March 16, 1943. G. M. HAUSLER 2,314,211

CONDITION RESPONSIVE CONTROL

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Fig. 2.

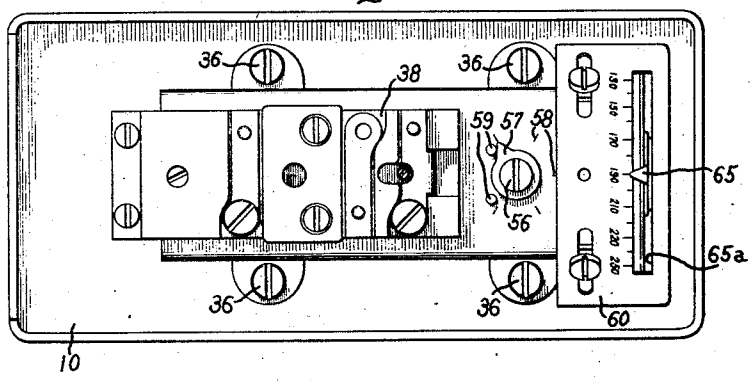


Fig. 1.

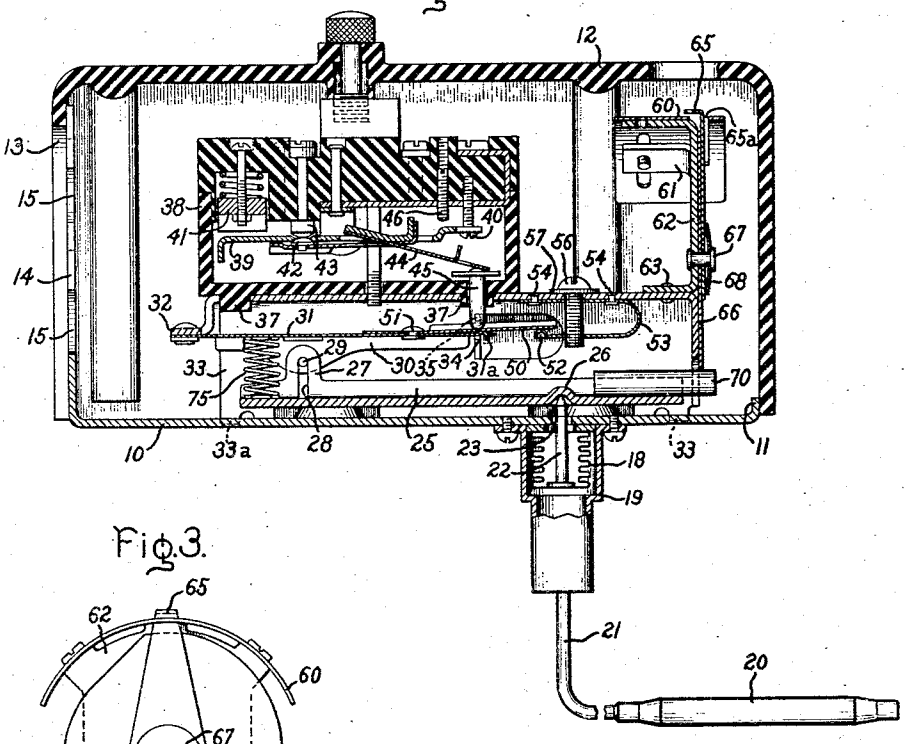
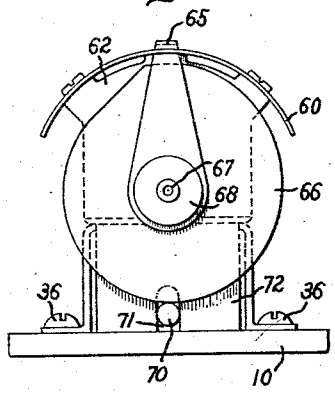


Fig. 3.



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Fig. 4.

