March 24, 1953 A. P. GAUVREAU 2,632,820

MAGNETICALLY OPERATED CONTROL MECHANISM

Filed June 10, 1949 2 SHEETS—SHEET 1

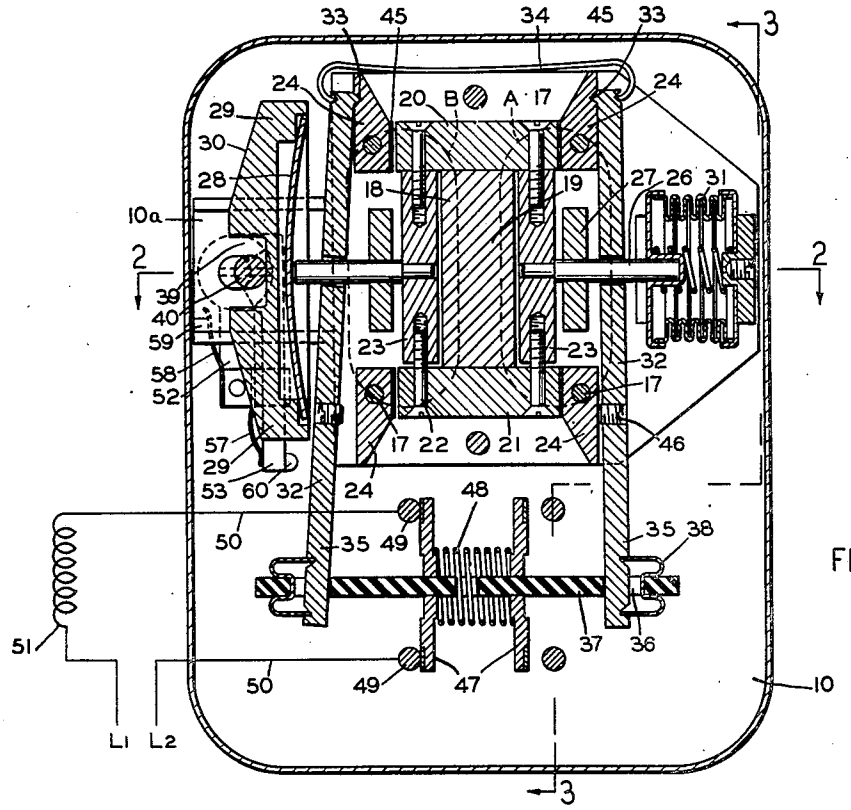


FIG.-1

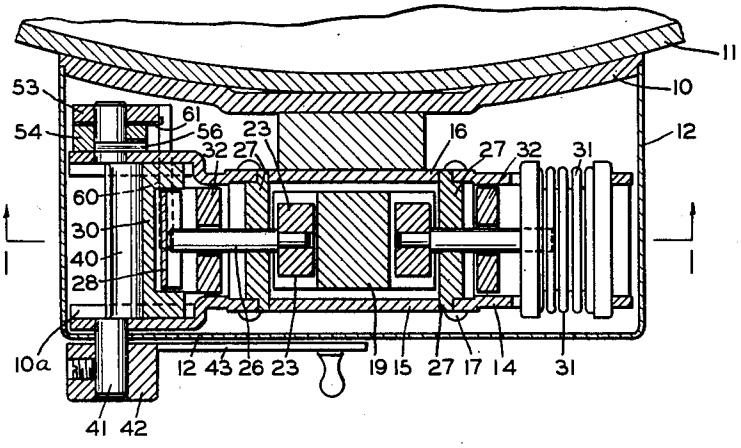


FIG.-2

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MAGNETICALLY OPERATED CONTROL MECHANISM

Filed June 10, 1949 2 SHEETS—SHEET 2

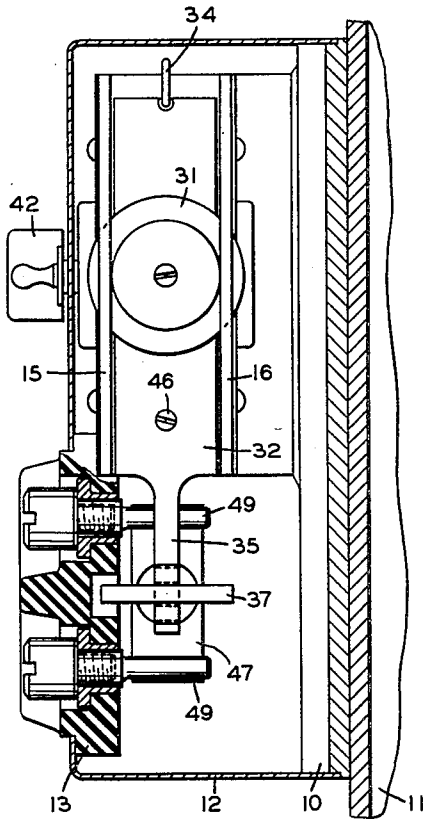


FIG.-3

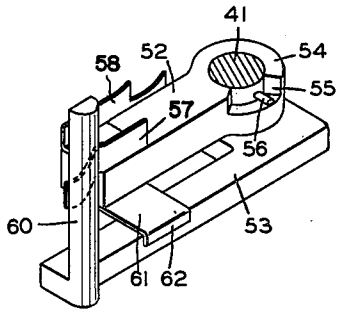


FIG.-5

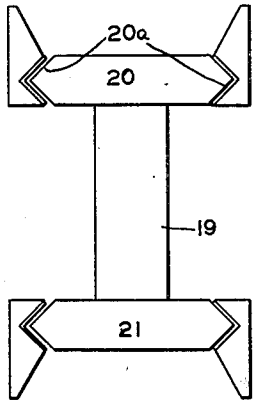


FIG.-6

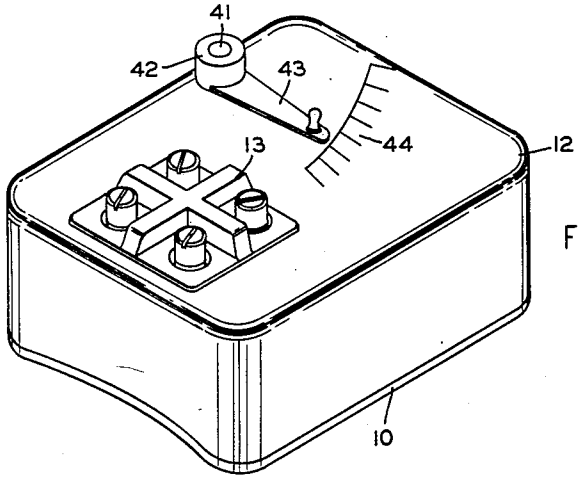


FIG.-4

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UNITED STATES PATENT OFFICE

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MAGNETICALLY OPERATED CONTROL MECHANISM

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Application June 10, 1949, Serial No. 98,307

12 Claims. (Cl. 200—88)

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This invention relates to automatic control mechanism for actuating controlling devices, as the result of variations in a controlling condition. Such mechanisms, for example, are used for automatically opening and closing valves, electric switches or the like, according to variations in temperature, pressure, or the like. More particularly the invention relates to control mechanism of the kind referred to including cooperating relatively movable magnet and armature members, together with power input means therefor for producing relative motion between them and output means by which their relative motion is put to use in the operation or control of the controlling device.

One object of the invention is to provide an improved arrangement or relative disposition of magnet and armature members for the purpose stated which provides considerable amplification or step up in force or motion and thus increases sensitivity.

Another object is to provide magnetically operated mechanism in which a single magnet cooperates with two distinct sets of armature members, one on each side, with increase in attraction on one side and decrease on the other, thus amplifying the output either of force or motion.

