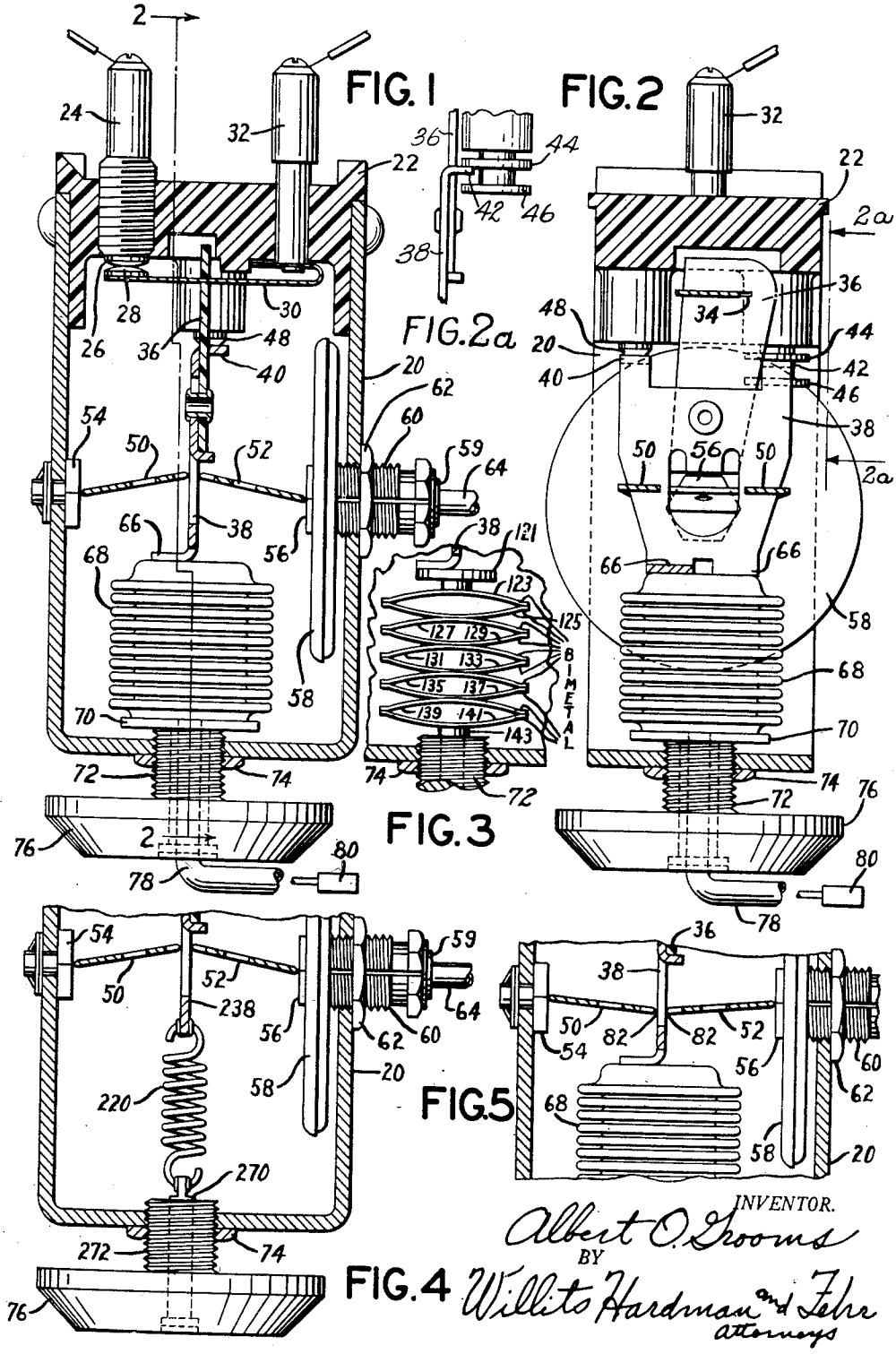
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ELECTRICAL APPARATUS

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ELECTRICAL APPARATUS

Albert O. Grooms, Dayton, Ohio, assignor to General Motors Corporation, Dayton, Ohio, a corporation of Delaware

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This invention relates to electrical apparatus and more particularly to control devices having a diaphragm of limited permissible expansion for actuating a switch member or a valve.