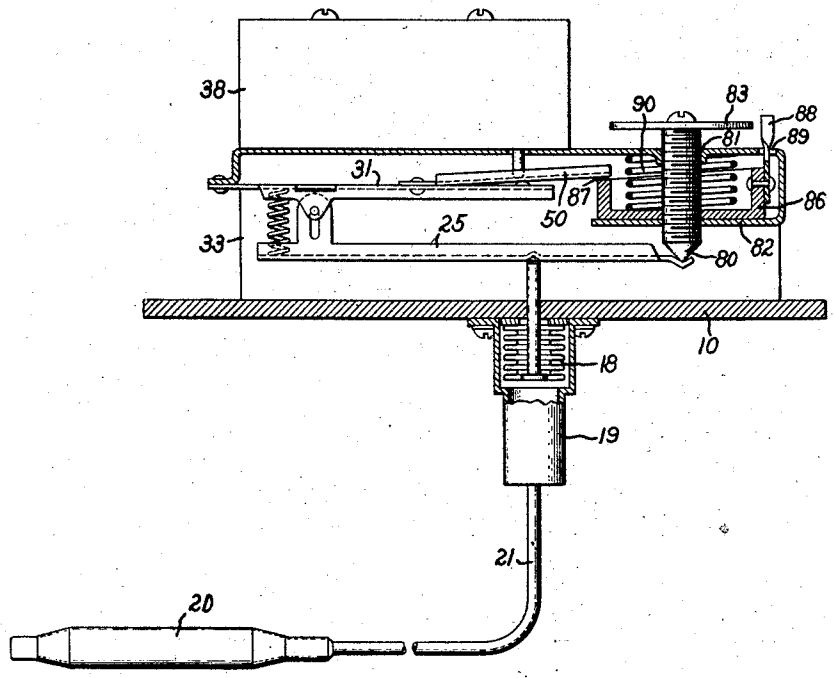
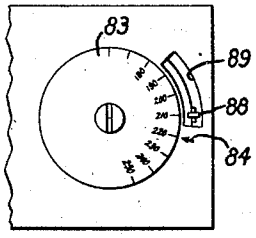


Fig. 5.



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UNITED STATES PATENT OFFICE

2,314,211

CONDITION RESPONSIVE CONTROL

George M. Hausler, Ballston Lake, N. Y., assignor to General Electric Company, a corporation of New York

Application November 27, 1941, Serial No. 420,652

16 Claims. (Cl. 200—140)

The invention relates to condition responsive control, particularly to control devices such as electric switches or the like operable with a differential in response to variations in a predetermined condition such as pressure, temperature or the like.

One of the objects is to provide an improved multiple lever operating mechanism capable of more accurately amplifying relatively small but powerful movements of a condition responsive element to effect operation of a control device.

Another object is to provide the improved operating mechanism with an improved multi-function compression biasing spring operating connection between the condition responsive operating element and the control device so as to bias all the parts of the improved multiple lever system into proper operating relation and thereby take up lost motion therebetween as well as take care of overtravel in case the control condition should vary outside the normal operating range of the control device.

A still further object is to provide the improved operating mechanism with an improved multi-fulcrum differential lever mechanism whereby different values of the control condition required to operate the control device to each of two control positions may be controlled by independently adjusting the fulcrums.

A more specific object is to provide an improved condition responsive operating mechanism of the above character in which the several operating parts are pivotally interconnected in cooperating relation as a unit with the unit pivotally suspended within a channel frame which also carries the improved form of condition calibrating scale as well as the control switch and the condition responsive operating element.

Other objects and advantages of the present invention will become evident from the following description of the accompanying drawings in which Fig. 1 is a mid-sectional view of a condition responsive control switch embodying the invention in a preferred form; Fig. 2 is a top view of the control switch shown in Fig. 1 with the cover removed; Fig. 3 is an end view of the control switch shown in Fig. 1 showing more clearly the details of the calibrating scale mechanism; Fig. 4 is a sectional view of a condition responsive switch embodying the invention in a modified form to enable both the trip and the reset values of the condition required for operation of the switch to be indicated on a common calibrating scale; and Fig. 5 is a top view of the calibrating scale mechanism of the modified switch shown in Fig. 4.

In the improved preferred form of condition responsive control switch illustrated in Fig. 1, all of the parts are mounted on a base 10, preferably provided with an upturned rim 11 for dust-tight engagement with the edges of a removable enclosing cover 12 for the operating parts of the switch. The cover 12 has an opening 13 at one end for receiving the upturned plate 14 in which suitable knock-out openings 15 are provided for receiving the wiring connections of the external circuit to be controlled by the switch.

