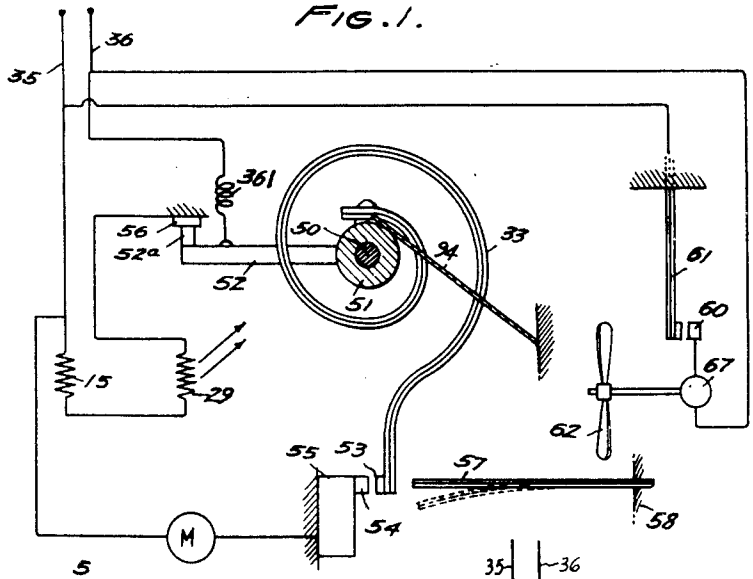
April 11, 1950 W. D. HALL 2,503,259

LOST MOTION CONTROL SYSTEM

Filed Oct. 31, 1944

FIG. 1.



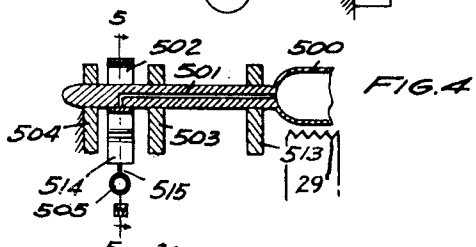


FIG. 4

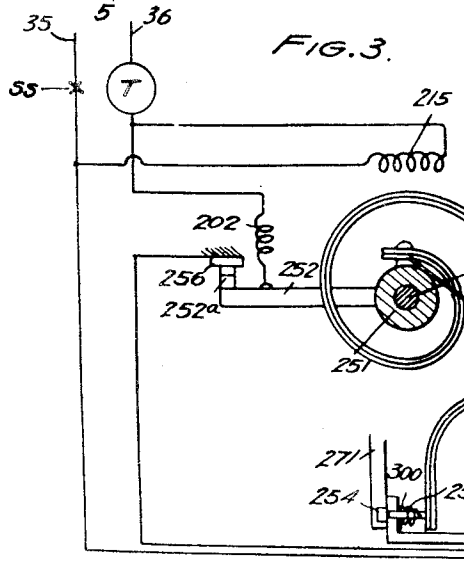


FIG. 3.

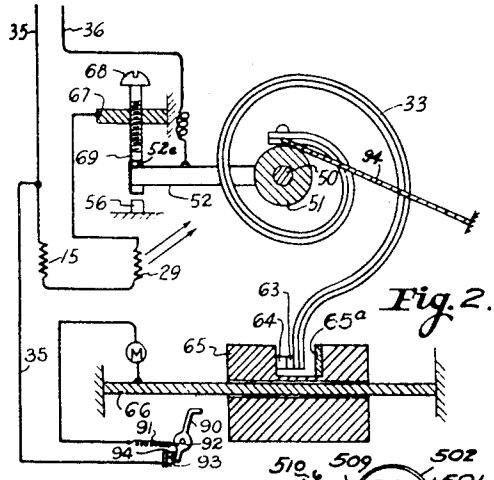


Fig. 2.

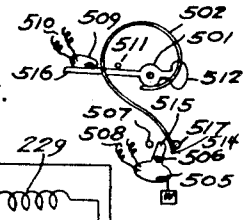


FIG. 5.

INVENTOR

William D. Hall.

Patented Apr. 11, 1950

2,503,259

UNITED STATES PATENT OFFICE

2,503,259

LOST MOTION CONTROL SYSTEM

William D. Hall, Elkins, W. Va.

Application October 31, 1944, Serial No. 561,253

17 Claims. (Cl. 200—138)

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This invention relates to control devices and more particularly to thermally operated slip-friction devices. The primary object is the provision of an improved form of slip friction device.

According to this invention, a thermal element is mounted on a movable support and upon heating of the element it moves its support and thereby creates the "lost-motion" effect that is a part of the operation of slip friction switches.