Still another object is to provide improved control mechanism embodying two separate operating armatures, both of which are effective upon the controlled device and are influenced by the same magnet, but which are so remote that their leakage paths do not interfere with each other.

Another object is to provide improved control mechanism of the kind described, sensitive to normal variations in a controlling condition, together with emergency cut off means actuated by an abnormal variation in the same or some other condition.

Still another object is to provide improved control mechanism of the character described, including both condition sensitive means for taking care of normal variations in the condition and emergency cut off means effective upon abnormal variation, and in which the same device which is used for adjustments within the range of normal variation is also operative to reset the mechanism after abnormal cut off.

Further objects of the invention in part are obvious and will appear more in detail hereinafter.

In the drawings,

Fig. 1 is a sectional plan view, on the line 1—1, Fig. 2, with the cover omitted, the parts being shown in one of their extreme positions;

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Fig. 2 is a cross-section on the line 2—2, Fig. 1;

Fig. 3 is a sectional elevation on approximately the line 3—3, Fig. 1;

Fig. 4 is an outside perspective view, on a smaller scale;

Fig. 5 is a detail perspective view illustrating certain emergency lever mechanism; and

Fig. 6 is a diagram showing some of the parts in Fig. 1, and illustrating a modification.

While the invention is capable of use in a variety of ways, such as for the control of valves, switches or the like, and the magnet mechanism may be made sensitive to variations in any condition, of which temperature, pressure, water level or the like are typical, for convenience and in no sense of limitation, Fig. 1 illustrates an arrangement for automatically controlling a switch to regulate the supply of current to a water heater. The device is sensitive to variations in the water temperature and automatically actuates the heater switch to maintain any desired water temperature.

The device shown includes a heat conducting metal base 10 of shallow arched or saddle form designed for direct application to the cylindrical wall of a hot water tank 11. Attached to the base is an enclosing shell or casing 12 supporting an insulating block 13. Within the casing and attached to the base is a non-magnetic frame 14 including upper and lower plates 15, 16 connected by rods 17. Between the two plates is mounted a movable magnet or magnet member marked generally 18. This may be either a permanent magnet or an electro-magnet, as will be readily understood, the former being shown for simplicity of illustration.

Magnet 18 includes a body member 19 and two pole members or pole extensions 20, 21 clamped to the ends of the body member by non-magnetic screws 22 and spacers 23, so that the magnet, as a whole, is of generally I form, provided at the ends of the two pole members with two north and two south faces which cooperate through air gaps with four like soft iron members 24 which may be referred to as armature members, or pole members, or pole pieces, as their functions indicate, all rigidly clamped to the frame 14, as by the magnetic rods or rivets 17.

The supporting means for magnet 18 includes a pair of alined non-magnetic rods 26 attached to the spacers 23 and slidable in posts or pillars 27 of the base structure. One rod 26 abuts a leaf spring 28 mounted in the arms 29 of an adjustable carrier 30 and the other abuts a suitable device having a part which moves back and forth in

response to variations in a controlling condition, such as temperature in the form shown. That device here is an expanding and contracting metal bellows 31. Spring 28 and bellows 31 will be later referred to.

The magnetic circuit is of divided or duplex form including two paths in parallel, indicated by the dotted lines, A at the right and B at the left, in Fig. 1. Both paths are alike. Each includes the magnet member 18 and its pairs of pole members 20, 21, and two of the cooperating stationary armature members 24, and a movable armature member or bridge member 32. Each of the movable armature members 32 is an elongated bar of soft iron mounted so that it is capable of back and forth movement into and out of bridging or short circuiting relation (magnetically) with its two cooperating stationary armature members 24. Both ends of member 32 may move. The upper ends of each move to each to open or close a gap between it and a member 24, but as shown, each member 32 is provided with a loose knife edge pivot connection 33 with the member 24, the pivots of both members 32 being tightly held to their seats by a cross connecting spring 34 made of hard brass or other non-magnetic wire, to avoid flux leakage. Thus the reluctance in the path across the pivot connections is maintained fairly constant.