In the preferred form shown, the condition responsive element 18 is a bellows sealed within the casing 19 to which the bulb 20 is connected by the tube 21, all of which are solidly filled with an expansible liquid so as to produce contraction and expansion of the bellows 18 upon opposite variations of the temperature of the liquid in the bulb 20. The casing 19 is suitably secured to the base 10 so that the operating pin 22 extends upwardly from the bottom of the bellows 18 through the opening 23 formed in the base 10 into operating engagement with the main operating lever 25. Other suitable forms of condition responsive elements may be employed for operating lever 25 if desired. Preferably, the upper end of pin 22 is suitably pointed so as to pivotally seat within the depression 26 formed in the main lever arm 25 and thereby provide an anti-friction pivotal operating bearing therefor. The main lever arm 25 preferably is of channel shape to insure stiffness and is provided with a pair of slotted mounting ears 27 extending upwardly in spaced apart alignment from the channel sides adjacent one end thereof for receiving in the slots 28 the pin 29 which extends between the channel sides 30 of the auxiliary motion multiplying lever 31. The auxiliary motion amplifying lever 31 preferably is formed of resilient material centrally stiffened by a channel shape, as shown, so that it may be pivotally mounted by riveting one end thereof to the downwardly projecting mounting finger 32 formed at one end of the channel frame 33, within which all of the parts of the operating lever mechanism are enclosed. The pivotal movement of auxiliary lever 31 is limited by the spaced apart limit stops 34 and 35 which, as shown, are punched inwardly from the sides of the channel frame 33. If desired, the mounting finger 32 may be bent so as normally to bias the auxiliary lever 31 into engagement with the lower stop 34, but this is not essential.

The channel frame 33 preferably is provided

with suitable guide ears 33a at the four corners thereof which seat within suitable slots formed in the base 10 so as to properly position the channel frame on the base when the holding down screws 36, shown in Fig. 2, are tightened. The channel frame 33 is provided with suitable openings for receiving the anchoring bosses 37 of an enclosed snap action circuit controlling switch unit 38. In the preferred form illustrated, switch unit 38 is of the improved variable opposing bias snap action type more fully described and broadly claimed in the copending patent application Serial No. 403,474, filed July 22, 1941, and assigned to the assignee of the present invention, although other suitable forms of variable bias snap action switch units may be employed if desired.

Briefly, the improved form of switch unit 38 illustrated has a centrally pivoted contact operating lever 39 formed of magnetic material and variably biased into the position in which it is shown in engagement with the stop 40 by the permanent magnet 41 so as to carry the resiliently mounted movable switch contact 42 into engagement with the stationary switch contact 43. Operation of the movable switch contact 42 to the circuit opening position is effected through the agency of the opposing variable biasing spring strip 44, one end of which is fixedly mounted on the centrally pivoted lever 39 and the other end of which is engaged by the switch operating pin 45 that slides through a suitable guide opening formed in the mounting boss 37. The permanent magnet 41 serves to bias the movable switch contact 42 to the circuit closing position until the magnetic biasing force is overcome by the opposing spring biasing force set up in the spring 44 when the operating pin 45 is raised to effect operation of the centrally pivoted switch operating lever 39 out of engagement with the stop 40 and into engagement with the stop 46, thereby moving contact 42 to the circuit opening position. Due to the decrease in the magnetic biasing force occurring when the lever 39 moves away from the magnet 41, the switch cannot be reclosed until the opposing biasing force of spring 44 is reduced below the decreased biasing force of magnet 41.

In the improved differential operating mechanism of the present invention, the sliding movement of the switch operating pin 45 is controlled by the auxiliary differential regulating lever 50, which preferably is formed of resilient material so as to be pivotally mounted or hinged by securing one end thereof to the auxiliary motion multiplying lever 31 by the rivet 51. The other end of lever 50 engages with the adjustable stop 52 that is provided to vary the operating differential in the manner described hereinafter. The adjustable stop 52 is carried in the path of lever 50 at the end of the spring strip 53 which is suitably secured to the channel frame 33 as by the rivets 54. The position of stop 52 in the path of lever 50 is adjusted by turning the screw 56 which is rotatably mounted in the top of the channel 33 and is in threaded engagement with the spring strip 53. The screw 56 is provided with a pointer 57 for operation over the differential calibration scale markings 58 provided on the top of the channel frame 33 between the limit stops 59, as shown in Fig. 2.

