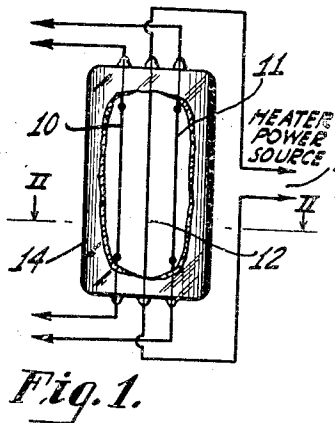
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V. K. ZWORYKIN

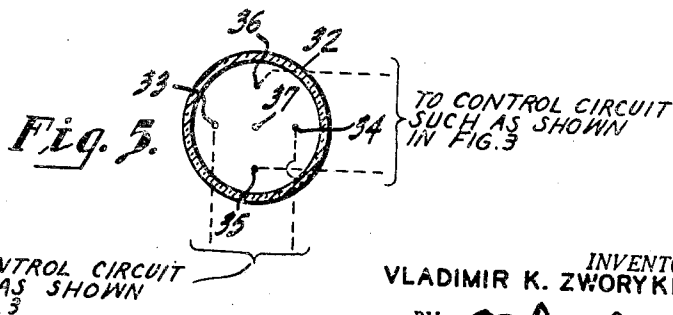
2,440,189

CONVECTION CURRENT RESPONSIVE INSTRUMENT

Filed April 13, 1945



MOUNTED SIMILARLY
TO MOUNTING OF
PLATFORM 25



TO CONTROL CIRCUIT
SUCH AS SHOWN
IN FIG. 3

INVENTOR.
VLADIMIR K. ZWORYKIN

BY

Oluska
ATTORNEY

UNITED STATES PATENT OFFICE

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CONVECTION CURRENT RESPONSIVE INSTRUMENT

Vladimir K. Zworykin, Princeton, N. J., assignor
to Radio Corporation of America, a corporation
of Delaware

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10 Claims. (Cl. 177—351)

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The present invention relates to control and measuring devices and more particularly to an instrumentality wherein an unbalance between two normally balanced resistances develops a potential useful as a control or measure of a condition.

Some of the objects of the present invention are: to provide a novel apparatus wherein a heat convection current functions in association with an electrical agency for a useful purpose; to provide a unit, including two electrical conductors and a heating element, wherein variation of the impinging angle of the convection currents from the heating element upon one conductor causes a differential resistance between the conductors to actuate an indicator, a measuring instrument or a control mechanism; to provide a unit responsive to a change of position for stabilizing a body otherwise subject to the motion imparted to the unit; to provide a device including two electrical conductors so positioned and arranged with respect to a heating element as to have a selected ratio of resistance and functioning upon a change of position with respect to said heating element to vary the resistance ratio, such varied ratio being utilized to operate an associated agency; to provide a device including two electrical conductors arranged in one position to be equally heated by a heating element and balanced as to resistance, and in a second position to be unequally heated and unbalanced as to resistance, whereby an associated agency is caused to operate as a function of the differential resistance; and to provide other improvements as will hereinafter appear.

In the accompanying drawings, Fig. 1 represents one form of the present invention, the same being embodied in a tube shown in elevation; Fig. 2 represents a section on line 2—2 of Fig. 1; Fig. 3 is a diagram of a bridge circuit as associated with the invention for response to a differential resistance caused by an angular impinging of a heat convection current upon one of two electrical conductors; Fig. 4 represents a perspective of an apparatus illustrating one application of the invention; and Fig. 5 represents a transverse section of a tube showing a modified form of the invention for two dimensional operation.

Referring to the drawings, the present invention broadly comprehends mounting two electrical conductors 10 and 11 in position to be heated by a heating element 12 preferably in the form of wire disposed between and spaced from the conductors 10 and 11. These conductors are preferably composed of a metal having a high

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temperature coefficient of resistance in order that small temperature variations will be manifest by the change of resistance in the conductor. Since the device is arranged to function by reason of a change of the angular relation of a convection current from the element 12, the conductors 10 and 11 and the element 12 are preferably mounted vertically parallel and in the same plane, the conductors being generally equidistant from the element 12. The element 12 is included in a circuit energized by a source of voltage 13.

One form of the invention mounts the conductors 10 and 11 and the element 12 in a glass tube 14, preferably sealed and filled with an inert gas as the medium for circulating convection currents emanating from the heating element 12. As long as the circulation is such as to maintain a balance of the resistances of the two conductors, no useful potential is created but when the angular relation of the convection current is altered to influence one conductor more than the other, then the relative temperature change of the conductors produces a differential resistance capable of operating an electrical agent associated therewith.