In general, the fluid actuating elements of controls having a limited expansion such as the wafer shaped diaphragm type are less expensive than the accordion bellows type. They can operate under greater pressure but the permissible deflection or expansion is much less. It has therefore been customary to provide compound primary and secondary multiplying levers to provide a double multiplication of the deflection diaphragm. Thus, although the cost of the control has been reduced by the substitution of the less expensive wafer shaped diaphragm for the more expensive bellows, the cost of the remaining portions of the control is increased by the additional expense and difficulties encountered in the use of a double multiplying system.

It is an object of my invention to provide a wafer type diaphragm actuated control which will not require multiplying levers.

It is another object of my invention to use a buckling column arrangement to transmit actuation from a diaphragm to a control device.

It is another object of my invention to provide a snap acting buckling column for transmitting actuation from an actuating diaphragm to a control device.

It is a more specific object of my invention to operate a control device by applying the principal actuating force as a column loading upon a set of substantially rigid toggle links.

In the form of invention shown, two substantially rigid toggle links have their adjacent ends pivotally connected to a transversely arranged connecting member which connects to a switch member. The connecting member is also connected directly to an adjustable spring or a bellows which may serve as a spring. The other end of one of the toggle links is pivotally connected to the adjacent face of a wafer shaped diaphragm which is adjustably mounted upon the adjacent portion of the support. The corresponding end of the other toggle link is pivotally connected to another portion of the support so that the links and the diaphragm are confined between two portions of the support in a column arrangement. Since the links are not directly in alignment, the column arrangement has a tendency to buckle. This buckling is opposed by the spring force of either a spring or a bimetal structure or a bellows. This arrangement under adequate loading provides the snap action movement within the limits of expansion of the diaphragm.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a vertical sectional view through one form of my invention;

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1;

Figure 2*a* is a fragmentary side view taken along the lines 2*a*—2*a* of Figure 2 showing the stop arrangement.

Fig. 3 is a fragmentary view of a modified form of the invention;

Fig. 4 is a fragmentary view of another modified form of the invention; and

Fig. 5 is a fragmentary view of a form of the invention which may be used as a heating control.

Referring now to the drawings and more particularly to Figs. 1 and 2, there is shown a U-shaped metal frame **20** between the open legs of which is mounted a switch block **22** of insulating material. The switch block **22** is provided with an adjustable terminal **24** which is threaded through the switch block and carries a switch contact **26** upon its inner end. By this construction, the switch contact **26** is made adjustable. A movable switch contact **28** cooperates with the adjustable switch contact **26**. This movable switch contact **28** is mounted upon the end of a leaf spring **30** which is anchored at its opposite end to a second terminal **32** which extends through the switch block **22**. The leaf spring **30** is normally sprung or tensioned so that it will tend to hold the contacts **26** and **28** in the open circuit position.

The leaf spring **30** is received within a notch **34** in a connector **36** of electrical insulating material. This connector **36** is riveted to a connector **38** of metal. The connector **38** of metal has a pair of feet **40** and **42** extending from its leg portions. The foot **42** operates between the shoulders **44** and **46** provided upon an adjusting screw threaded through the switch block **22**. An additional stop screw **48** may be provided for cooperating with the foot **40**. This stop **48** is likewise upon the end of a screw threaded through the block **22**. Through the use of these feet **40** and **42** and the stop screws associated with them, the movement of the connectors **38** and **36** as well as the movement of the spring **30** and the contact **28** are limited to a particular range of movements which can be adjusted both as to length and position.

The connector **38** is provided with a pair of notches on each side which receive the knife edges formed on the adjacent ends of the substantially rigid toggle links **50** and **52**. The outer end of the toggle link **50** is provided with a knife edge and is thereby pivotally connected to a bearing member **54** mounted upon the side of the U-shaped frame and provided with a notch for receiving the knife edge upon the outer end of this toggle link **50**. The toggle link **52** is likewise provided with a knife edge upon its outer end by which it is pivotally connected to a bearing pad **56** upon the adjacent face of the wafer shaped diaphragm **58**. The bearing pad **56** is provided with a suitable notch for receiving the knife edge on the adjacent end of the toggle link **52**.

The diaphragm **58** is a hollow flat round container preferably having concentrically corrugated faces and preferably made of stainless steel or other resilient corrosion resisting material. The diaphragm **58** is provided with an integral stem **59** upon which is rotatably mounted an externally threaded sleeve **60** which is threaded within a threaded aperture in the adjacent side wall of the frame **20** so as to adjustably support the diaphragm **58** in the general position shown in Fig. 1. A lock nut **62** may be provided for locking the sleeve **60** in any suitable location. The stem **59** is provided with a capillary tube **64** which may connect to a thermostat tube or some other source of fluid pressures. The sleeve **60** must be adjusted to cause the spring function of the diaphragm **58** to apply at all times a component of force along the axis of the bellows **68** which is greater than the combined spring force of the bellows **68** and the spring **30** and all friction and drag. This insures snap action in both directions.