The main temperature calibrating scale 60 is curved so as to be carried upon the bent over fingers 61 of the supporting bracket 62 which is secured to the channel frame 33 by the rivet 63. The movable pointer 65 extends through slot 65a formed in the scale 60 and is fixedly secured to the large adjustment cam 66 which is rotatably mounted upon the rivet 67 extending from the bracket 62 and carrying the resilient washer 68 for holding the cam 66 and pointer 65 in the position to which they may be adjusted.

As shown more clearly in Fig. 3, the adjustment cam 66 has its periphery in sliding seated engagement with the pin 70 which is fixedly secured to and extends from the main operating lever 25 through the guide slot 71 formed in the bent over end 72 of the channel frame 33. Thus the adjustment cam 66 constitutes an adjustable fulcrum having sliding engagement with the pin 70 at the right-hand end of the main operating lever 25.

An improved multi-function biasing means, preferably in the form of a pair of compression springs 75, is interposed between the left-hand end of the main operating lever 25 and the auxiliary motion multiplying lever 31 so as to normally exert a force therebetween to bias the pin 28 into engagement with the upper end of the slots 29. These springs also bias arm 31 into engagement with stop 34, pin 70 into engagement with cam 66, and in addition provide an overtravel yielding connection between the levers 25 and 31 while transmitting the normal operating force and effectively preventing lost motion in the entire motion amplifying lever system. As a result, the improved form of motion multiplying lever mechanism of the present invention more accurately transmits small motions of the condition responsive element, and requires only one fixed pivotal connection to the channel frame 33; namely, the yielding hinge connection of the auxiliary lever 31 to the bent over fingers 32.

Operation

Assuming the main calibration pointer 65 set at the particular temperature value of bulb 20 at which it is desired to open the control switch 38 and also the differential calibrating screw set at the particular differential temperature value at which it is desired that the switch 38 be reclosed, the operation is as follows:

As the temperature to which the bulb 20 is subjected increases, expansion of the liquid enclosed within the sealed system causes the bellows 18 to contract and raise the pin 22 thereby rotating the main operating lever 25 about its sliding pivotal bearing with the adjustment cam 66. The amplified rotary movement of the left-hand end of lever 25 is transmitted through the compressed springs 75 to rotate the auxiliary motion multiplying lever 31 about its pivotal mounting on arm 32 while at the same time maintaining pin 29 in firm engagement with the upper end of the slots 28, and pin 70 in firm engagement with cam 66. This further compresses springs 75 to some extent. As a result, any very slight but powerful movement of the bellows 18 is accurately amplified in the rotary movement of the right-hand end of auxiliary lever 31 with practically no lost motion.

As the right-hand end of the auxiliary lever 31 is moved upwardly, the auxiliary differential control lever 50 remains in contact with the differential adjustment stop 52 until the projecting finger 31a at the end of the lever 31 engages with lever 50. Thereafter, the auxiliary levers 31 and 50 both move as a unit to actuate the operating pin 45 of the switch unit. When the switch op-

erating pin 45 has been raised sufficiently to build up sufficient force in the variable biasing spring 44 to predominate over the magnetic force of magnet 41 on the switch operating lever 39, then the switch contact 42 will be operated with a snap action to the circuit opening position. This will occur with the bulb 20 at substantially the temperature value to which the adjustable calibrating pointer 65 is set when the operating mechanism is once properly calibrated.

In case the temperature to which the bulb 20 is subjected should continue to increase after the opening of the switch, the bellows 18 will continue to contract, thus still further continuing the upward movement of the pin 22 and the rotation of the main operating lever 25. When auxiliary lever 31 engages with its upper limit stop 35, further upward movement of lever 31 and switch operating pin 45 is impossible. Then the pair of springs 75 will be further compressed, and the slots 28 formed in the ears 27 will permit the continued upward movement of the left-hand end of the main lever 25 without introducing any abnormal strains in the lever system. Suitable openings 31 are provided in the auxiliary lever 31 for permitting the upturned ears 27 to pass therethrough in case of excessive overtravel.