One mode of operating the invention is to mount the tube 14 to swing with a pendulum movement whereby the conductors 10 and 11, and the element 12, assume an angular position with respect to the vertical axis of the tube. As shown, the tube 14 is clamped or otherwise made fast to a base 15 carried by and keyed to a rock shaft 16 arranged to be oscillated by any suitable mechanical movement. With the base 15 stationary so that the tube 14 and the contained conductors 10 and 11 and the element 12 are vertical, then the convection current from the heated element 12 will maintain both conductors at the same temperature so that the resistance thereof is balanced. If the base 15 is now swung counterclockwise, as seen in Fig. 4, the top of the tube will swing to the left and angularly dispose the conductor 11 above the heating element 12 and the conductor 10 below the heating element 12. As a result, the conductor 11 is in the path of the rising convection current which impinges thereagainst at an angle so that the temperature of that conductor rises to thereby cause a change of resistance giving a differential which serves as a measure or control voltage. When the tube 14 is rocked to the right, a differential resistance is obtained in the same way by the impinging of the convection current upon the conductor 10.

As a means of utilizing this change of resistance for a useful purpose, the two conductors 10 and

11 form respectively two arms of a bridge circuit, shown in Fig. 3, wherein the other arms comprise two resistances 17 and 18 in series relation as a part of a variable resistance whereby the bridge is initially balanced with respect to the conductors 10 and 11. A source of voltage 20 serves to energize the bridge as will be understood and in the present instance is in the form of an A. C. generator. The bridge is preferably balanced with the tube 14 in a vertical position so that the resistance of the two control conductors 10 and 11 is equal, though the invention is not limited to such vertical position, as obviously an inclined position may be taken and a selected ratio of resistance become the zero or reference position. When the tube is moved, either as a swing or bodily laterally, one of the conductors 10 or 11 (according to the direction of motion) has its temperature raised so that the bridge becomes unbalanced. This unbalance creates a voltage in the output, which can be measured by a galvanometer or other indicating instrument, or can be used for control purposes by any suitable amplification. As shown in Fig. 3, the output conductors 21 and 22 are connected to the input of an amplifier 23 which amplifies the differential voltage as a control for a two-phase motor 24. One of the phases is applied from a source which may be the generator 20. The other phase is applied through an amplifier 23. The amplifier 23 is preferably of the type shown in U. S. Patent No. 2,208,623, which has the necessary characteristics to minimize hunting.

Referring to Fig. 4, the motor 24 is shown mounted upon a platform 25 which is carried by journals 26 supported by standards 27 from a fixed base 28. The platform 25 receives an undesired oscillating movement from any suitable source and the function of the tube 14 is to prevent the platform oscillations from being reproduced in the base 15. Thus, the platform 25 may be a part of a ship or other vehicle or object subject to wave motion while the base 15 may be a gun or camera mount which is to be stabilized and to be made unresponsive to the oscillation. A box 30 forms a housing for a reduction gear whereby the speed of the motor shaft 31 is reduced at the shaft 16. Applying the functioning of the bridge of Fig. 3 to the apparatus of Fig. 4, it will be seen that a swing of the platform 25 in one direction will be transmitted to the base 15 and thereby tilt the tube 14 so that one of the conductors 10 or 11 will be heated more than the other thereby to unbalance the bridge, and cause a voltage to operate the motor 24 to turn the shaft 16 in a direction counter to the transmitted swing. When the platform 25 swings in the opposite direction the tube 14 again controls the motor 24, this time to cause a reverse rotation again to nullify any movement to the base 15. The control by the motor 24, in response to the resistance differential of the conductors in the tube 14, is so sensitive that the shaft 16 is held stationary and consequently while the platform 25 continues to oscillate, the base 15 is held fixed.

In Fig. 5 of the drawings a transverse section of a modified form of the invention wherein a tube 32 is provided with two conductors 33 and 34 in the same plane and two conductors 35 and 36 in the same plane but at right angles to the plane of the other two conductors. All of the four conductors are symmetrically disposed with respect to a centrally located heating element 37. Thus, a two dimensional control is possible by including the two pairs of conductors in bridge

circuits, as will be understood. The tube 32 is arranged for mounting on a suitable tiltable unit to function in the manner described for the form of the invention shown in Fig. 1.

The same device can be used for measuring the acceleration. It is due to the fact that when the tube is accelerated, the gas inside of the tube has the tendency to preserve its initial position in space and, therefore, will be displaced in the respect of the filaments. Therefore, the filaments in the opposite side of the displacement will be heated more than the one on the same side. The actual measurements indicate that for certain range of acceleration the change in resistance is linear proportional to acceleration. Such a tube can be used as an indicator for measuring the acceleration or information from this tube can be applied to other devices to produce the controls as forms of acceleration.