Rods 26 slide freely, without contact, through holes in members 32, and the members 32 at their free ends are provided with arm extensions 35 passing loosely through openings 36 in a contact carrier 37, here shown as a plate made of non magnetic material and confined in place on the free ends of the members 32 by spring clips 38.

Carrier 30, which is slidably mounted between channeled portions 10a of the frame 14, is provided, intermediate its ends, with an elongated slot 39 to receive an eccentric or cam portion 40 of an operating spindle 41 journalled in the upper and lower plates 15, 16 and passing through the cover 12 and provided, outside of the cover, with a knob 42 having an operating arm and pointer 43 traveling over a scale 44 provided with indicia with reference to the variable condition, here temperature. By rotation of spindle 41 the biasing or loading effect of spring 29, in opposition to the effect of bellows 31, may be varied within limits.

In each magnetic path A or B there are four gaps. Two are between the pole members 20 and 21 and two of the stationary armature members 24, and two between said members 24 and one of the movable armature members 32. The first two gaps are quite short, only a few thousandths of an inch, determined by proportioning and positioning of the parts. The third, at the pivot connection 33, may be disregarded because the metal parts are always in contact and reluctance is maintained uniform. The fourth, at the swinging end of member 32, is a rather long gap, because here the parts not only should have sufficient relative motion so that when the gap is closed there is very strong attraction across it, and so that when it is open the parts will be definitely so widely separated that the attractive force is practically negligible, but also because the motion of the swinging ends of members 32 is translated into motion of the contact carrier 37 and should be substantial.

The magnet comprising the pole extensions 20—21 is movable back and forth, horizontally as viewed in Fig. 1, and thereby will reduce or close the two air gaps at one end of the extensions and increase those at the other end, and vice versa.

At the first two gaps referred to, a thin wafer or plate 45, of non magnetic material, may be applied to one or the other of the opposed faces, to prevent sticking when the gap is closed. So also, at the fourth gap, an adjustable non magnetic screw 46 prevents metal to metal contact and also serves to variably limit approach of the parts.

Contact carrier 37, by its motion to and fro, turns on or off the supply of heat which varies the condition to which the bellows 31 is sensitive. Thus it may actuate the valve for a gas burner or the switch in a circuit to an electric resistance heater. The latter form is shown.

Upon contact carrier 37 are slidably mounted two current conducting plates 47, yieldably biased apart by a compression spring 48 and held thereby against lateral portions of the carrier overlapping the plates 47 as indicated in Fig. 3, and cooperating with pairs of fixed contacts 49, post form, mounted upon insulating block 13, to which may be connected lead wires 50 connected to an electric resistance heater, indicated conventionally at 51, for the water in tank 11.

In Fig. 1, the parts are shown in their positions when heat is demanded. Bellows 31 has contracted and spring 28 has moved the magnet 18 to the right, which increased the attracting force in magnetic path A by decreasing the gaps between the pole members 20 and 21 and the right hand stationary armature members 24—24 and caused the right hand armature member 32 to be attracted against the right hand stationary armature members 24—24. All gaps in the left path B are fully open. The heating circuit is at this time closed at the contacts 49—47—49.

As the water temperature rises, the bellows 31 expands and acting through the rod 26 connected to it slowly moves the magnet to the left. Total magnet motion, of course, is only a few thousandths of an inch. During the first half or so of total magnet motion, the armatures 32 and carrier 37 remain stationary. During the same period and thereafter magnetic flux and attractive force decrease in path A and increase in path B due to movement of the pole members 20—21 away from the right hand stationary armature members and toward the ones on the left. Finally, when the attracting force has sufficiently increased, the opposing attracting forces have become so over balanced, or preponderance has been so reversed, that the magnet jumps clear over to its extreme left hand position, closing the left hand gaps of the pole members 20—21 with decided snap action. The effect of such magnet motion is to so increase the attraction of the left hand armature 32 and decrease that of the right hand armature, as to cause them, as a unit, with carrier 37, to suddenly shift to the right, thus opening the switch contacts 49—47—49 with snap action and cutting off the supply of heat.