When the temperature to which the bulb 20 is subjected decreases after the switch 38 has been opened in the manner described above, the bellows 18 will be expanded to permit the downward biasing force exerted by springs 75 on lever 25 to move the pin 22 downwardly. This in turn will permit the biasing forces of springs 75 and spring 44 to lower the right-hand end of the motion multiplying lever 31 away from stop 35. However, the switch contact 42 will remain in the circuit opening position until the biasing force of the spring 44 has been reduced to a value below the reduced magnetic biasing force tending to reclose the switch contact 42. Consequently, the switch operating pin 45 must be lowered to a position below that at which the switch contact 42 was initially opened. This enables the adjustment of the stop 52 to determine the exact position to which the auxiliary motion multiplying lever 31 must be returned in order to effect reclosure of the switch. Thus, as the auxiliary motion multiplying lever 31 moves downwardly, the end of the auxiliary differential regulating lever 50 will engage with the adjustable differential control stop 52. Thereafter the right-hand end of the differential lever 50 will pivot about stop 52 while the left-hand end of lever 50 continues to be lowered due to the continued lowering movement of the lever 31. When the bulb 20 reaches the predetermined differential temperature value corresponding to the adjustment of the screw 56, switch operating pin 45 will be lowered sufficiently so that the reduced magnetic biasing force of magnet 41 will again predominate over the variable spring biasing force of spring 44, and the switch contact 42 will be returned to the circuit closing position with a snap action. The differential adjustment screw 56, being normally stationary, may be readily adjusted at any time without interfering with the operation of the movable parts of the device. In this respect, the present invention provides further improvements upon the improved differential adjustment invention disclosed and claimed in the patent application Serial No. 403,474 noted above.

With the improved operating mechanism of the present invention, the pointer 65 may be adjusted over the temperature calibration scale 60 so as to vary the point of engagement of the cam 66 with the pin 70 thereby varying the temperature of the bulb 20 required to effect operation of the switch 38 to the circuit opening position. The relatively small but powerful operating force of the bellows 18 is amplified with substantially no lost motion to effect the opening movement of the switch due to the improved operating connection provided by the biasing springs 75. The sliding pivotal bearing between pin 70 and the calibrating cam 66 permits any necessary slight endwise movement of the main operating lever 25 to occur. This is also true of the pointed pivot pin operating connection between the main operating lever 25 and the bellows pin 22. All of these improvements insure reliable and accurate operation of the switch by the condition responsive device.

Fig. 4 shows the improved condition responsive switch operating mechanism provided with an improved modified form of calibrating mechanism specially arranged to enable both the switch opening and reclosing temperature values to be indicated directly on a single calibrating scale. This is accomplished by pivotally mounting the right-hand end of the main operating lever 25 on the pointed end of the main adjusting screw 80 which extends through the channel frame 33 and is in threaded engagement with the arm 82 bent over from the end of the channel 33. The adjusting screw 83 carries a movable temperature calibrating scale which, as shown more clearly in Fig. 5, cooperates with the pointer 84 formed in the channel frame 33 to indicate the temperature value at which the switch 38 is operated to the circuit opening position. A specially formed rotatable cam element 86 rotates about the adjusting screw 80 as an axis as the cam 86 is of sufficient thickness to rotatably engage only with the ends of the threads formed on the screw 80 and thus is not in threaded engagement therewith. The rotatable cam 86 is provided with a spiral cam face 87 for engaging with the right-hand end of the auxiliary differential regulating lever 50 so as to vary the position at which the motion of the right-hand end of this lever is arrested in the switch closing operation. The rotatable cam 86 carries a pointer 88 extending upwardly through the slot 89 formed in the channel frame 33 into cooperating relation with the movable scale 83 carried by the adjusting screw 80, as clearly shown in Fig. 5. The spring 90 serves to hold the rotatable cam 86 in frictional engagement with the arm 82 in the particular position to which it may be adjusted.

The operation of the switch 38 by the bellows 18 in response to variations in the temperature of the bulb 20 in the modified form of the invention shown in Fig. 4 is accomplished by means of the improved operating mechanism in substantially the same manner as previously described. The adjustment of screw 80 determines the temperature to which bulb 20 must be subjected in order to effect the opening of the switch 38 while the adjustment of pointer 88 determines the temperature of the bulb at which the switch 38 is reclosed.