As shown, the switch contacts **26** and **28** close when the connecting members **36** and **38** move towards the switch block **22** and open when the connecting members **36** and **38** move away from the switch block **22**. This arrangement could be reversed if it is desired to reverse the actuation in this way. The inner ends of the toggle links **50** and **52** are with the diaphragm **58** arranged in the form of a buckling column which buckles in the direction of the switch block **22** so that any expansion of the diaphragm **58** will force the connecting members **36** and **38** as well as the spring **30** and the contact **28** toward the switch closing position.

The opposite end of the connecting member **38** is provided with a pair of feet **66** welded or otherwise bonded to the flexible metal bellows **68**. The opposite end of

this bellows 68 is sealed to a plate 70 provided with a tubular stem rotatably mounted within a hollow screw 72. This hollow screw 72 is threaded through a threaded aperture in the yoke portion in the frame 20 and may be provided with a lock nut 74 for locking it in position and a dial knob 76 for moving the screw 72 to any desired adjustment position in order to adjust the location of the adjacent end of the bellows 68. The bellows 68, in this particular arrangement, functions as a tension spring and also functions as a second pressure actuated element, if desired. The tubular stem of the plate 70 is connected to a capillary tube 78 opening into the interior of the bellows 68 and connecting with a thermostat bulb 80 or some other suitable source of fluid pressure actuation.

Under such an arrangement, the spring of the bellows 68 and the spring of the spring member 30 pull downwardly upon the connecting members 36 and 38 away from the switch block 22 against the force of the toggle links 50 and 52. The force of the toggle links 50 and 52 is derived from the aforesaid column loading applied to them by the resilient metal structure of the wafer shaped diaphragm 58. When the absolute pressure within the wafer shaped diaphragm 58 is reduced below a certain amount, the spring force provided by the bellows 68 and the leaf spring 30 will overcome the opposing force provided by the toggle blades 50 and 52 so that the movable contact 28 will snap to the open circuit position. The snap action results from the fact that when the absolute pressure within the diaphragm 58 is lowered sufficiently to start the movement, the lowered pressure or vacuum will be low enough to insure the rapid completion of the movement because of the aforesaid column loading. In moving in the opposite direction, the absolute pressure within the diaphragm 58 must rise sufficiently to apply a column loading upon the toggle links 50 and 52 sufficient to provide a component of force in the direction of the switch block 22 sufficient to overcome the opposing spring force of the bellows 68 and the leaf spring 30. The absolute pressure within the diaphragm 58 sufficient to start such a movement will be more than sufficient because of the increasing angularity of the toggle links 50 and 52 to insure the rapid completion of such a movement.

The connecting members 38 and 36 may also operate the leaf spring member 30 and the switch contact 28 to open and closed positions by changes in the absolute pressure within the bellows 68 by reason of changes of temperature in the thermostat bulb 80 or some other source of variable absolute pressure. Thus when the absolute pressure within the bellows 68 falls, the opposing force of the toggle links 50 and 52 will be moved to the open circuit position. When the absolute pressure within the bellows 68 rises, the connecting members 36 and 38 will with the assistance of the toggle links 50 and 52 move the switch contact 28 to the closed circuit position. Both of these movements will proceed rapidly to completion thus insuring a snap action. The capillary tube 64 connecting with the diaphragm 58 may be mounted upon an evaporator of a refrigerating system while the thermostat bulb 80 may be mounted in the air stream or vice versa. For air conditioning, the capillary tube 64 could be mounted within the room or space to be conditioned while the thermostat bulb 80 may be mounted in the air outside of the building or vice versa so that the control would be responsive both to room temperature and to temperature outside of the building. This arrangement would provide increased cooling when the outdoor temperatures were higher to compensate for the increased heat radiating and passing through the walls of the building.