As another demand for heat arises contrary operations and effects occur, with sudden snap action motion of the carrier to the left, and so on, as will be readily apparent.

One important feature of the invention relates to amplification and consequent increase in sensitivity. Movement of the magnet 18 in either direction simultaneously varies two short gaps to effect a change in the attracting force on the movable armature member at only one gap, since the gap at the pivotal connection is of constant

reluctance, regardless of armature position. Roughly, therefore, 2 to 1 amplification, as between magnet and armature, is secured. Further, as the forces increase in one path, A or B, they decrease in the other, and the carrier 37 connecting the two armatures transmits the force applied to one thereof, to the other, to assist in the operation thereof. These and other properties increase the amplification factor to as much as 7 to 1.

Beyond that, the biasing spring 48 serves as a means for building up force to increase the useful total stroke through which the movable armature members will operate. The parts are so formed and proportioned that the armature stroke is of sufficient length to cause considerable compression of spring 48 during each "carryover." This not only insures good electrical contact and provides for "snap action" on make and break, but it also supplies reserve force to assist in carrier travel upon reverse operation in each direction.

Again, the forms of the pole members 20—21 and armature members and the shapes and areas of their contact surfaces may be varied to take advantage of consequent variations in flux densities at different points in the magnetic paths. In the form shown in Fig. 1 the contact faces on opposite sides of the stationary armature members 24 are in parallel planes. However, these faces may take a variety of shapes, such as cones, prisms, cylinders or the like, and Fig. 6 illustrates conventionally an arrangement in which the faces 20a are of wedge form and lie askew to the direction of magnet motion.

The device shown also embodies emergency safety means so designed that in the event of an abnormal departure or variation in the controlling condition, the energy supply being controlled is promptly cut off, subject to resetting of the mechanism by the operator when normal conditions are resumed.

As shown, one end of spindle 41 serves as a bearing upon which are independently and rotatably sleeved two levers 52, 53, the former provided with a boss 54 having a recess 55 in which works a radial pin 56 on the spindle. The two levers are biased apart (circumferentially of the spindle axis) by a leaf spring 57 fastened to one, 53, and abutting the other, and lever 52 is biased to turn counterclockwise in Fig. 1 by a similar spring 58 abutting a fixed stop 59 mounted on the base.

Lever 53 has an ear 60 lying opposite the adjacent (left hand) movable armature member 32.

In the normal position of these parts, when the relay is taking care of normal fluctuations in the controlling condition, the two levers are locked together, with spring 57 flexed under tension, by the embrasure of lever 53 by a bimetal arm 61 attached to lever 52. The hooked end portion 62 of the arm extends over or around the side edge of lever 53. These parts are all located at the upper end of spindle 41 as viewed in Fig. 1 close to the base plate 10 and hence the bimetal arm 61 is sensitive to variations in temperature of the water in the tank, in the form shown.

During normal temperature variations the emergency parts just described, and illustrated in Fig. 5, occupy the positions shown, and simply lie idle within the casing having no effect upon other parts. Particularly, the movable armature member 32 is freely movable without interference by the emergency parts. Also, the slot 55 in boss 54 is long enough (circumferentially) to permit rotatable adjustment of the spindle 41 to vary the working temperature within the full range of the scale 44, without effect upon the emergency parts. The device may be so constructed, calibrated and adjusted, for example, as to take care of a variation in temperature between 90 and 190 degrees.