This application is a continuation in part of my prior copending application S. N. 347,951, filed July 27, 1940, entitled Control systems. The devices shown in Figures 1, 2 and 3 of this application and the description pertaining to those figures are fully disclosed in said prior copending application. My aforesaid prior copending application became abandoned on November 4, 1948, but the inventions disclosed therein were not abandoned since they are being claimed in my copending application Serial No. 735,983, filed March 20, 1947, as well as in this Letters Patent, and in my Letters Patent 2,399,673, entitled Control system, granted May 7, 1946.

In the drawings:

Figures 1, 2, 3 and 4 are respectively sectional views of four forms of the invention; and Figure 5 is an end view of the form shown in Figure 4.

While the system of Figure 1 is very effective for many purposes, it is particularly useful in systems subjected to considerable jarring, and it uses a lost-motion or slip-friction switch having rotary motion instead of linear motion. In Figure 1, a central rigidly supported shaft **50** is composed of stainless steel. An outer sleeve **51** has a diameter slightly larger than shaft **50** and is arranged to freely slip around the shaft **50**. A spring **94** bears downwardly on sleeve **51** and places considerable contact pressure between the sleeve **51** and the shaft **50**. Spring **94** does not engage either the arm **52** or bimetal **33** as this spring bears against a portion of sleeve **51** which is in front of the strip **33** and sleeve-arm **52**. Spring **94** may be omitted from the construction if desired with good operation, since the sleeve **51** and rod **50** may be provided with a proper amount of friction without the spring **94**. The strip **33**, I have found, may be rather heavy and one specimen device has a strip **33** approximately one-half inch wide, 0.05 inch thick, and of five inches developed length.

The coiled bimetallic element **33** is composed preferably of the highest quality heat withstanding bimetal and has an inner end rigidly bolted or welded to the sleeve **51**. The outer end of this bimetallic strip carries a contact point **53**. A

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stationary contact point **54** supported by the rigid block **55** cooperates with contact **53**. The sleeve **51** carries an arm **52** which arm is relatively light as compared to the total weight of the sleeve **51**. This relationship may be effected by making the sleeve much longer in a direction parallel to the shaft than the arm **52** in such direction. The arm **52** carries a contact **52***a*. The stationary contact point **56** is arranged to cooperate with movable contact **52***a*. Another bimetallic strip **57** may be employed, although this strip can satisfactorily be composed of an ordinary rigid metal as under normal conditions the operation of the system does not depend upon flexure of this strip. The strip **57** is composed of a thick piece of bimetal and deflects to the dotted line position at a temperature of about —50° F. At normal temperatures it is straight or at least curved downwardly only slightly. The reason for flexure of this strip **57** is that should the temperature go to say —50° F. during a cold winter month and at a time when the heating system is not in operation, the bimetal strip **33** will not be overstressed but the strip **57** will move from the path of **33** and the free end **53** thereof can rotate counterclockwise without striking any obstruction. If a strip **57** of rigid ordinary metal is used, it is possible for the ambient temperature to fall so low, —50° F. for example, that strip **33** will strike strip **57** and upon further fall in temperature internally stress itself to such a large extent as to take on permanent deformation. Since it is necessary for the ambient temperature to fall approximately 150° F. after the end of **53** strikes **57** before the strip **33** would be permanently stressed in event strip **57** was of rigid metal, the outer end of strip **33** will touch **57** at room temperatures and exert a slight tension against **57**. This small tension will not premanently deform the resilient bimetallic strip **33**. Contacts **52***a*, **56** are therefore closed at ordinary room temperatures, but contacts **53—54** open. The wire **36***l* is a flexible lead and fastens to arm **52**; however, the wire **36***l* does not have any spring action or in any way mechanically exert a force directly upon arm **52**; it merely connects electrically thereto.

Upon applying potential to wires **35**, **36** while the apparatus is in the initial off position, only one current path exists, namely: **35—15—29—56—52***a*—**36**. Heat from resistor **29** affects strip **33** and causes the same to tend to coil up. This will not break the circuit at **52***a*—**56** at this time inasmuch as the friction between **50** and **51** is appreciable and will tend to hold the position