This same control can be readily modified to be used for heating purposes as shown in Fig. 5. All that is required is to provide an additional pair of notches 82 upon the opposite side of the dead center location upon the connection member 38 and to move the adjacent inner ends of the toggle links 50 and 52 into these notches 82. With this arrangement, the togggle links 50 and 52 will always operate on the opposite side of dead center from the position in which they operate in Fig. 1. Therefore upon heating of the capillary tube 64, the diaphragm 58 will expand thereby causing the toggle links 50 and 52 to buckle more and move the connecting members 36 and 38 downwardly to move the contact 28 to the open circuit position. Upon a fall in temperature and absolute pressure, the spring force of the bellows 68 will move the connecting members 36 and 38 and the switch contact

28 upwardly to closed position. In this form also, the sleeve 60 must be adjusted to provide a column loading which provides a component of force in the direction of movement of the connecting member 38 which is greater than the total opposing spring force and resistance to movement. Both of these movements will take place with a snap action because the initial absolute pressure level within the diaphragm 58 necessary to start the movement will be more than sufficient to insure rapid completion of the movement.

In Fig. 3, there is shown a modification in which an arrangement of stacked resilient bimetal strips is substituted for the bellows 68. Upon the bottom of the connection member 38, there is provided a plate 121 having a projection upon its lower face to which is fastened a curved bimetal strip 123. The ends of this curved bimetal strip 123 are fastened to the ends of the curved bimetal strip 125 so that the two together are in the shape of full elliptic spring. Both of the bimetal strips 123 and 125 have their high expanding sides upon their convex faces so that upon a rise in temperature, they lift the plate 121 and the connecting member 38. Attached to the midportion of the lower face of the bimetal 125 is a second full elliptical construction of bimetal strips 127 and 129 similarly connected and also arranged with their high expanding sides upon their convex faces. The bimetal strips 131, 133, 135, 137, 139 and 141 are similarly arranged. The bimetal strip 141 is fastened to a pin 143 which is rotatably mounted in the adjusting screw 72.

Upon an increase in temperature, the stack of bimetal members will move the connecting member 38 and the plate 121 upwardly to serve a similar purpose as an increase in pressure within the bellows 68. Likewise a drop in temperature will cause the stack of bimetals to lower the plate 121 and the connecting member 38 to act in the same manner as a fall in pressure within the bellows 68. The stack of bimetals, since they are connected together, function as either a tension or compression spring in addition to their temperature responsive movement. If no temperature responsive movement is desired, the strips may be of some form of spring metal.

In Fig. 4, instead of the bellows 68 of Figs. 1 and 2 or the stack of bimetals shown in Fig. 3, there is substituted a simple coil spring 220 having its upper end hooked through the lower end of a modified connection member 238 and its lower end hooked through an eyelet 270 which is rotatably mounted within the adjusting screw 272 which is threaded through the yoke of the frame 20 and provided with a lock nut 74 and a knob 76. The hooks of the spring 220 are soldered rigidly to the connection member 238 and to the eyelet 270 so that the spring may be adjusted to function either in tension or in compression. The spring 220 may be brought under sufficient tension to cause the control to operate with a positive (gauge) pressure within the diaphragm 58. If the spring 220 is adjusted to function in compression and to push upwardly on the connecting member 238, the control will require a vacuum within the diaphragm 58 for its operation. As in the other figures, the sleeve 60 must be adjusted to provide a column loading sufficient to provide a component of force in the direction of movement of the connecting member 238 which is greater than the total opposing spring force and resistance to movement. In this way, the control may be arranged and readily adjusted to operate under many different fluid pressures and to be responsive to the temperature of various volatile fluids in this or any of the other forms. In this arrangement, the control will operate in the same way as in Figs. 1 and 2 excepting that of course there will be no effect corresponding to the effect of varying pressures within the bellows 68 or the effect caused by varying temperatures upon the stack of bimetals in Fig. 3. That is, the effect will be the same as if the capillary tube 78 were cut so as to allow atmospheric air to flow freely into and out of the bellows 68. The force of the leaf spring 30 adds or substracts from the spring function of the bellows 68 in Figs. 1 and 2, the stack of bimetals in Fig. 3 and the spring 220 in Fig. 4. If desired, the spring 220 could be eliminated by incorporating its spring force into the spring force of the leaf spring 30.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, as may come within the scope of the claims which follow.

What is claimed is as follows:

1. A control including metal means arranged in an unstable column, a diaphragm means located in alignment with the axis of the column and having one face in contact with said metal means, said diaphragm means being provided with a fluid capable of effecting its expansion and contraction, confining supporting means for the opposite face of said diaphragm means and the opposite end of the metal means to apply a variable column loading to force the metal means to deflect laterally upon expansion of the diaphragm means, a control device connected to the deflecting portion of the metal means and operated from one position to another by the deflection thereof, and a temperature responsive means connected to the deflecting portion of said metal means.