I claim as my invention:

1. An apparatus of the character stated, comprising a heating element, means to heat said element, two temperature responsive electrical conductors equally spaced from said element and initially balanced as to resistance by equal convection currents from said element and responsive to changes of the impinging angle of said convection currents relative to said conductors to cause a differential resistance between said conductors, means to mount said element and said conductors in a vertical position, means to tilt said mounting means to cause unequal currents to unbalance said conductors, and an electrical agency associated with said conductors and operable as a function of said differential resistance.

2. An apparatus of the character stated, comprising a heating wire mounted in stretched condition, means to heat said wire, two electrical conductors having the same resistance, means to mount said conductors parallel to said heating wire and equally spaced therefrom, means to move said wire and conductors while maintaining the spaced parallel relation to change the relative intensity of said convection currents from said wire to said conductors to minimize the differential resistance between said conductors, and means responsive to said differential resistance for indicating said relative intensity.

3. An apparatus of the character stated, comprising a heated wire mounted in vertical stretched condition, means to heat said wire, two electrical conductors having the same resistance, means to mount said conductors parallel to said heating wire and equally spaced therefrom so that the wire convection current maintains a state of resistance balance between said conductors, means to swing said wire and conductors while maintaining the spaced parallel relation to change the impinging angle of said convection current to cause a differential resistance between said conductors, means responsive to said differential resistance for restoring a state of balance between said conductors.

4. An apparatus of the character stated, comprising a tube, an inert gas sealed in said tube, a heating wire in said tube, two electrical conductors having the same resistance in said tube means to mount said wire and conductors in stretched parallel relation, said conductors being equally spaced from said wire and in the same plane, means to heat said wire, means to mount said tube to normally maintain said wire and conductors vertical, means to swing said tube to bring one of said conductors in the path of the

convection current from said wire to cause an unbalance of said resistances, and means connected to said conductors to indicate the amount of said unbalance.

5. An apparatus of the character stated, comprising a tube, an inert gas sealed in said tube, a heating wire in said tube, two electrical conductors having the same resistance in said tube, means to mount said wire and conductors in stretched parallel relation, said conductors being equally spaced from said wire and in the same plane, means to heat said wire, means to mount said tube to normally maintain said wire and conductors vertical, means to swing said tube to bring one of said conductors in the path of the convection current from said wire to cause an unbalance of said resistances, and means associated with said conductors and responsive to the differential resistance for restoring the balance between said conductors.

6. An apparatus of the character stated, comprising a tube, an inert gas sealed in said tube, a heating wire in said tube, two electrical conductors in said tube having a predetermined resistance ratio, means to mount said wire and conductors in stretched parallel relation, said conductors being equally spaced from said wire and in the same plane, means to heat said wire, means to swing said tube from its initial position to vary said resistance ratio due to a change in the impinging angle of the convection current on said conductors, and means responsive to the varied differential ratio for restoring said tube to its initial position.

7. An apparatus of the character stated, comprising a tube, an inert gas sealed in said tube, a heating wire in said tube, means to heat said wire, two electrical conductors in said tube having a predetermined resistance ratio, means to mount said wire and conductors in stretched parallel relation, said conductors being equally spaced from said wire and in the same plane, a bridge circuit including said conductors, means to balance said circuit for zero voltage output, means to swing said tube from its initial position to vary said resistance ratio, due to a change in the impinging angle of the convection current on said conductors, and unbalance said bridge to produce a voltage output, and means including a reversible motor responsive to said voltage output to restore said tube to its initial position.

8. An apparatus of the character stated, comprising a heating element, means to heat said element, four temperature responsive electrical conductors equally spaced from said element and arranged in parallel pairs respectively in planes at right angles, said element being common to

said planes, a tube enclosing said element and conductors, means to mount said tube to swing in either conductor plane to change the impinging angle of convection currents from said element to cause a differential resistance between a corresponding pair of said conductors, and an electrical agency for each pair responsive to said differential resistance and operable as a function of said resistance.

9. An apparatus of the character stated, comprising a tube, a heating wire in said tube, two electrical conductors having resistance in said tube, means to mount said wire and conductors in substantially parallel relation, said conductors being spaced from said wire and in substantially the same plane, means to heat said wire, means to mount said tube to normally maintain said wire and conductors in a reference condition whereby movement of said tube causes an unbalance of said resistances, and means connected to said conductors to indicate the amount of said unbalance.

10. An apparatus of the character stated, comprising a tube, an inert gas sealed in said tube, a heating wire in said tube, a plurality of electrical conductors having the same resistance in said tube, means to mount said wire and conductors in stretched parallel relation, said conductors being spaced from said wire, means to heat said wire, means mounting said tube to normally maintain said wire and conductors vertical, means to move said mounting means to bring at least one of said conductors in the path of the convection current from said wire to cause an unbalance of said resistances, and means for indicating the amount of said unbalance.

VLADIMIR K. ZWORYKIN.

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