With the improved calibrating mechanism shown in Figs. 4 and 5, both of these temperature values may be indicated directly upon the moving scale 83. In this respect, my present invention provides further improvements in the

improved differential calibrating mechanism described and claimed in my patent application Serial No. 412,415, filed Sept. 26, 1941.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, a control member movable between two control positions, opposing biasing means therefor having a reversible predominance, a main operating lever having lost motion pivotal connecting means adjacent one end thereof, an adjustable fulcrum for engaging the other end of said main lever, condition responsive means having an operating member engaging said main lever between the ends thereof, an amplifying lever overlapping the said one end of said main lever and interconnected with said lost motion pivotal connecting means, means for rotatably supporting one end of said amplifying lever, a compression spring interposed between said amplifying lever and the said one end of said main lever to take up the lost motion in said pivotal connecting means and bias said levers to rotate in opposite directions about said pivotal connecting means and thereby provide both a yielding and a biasing operating connection therebetween, a differential control lever hinged adjacent the other end of said amplifying lever to be moved as a unit therewith to render one of said biasing means predominant over the other to bias said control member to move from one of said positions to the other and to be moved relatively to said amplifying lever to render the other of said biasing means predominant over said one biasing means to bias said control member to return from said other position to said one position, and an adjustable stop disposed in the path of said differential control lever to regulate the said relative movement thereof.

2. In combination, a movable control member, a main operating lever therefor provided with a pair of slotted ears in spaced apart lateral alignment adjacent one end thereof, an adjustable fulcrum for engaging the other end of said main lever, condition responsive means having an operating member engaging said main lever between the ends thereof, an amplifying lever overlapping the said one end of said main lever and having a connecting pin extending through said slotted ears, a differential control lever hinged adjacent one end of said amplifying lever to be moved as a unit therewith to move said control member from one position to another position and to be moved relatively to said amplifying lever to move said control member from said other position to said one position, means for rotatably supporting said amplifying lever, a compression spring interposed between the said one end of said main lever and said amplifying lever to provide a yielding operating connection therebetween, and an adjustable fulcrum for said differential control lever to regulate the said relative movement thereof.

3. In combination, a movable control member, opposing biasing means therefor, condition responsive operating means having an amplifying lever, a differential control member hinged adjacent one end of said lever to be moved as a unit therewith to render one of said biasing means predominant over the other to bias said control member to move from one control position to another and to have relative movement with respect to said lever to render the other of said biasing means predominant over said one biasing means to bias said control member to return from said other position to said one position, and an adjustable stop disposed in the path of said differential control member to regulate the said relative movement thereof.

4. In combination, a control member movable between two control positions, opposing variable biasing means therefor, one variable into predominance over the other to bias said control member to move from one of said positions to the other and out of predominance over the other to bias said member to return to said one position, and condition responsive means having a multiple lever mechanism operated thereby for varying said one biasing means and provided with one adjustable fulcrum for controlling the operation thereof to vary said one biasing means into predominance over the other and a second adjustable fulcrum for controlling operation thereof to vary said one biasing means out of predominance over the other.

5. In combination, a lever pivotally supported at one end and having a pair of levers pivotally connected thereto, a pair of separately adjustable fulcrums, each disposed in the path of a corresponding one of said pair of levers, condition responsive means for moving one of said pair of levers to effect movements of said first lever and the other of said pair of levers, and control means having a member operated by the other of said pair of levers to one control position upon variation of the condition to a value determined by the adjustment of one of said fulcrums and to another control position upon variation of the condition to a value determined by the adjustment of both of said fulcrums.

6. In combination, means responsive to variations in a predetermined condition, a multi-lever mechanism having one lever operated by said condition responsive means and provided with an adjustable fulcrum and another lever connected to be operated by said one lever and provided with a separately adjustable fulcrum, and control means having a member operated by said other lever to one controlling position upon variation of said condition to a value determined by the adjustment of one of said fulcrums and to another control position upon variation of said condition to a value determined by the adjustment of both of said fulcrums.