2. A control including metal means arranged in an unstable column, a diaphragm means located in alignment with the axis of the column and having one face in contact with said metal means, said diaphragm means being provided with a fluid capable of effecting its expansion and contraction, confining supporting means for the opposite face of said diaphragm means and the opposite end of the metal means to apply a variable column loading to force the metal means to deflect laterally upon expansion of the diaphragm means, a control device connected to the deflecting portion of the metal means and operated from one position to another by the deflection thereof, and a pressure responsive means connected to the deflecting portion of said metal means.

3. A control including two substantially rigid toggle members pivotally connected together at their adjacent ends and arranged in an unstable column, a diaphragm means having one face pivotally connected to the second end of one of said rigid members, confining supporting means for said diaphragm means and the second end of the second of said rigid members, said diaphragm means being provided with a fluid capable of effecting its expansion and contraction to apply a variable column loading to cause a lateral deflection of the pivotal connection between said rigid members, and a control device connected to said pivotal connection and operated from one position to another by the deflection of said pivotal connection and a temperature responsive means connected to said pivotal connection.

4. A control including two substanitially rigid toggle members pivotally connected together at their adjacent ends and arranged in an unstable column, a diaphragm means having one face pivotally connected to the second end of one of said rigid members, confining supporting means for said diaphragm means and the second end of the second of said rigid members, said diaphragm means being provided with a fluid capable of effecting its expansion and contraction to apply a variable column loading to cause a lateral deflection of the pivotal connection between said rigid members, and a control device connected to said pivotal connection and operated from one position to another by the deflection of said pivotal connection and a pressure responsive means connected to said pivotal connection.

5. A control including two substantially rigid toggle members pivotally connected together at their adjacent ends and arranged in an unstable column, a diaphragm means having one face pivotally connected to the second end of one of said rigid members, confining supporting means for said diaphragm means and the second end of the second of said rigid members, said diaphragm means being provided with a fluid capable of effecting its expansion and contraction to apply a variable column loading to cause a lateral deflection of the pivotal connection between said rigid members, and a control device connected to said pivotal connection and operated from one position to another by the deflection of said pivotal connection, said confining supporting means being provided with adjustment means for adjusting the column loading of the diaphragm means and the substantially rigid members.

6. A control including a control device having an extending portion by which it may be moved from one position to another, two substantially rigid toggle members having their adjacent portions pivotally connected to said extending portion, a diaphragm means having one face pivotally connected to a second portion of one of said rigid members, said diaphragm means comprising a resilient metal structure, and confining supporting means confining said rigid members and said diaphragm means

in a column loading great enough to provide a component of force in the direction of movement of said extending portion which is greater than the total resistance to its movement.

7. A control including two substantially rigid toggle members pivotally connected at their adjacent ends and arranged in an unstable column, a diaphragm means having one face pivotally connected to the second end of one of said rigid members, confining supporting means for said diaphragm means and the second end of the second of said rigid members, said diaphragm means being provided with a fluid capable of effecting its expansion and contraction to apply a variable column loading to cause a lateral deflection of the pivotal connection between said rigid members, and a control device connected to said pivotal connection and operated from one position to another by the deflection of said pivotal connection, said diaphragm means comprising a resilient metal structure confined under load by said confining supporting means sufficiently to provide a component of along the line of lateral deflection of the pivotal connection which is greater than the total of any spring and frictional resistance to which the pivotal connection is subject to along said line of lateral deflection.

8. A control including a control device having an extending portion by which it may be moved from one position to another, resilient means connected to said extending portion, two substantially rigid toggle members having their adjacent portions pivotally connected to said extending portion, a diaphragm means having one face pivotally connected to a second portion of one of said rigid members, said diaphragm means comprising a resilient metal structure, and confining supporting means confining said rigid members and said diaphragm means in a column loading, said supporting means being provided with adjustment means for adjusting said column loading sufficiently to provide a component of force in the direction of movement of said extending portion which is greater than the component of force in the same direction of said resilient means.

9. A control including a control device having an extending portion by which it may be moved from one position to another, two substantially rigid toggle members having their adjacent portions pivotally connected to said extending portion, a diaphragm means having one face pivotally connected to a second portion of one of said rigid members, said diaphragm means comprising a resilient metal structure, and confining supporting means confining said rigid members and said diaphragm means in a column loading providing a component of force tending to move said extending portion in one direction, and a spring means acting upon said extending portion to oppose said component of force, said confinement by said supporting means being sufficiently great to provide a component of force greater than the force of said spring means to cause snap-action operation, said control device also including stop means for limiting the movement of said toggle members to a sufficiently short distance on one side of the dead center position of the toggle members to prevent their movement beyond the point at which said component of force becomes less than said force of said spring means.