However, should the temperature rise more than 10 degrees, more or less, above the range referred to, e. g. to 200 degrees or more, the bimetal arm 61, sensitive to water temperature, flexes and its outer end bends upwardly in Fig. 5 sufficiently to release it from the lever 53. The two levers thereupon become sensitive to the stored power in the flexed spring 57, which immediately separates said levers, turning lever 53 counterclockwise in Figs. 1 and 5. During such motion the projections 60 on lever 53 engages the adjacent movable armature member 32. If the armature member is in the position to maintain the contacts 49, 47, 49 closed, the engagement will move it to open them, cutting off the flow of electric current to the heater 51.

As soon as the emergency condition has passed, and normal conditions are restored, the emergency mechanism may be reset by manually rotating the spindle 41 in the counterclockwise direction, Figs. 1 and 5. Pin 56 thereon engages the shoulder at the end of recess 55 and forcibly urges lever 52 toward lever 53, with compression of spring 57, until the bimetallic arm 61 snaps over the edge of lever 53 into interlocking relation therewith. Spindle 41 is then returned to its original position. The emergency parts are then ready for the next emergency operation and other parts function in the ordinary way to take care of normal variations in temperature or other condition. Expansible bellows 31, it will be understood, is filled with any suitable expansible fluid such as butane and is illustrated only as typical of various forms of thermostat that may be employed.

The apparatus described is of simple form, may be made and sold at low cost, is not likely to get out of order in service, and is highly efficient in operation. It may be constructed with minimum bulk in a form adapted to lie flat against the exposed face of a water tank or like device, and is of pleasing appearance. Its operating mechanism provides substantial amplification and not only is extremely accurate in operation, but is also delicate, with a high degree of sensitivity. In addition, it takes care not only of normal variations in the controlling condition, but also of an emergency condition and enables the mechanism to be reset after emergency operation by manipulation of the same device which regulates the condition to be maintained. Other advantages of the invention will be apparent to those skilled in the art.

What I claim is:

1. Control mechanism of the character described, comprising a movable magnet member which is bi-laterally symmetrical about a median plane and is provided on each polar end with oppositely directed pole extensions, means for moving said magnet member, four stationary pole members, a pair on each side of said oppositely directed pole extensions, the pair on one side being spaced from said pole extensions by short gaps and the pair on the other side being spaced from said extensions by long gaps, two movable armature members, one on each side, spaced from said pairs of stationary pole members by work gaps, the movement of said magnet member relative to said stationary pole members, increasing said short gaps and decreasing said long gaps, thereby increasing and reducing the magnetic reluc-

tance between the respective armatures and the stationary pole members, to cause one of the movable armature members to move, means cross connecting the two movable armature members for movement with each other as a unit, and a control device actuated by said movable armature members.

2. Control mechanism of the character described in claim 1, in which each of said movable armature members is in the form of an elongated bar pivotally connected near one end to one of its cooperating stationary pole members by means of a pivot joint, the total reluctance of the magnetic circuit remaining constant regardless of the relative position of said bar to said cooperating stationary pole member, said bar being, near its other end, spaced from the other cooperating stationary pole member by a long gap which is caused to be opened and closed upon magnet member movement back and forth between said pairs of stationary pole members in a manner to vary the said air gaps, between the pole extensions of said magnet member and the said stationary pole members.

3. A control mechanism comprising a two-pole magnet member operable between two pairs of fixed pole pieces, each pole of said magnet magnetically energizing one of the pole pieces of each pair across a short gap of relatively small cross-sectional area between said magnet pole and said pole piece, means for moving said magnet member, motion of said magnet member causing it to alternately energize predominantly one or the other of said pairs of pole pieces, two movable armatures, each disposed across one of said pairs of pole pieces in a manner to be attracted thereto across a respective long gap of relatively large cross-sectional area upon energization of said pair of pole pieces by said magnet member, means connecting said movable armatures to cause them to move with like motions, and a control device actuated by said movable armatures.