7. In combination, a control device, a condition responsive multi-lever operating mechanism for said device including a lever pivotally supported at one end and having a second lever hinged adjacent the free end thereof for movement as a unit therewith for operating said control device and a third lever provided with a lost motion pivotal connection intermediate the ends of said first lever, condition responsive means for operating said third lever, an adjustable fulcrum at the other end of said third lever for calibrating said mechanism, and an adjustable fulcrum disposed in the path of said second lever for regulating the operating differential of said mechanism.

8. In combination, a first lever having an operating member hinged thereto, a control device operated by said member, a second lever having a lost motion yielding connection for operating said first lever, a condition responsive element for operating said second lever, and means for varying the response of said element required to operate said device including an adjustable fulcrum for said second lever, and a separately adjustable fulcrum for said hinged member.

9. In combination, a condition responsive element, a floating lever having an operating connection with said element and provided with a pair of slotted ears in spaced apart lateral alignment adjacent one end thereof and a longitudinal pin extending from the other end thereof, control means having a movable operating member provided with a connecting pin extending through said slotted ears, a compression spring interposed between said movable operating member and the said one end of said lever to provide a one-way biased operating connection therebetween, means providing a slotted guide for said longitudinal pin, and an adjustable fulcrum for varying the position of said pin in said slotted guide for controlling the movement of said operating member.

10. In combination, a control device having a control member effective upon movement thereof to each of two control positions and ineffective during movement intermediate said positions, a condition responsive device having an operating member movable in accordance with variations in a predetermined condition, means for operatively interconnecting said members including a supporting lever connected to be operated by said operating member, a multi-fulcrum lever having a fulcrum for abutment with one end thereof and a restricted hinge connecting the other end thereof with said supporting lever to effect pivotal movement of said multi-fulcrum lever away from said abutting fulcrum about the fulcrum of said supporting lever to operate said control member between an intermediate position and one of said control positions and to effect a pivotal movement of said multi-fulcrum lever about said abutting fulcrum to operate said control member between said intermediate position and the other of said control positions, and means for adjusting said abutting fulcrum to vary the operating differential of said control member.

11. In combination, a control device having a control member effective upon movement thereof to each of two control positions and ineffective during movement intermediate said positions, a condition responsive device having an operating member movable in accordance with variations in a predetermined condition, means for operatively interconnecting said members including a multi-fulcrum lever and mechanism operated by said operating member for moving said lever about one fulcrum to effect operation of said control member between an intermediate position and one of said control positions and about another fulcrum to effect operation of said control member between said intermediate position and the other of said control positions, and means for adjusting one of said fulcrums to vary the operating differential of said control member.

12. In combination, control means, condition responsive means having a multi-fulcrum lever mechanism for operating said control means, and means for adjusting said mechanism including an adjusting screw for controlling one fulcrum of said mechanism and having a rotatable calibrating scale element and a separately adjustable concentric cam element rotatably about said screw for controlling another fulcrum of said mechanism and having a rotatable calibrating element cooperating with said scale element.

13. In combination, a control member movable between two control positions, opposing biasing means therefor having a reversible predominance, condition responsive means having a multi-fulcrum lever mechanism for reversing the predominance of said biasing means to effect operation of said control member between said control positions, and means for adjusting said mechanism including a pair of separately adjustable members having interdependent calibrating elements and each controlling a fulcrum of said mechanism.

14. In combination, a control member movable between two control positions, condition responsive means having a multi-fulcrum lever mechanism for operating said member, and means for adjusting said mechanism including a pair of separately adjustable rotatable members having interdependent calibrating elements and each controlling a fulcrum of said mechanism.

15. In combination, control means, condition responsive means having a multi-fulcrum lever mechanism for operating said control means, and means for adjusting said mechanism including a pair of separately adjustable, concentric, rotatable members having interdependent calibrating elements and each controlling a fulcrum of said mechanism.

16. In combination, a condition responsive operating element, a floating lever provided with a lost motion coupling element at one end thereof and a sliding guide element at the other end thereof and having an intermediate operating connection with said operating element, a control device having a movable operating member provided with a coupling element and a biasing element for cooperating with said lost motion coupling element to provide a one-way yielding overtravel operating connection between said floating lever and said operating member, and an adjustable stop in sliding engagement with said sliding guide element for providing a fulcrum for said lever.

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