10. In a thermostatic switching device, a temperature responsive actuator having a definite path of motion in response to temperature change, a pair of links lying end to end in general alignment with said path of motion and being pivotally connected to each other at their adjacent ends, one of said links being pivotally connected at its other end to said actuator, and the other of said links being pivoted at its other end on a fixed pivot, a stationary switch contact and a cooperating movable switch contact arranged to be moved by one of said links as it is rotated due to movement of said actuator.

11. In a thermostatic switching device, a temperature responsive actuator having a definite path of motion in response to temperature change, a pair of links lying end to end in general alignment with said path of motion and being pivotally connected to each other at their adjacent ends, one of said links being pivotally connected at its other end to said actuator and the other of said links being pivoted at its other end on a fixed pivot, cooperating stationary and movable switch contacts, and means carried by one of said links for moving said movable contact as said link is rotated due to movement of said actuator.

12. A control including metal means arranged in an un-

stable column, a diaphragm means located in alignment with the axis of the column and having one face in contact with said metal means, said diaphragm means being provided with a fluid capable of effecting its expansion and contraction, confining supporting means for the opposite face of said diaphragm means and the opposite end of the metal means to apply a variable column loading to force the metal means to deflect laterally upon expansion of the diaphragm means, a control device provided in cooperation with the deflecting portion of said metal means, and temperature responsive means distinct from said diaphragm means cooperating with the deflecting portion of said metal means for deflecting said deflecting portion of said metal means.

13. In a thermostatic switching device, a temperature responsive actuator member having a fixed path of motion in response to temperature change, a fixed member spaced from said actuator member and substantially in alignment with the path of motion of said actuator member, one of said members being adjustably mounted, a pair of links lying end to end between said actuator member and said fixed member and being pivotally connected to each other at their adjacent ends, the other end of one link being pivotally connected to said actuator member, and the other end of the other link being pivotally connected to said fixed member, cooperating stationary and movable switch contacts, and means connected to one of said links for moving said movable contact as said link is rotated due to movement of said actuator member.

14. In a thermostatic switching device, a temperature responsive actuator member having a definite path of movement, a fixed member spaced from said actuator member and substantially in line with the path of motion of said actuator member, one of said members being adjustably mounted, a pair of links lying end to end between said actuator and said fixed member and being pivotally connected to each other at their adjacent ends, one of said links being pivotally connected at its other end to said actuator member and the other of said links being pivotally connected at its other end to said fixed member, stop means for limiting the rotation of said link members in a direction toward alignment and to a point slightly before alignment, a stationary switch contact, and a cooperating movable switch contact arranged to be moved by one of said links as it is rotated due to movement of said actuator member.

15. In a thermostatically operated control device, a pair of link members arranged end to end and being pivotally connected to their adjacent ends, a pivotal connection at the outer end of one of said links, a temperature responsive device having a pivotal connection with the outer end of the other of said links and arranged to act longitudinally thereon in response to temperature changes whereby said link are rotated thereby, one of said pivotal connections being manually longitudinally adjustable, a spring returned control member arranged to be actuated by the rotational movement of one of said links and arranged to normally urge said links in a direction toward alignment, and stop means for arresting the rotation of said links in a direction toward alignment to a point slightly short of alignment.

16. A control including two substantially rigid toggle members having their adjacent portions pivotally connected, a diaphragm means having one face operatively connected to a second portion of one of said toggle members in a column loading relationship, said diaphragm means containing a fluid under pressure, a stop arrangement for limiting the movement of said toggle members to a short distance adjacent to but wholly upon one side of the dead center position, and yielding means acting upon said toggle members to urge said members toward the dead center position within the limits of said stop arrangement.

17. A control including two substantially rigid toggle members having their adjacent portions pivotally connected, a diaphragm means having one face operatively connected to a second portion of one of said toggle members in a column loading relationship, said diaphragm means containing a fluid under pressure, a stop arrangement for limiting the movement of said toggle members to a short distance adjacent to but wholly upon one side of the dead center position, and yielding means acting upon said toggle members to urge said members toward the dead center position within the limits of said stop arrangement, said diaphragm means being in the form of a resilient metal structure confined with said toggle members to such an extent to provide a component of force which is greater than and in alignment with said yielding means.

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