4. A control mechanism comprising a two pole magnet member operable between two pairs of fixed pole pieces, each pole of said magnet magnetically energizing one of the pole pieces of each pair across a short gap of relatively small cross-sectional area between said magnet pole and said pole piece, means for moving said magnet member, motion of said magnet member being adapted to alternately energize predominantly one or the other of said pairs of pole pieces, two movable armatures, each disposed across one of said pairs of pole pieces in a manner to be magnetically responsive thereto across respective long gaps of relatively large cross-sectional area, and across respective short gaps of magnetic reluctance substantially unchanging with motion of said armature relative to said pair of pole pieces, means connecting said movable armatures to cause them to move with like motions and a control device actuated by said movable armatures.

5. A control mechanism comprising a two pole magnet member operable between two pairs of fixed pole pieces, each pole of said magnet magnetically energizing one of the pole pieces of each pair across a short gap of relatively small cross-sectional area, means for moving said magnet member, motion of said magnet member being adapted to alternately energize predominantly one or the other of said pairs of pole pieces, two movable armatures, each disposed across one of said pairs of pole pieces and magnetically responsive thereto across respective long gaps of relatively large cross-sectional area and in a manner to be attracted thereto upon predominant energization of said pair of pole pieces by said magnet, means connecting said movable armatures to cause them to move with like motion, one of said armatures moving toward one of said pairs of pole pieces while the other of said armatures moves away from the other of said pairs of pole pieces, and a control device actuated by said movable armatures.

6. A control mechanism comprising a two pole magnet member operable between two pairs of fixed pole pieces, each pole of said magnet magnetically energizing one of the pole pieces of each pair across a short gap of relatively small cross-sectional area, means for moving said magnet member, motion of said magnet member being adapted to alternately energize predominantly one or the other of said pairs of pole pieces, two movable armatures, each disposed across one of said pairs of pole pieces and magnetically responsive thereto across respective long gaps of relatively large cross-sectional area and across respective short gaps of magnetic reluctance substantially constant with motion of said armature relative to said pairs of pole pieces, means connecting said movable armatures to cause them to move with like motions, one of said armatures moving toward one of said pairs of pole pieces when the other of said armatures moves away from the other of said pairs of pole pieces, and a control device actuated by said movable armatures.

7. Control mechanism of the character described, comprising a movable magnet member provided with double ended opposite pole portions, an operating member sensitive to a variable condition for causing movement of said magnet member in one direction or the other, two pairs of stationary pole pieces, a pole piece of each of said pairs spaced respectively from the ends of one pole portion of said magnet member, and the remaining pole pieces of said pairs spaced respectively from the ends of the other pole portion, in each case by a short gap of relatively small cross-sectional area, the length of said gaps being variable by movement of said magnet member and pole portions by said operating member, two armature members movably connected each to one pole piece of one of said pairs of pole pieces and adapted to move relative to the other pole piece of said one of said pairs of pole pieces through a long gap of relatively large cross-sectional area into or out of proximity with said other pole piece responsive to change in magnetic flux therein due to movement of said movable magnet member, connecting means between the two said armature members to cause them to move with like motions, a control device operatively connected to said armature members and actuated by movement thereof.

8. Control mechanism as defined in claim 7, and wherein said magnet member is mounted for linear movement by said operating member.

9. Control mechanism as defined in claim 7, and provided with preadjustable biasing means effective upon said operating member to oppose the operating effect of said operating member.

10. Control mechanism as defined in claim 7, and wherein said operating member comprises means sensitive to normal variation in temperature within a preselected range.

11. Control mechanism as defined in claim 7, and wherein said operating member comprises means sensitive to temperature variation and additional means is provided for moving said

armature members in a control operating direction when said variable condition exceeds a safe operating range.

12. Control mechanism as defined in claim 11, and wherein said additional armature moving means comprises a spring normally restrained by a bimetallic latch element responsive to changes in temperature.

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