shown until a definite torque is exerted on the sleeve 51 by the bimetallic strip 33. The contact 53 moves through midair until it strikes contact point 54. During this time, prior to striking this contact point, it is clear that strip 33 cannot exert a torque on the sleeve 51. Finally as resistor 29 gets strip 33 hotter and hotter the contact 53 moves into engagement with stationary contact 54 and this engagement closes the motor circuit via the following current path: 35—M—55—54—53—33—51—52—36. For a time after this, both the motor M and the igniter 15 operate simultaneously. The time during which the two operate simultaneously is governed by the tension in spring 94. If this spring causes considerable tension between sleeve 51 and rod 50, the igniter 15 and the motor M will operate simultaneously for a long time. Another method of obtaining a long simultaneous operation of those parts is to have resistor 29 just powerful enough to barely heat strip 33 to the point where the circuit heats strip 33 barely to the point where the circuit between 52a and 56 is broken. Preferably, the tension and/or heating is so arranged so that the motor M and igniter 15 operate simultaneously for the time deemed best for the particular style of burner to which the invention is applied, which in general is about 15 to 30 seconds. As just stated, the igniter 15 and motor M operate simultaneously for a while. If the fuel ignites, heat will be supplied to strip 33 from the combustion chamber and this strip will continue to flex. Since contact 53 has now struck a rigid obstruction 54 further flexure of the strip will result in rotation of the sleeve 51 against the friction of stationary shaft 50. Consequently arm 52 will be rotated counterclockwise and contact between 52a and 56 broken. This deenergizes the igniter 15 and resistor 29. Further heating will continue to rotate arm 52 counterclockwise and contacts 53 and 54 will remain in engagement. If the heater becomes rather hot and then the flow of fuel ceases, the friction between 50 and 51 will be sufficient to hold arm 52 in the position it had when the flame went out. Cooling of 33 will therefore result first in a counterclockwise rotation of contact point 53, and a quick disengagement of 53 and 54. However, such rotation is limited as the free end of strip 33 strikes 57 after rotating clockwise a fraction of an inch. As soon as strip 33 strikes 57 the subsequent flexure of strip 33 will result in a clockwise rotation of arm 52 with slippage taking place at 50, 51. Strip 57 will finally return to a straight position from its high temperature condition and as strip 33 approaches room temperature its contacts 52a—56 will be reclosed. This closure will reclose the igniter circuit 15, reenergize resistor 29, reheat 33 which strip will begin to rotate 53 clockwise without any slippage taking place at 50—51, reclose 53—54, restart the motor, and subsequently reopen the circuit to the igniter at 52a—56. Hence an attempt at reignition will be made.

After being placed into operation, when the heating system reaches a predetermined temperature, the bimetallic switch 61 closes to 60 starting an added fan motor 67 that is also energized from wires 35 and 36.

The control system of Figure 2 will now be described in detail. It is shown in section in the drawing and has a shaft 50 fixed at the rear end thereof. Sleeve 51 is arranged to slip over the shaft 50 as the sleeve has a very slightly larger diameter than the shaft. The spring 94 is located in front of bimetallic strip 33 and presses

firmly on sleeve 51 (which obviously extends well in front of strip 33 as sleeve 51 is sectioned whereas the strip 33 is shown in full view). The arm 52 is fastened electrically and mechanically to sleeve 51 and extends behind bimetallic strip 33 and carries a contact 52a. The bimetallic strip is arranged to coil up when heated and to uncoil when cooled. A stationary support 67 supports screw 68, the latter carrying on its tip end a contact point 69. Another stationary contact, not electrically connected, is provided at 56. A stationary square bar 66 supports a large movable block 65. A contact point 64 is fastened to the block 65, moreover a piece of electrical insulation extends across block 65 at 65a. An electrical hot-wire igniter 15 has a resistor 29 in series with it. Resistor 29 is arranged to heat strip 33 when energized.

In the off position, arm 52 is initially against 69 and strip 33 has its lower end against 65a. Hence, contacts 63 and 64 are disengaged. When power is applied at 35, 36, current flows as follows: 35—15—29—67—69—52a—52—36. Hence resistor 29 becomes heated and causes strip 33 to coil up until contact 63 engages 64. This causes motor (or valve) M to be energized via the following circuit, 36—52—33—63—64—65—66—M—91—93—94—35. For an interval the motor M and igniter 15 will simultaneously operate thus igniting the fuel. Further heating of 33 due to heat from the flame (or 29) will result in further coiling up of 33. Since block 65 is very heavy, slippage will take place at 50—51 before 65 will slip. Hence contacts 69—52a will be broken and arm 52 will move into engagement with 56. Since 56 is stationary, the slippage will now take place at 65—66 and as the burner continues to heat, the block will slip along 66 with 63 and 64 maintaining contact. An arm 90 is pivoted near its center at 92. It carries on its lower end a contact point 93. A complementary stationary contact point 94 connects to wire 35. A spring 91 tends to produce clockwise motion of the arm and thereby normally maintain the contacts 93 and 94 together. When overheating takes place block 65 moves to the left, engages arm 90, rotates the latter, and breaks the motor circuit at 93, 94. If spring 91 is omitted the system cannot be restarted without manually resetting arm 90. With spring 91 connected, the system will restart automatically when strip 33 cools.

Should the burner satisfactorily ignite and burn for a long while, then the flame be accidentally extinguished, 63 will immediately drop away from 64 and rotate counterclockwise until it comes into contact with 65a. Strip 33 will tend to further uncoil and reclose 52a—69 thus reenergizing the igniter circuit 15. Heater 29 will reheat 33 thus reclosing 63 and 64 restarting the motor M. Should the flame fail to relight, the heat from 29 will tend to further coil up 33 so as to break the circuit at 52a—69. This will cause 33 to cool and move into engagement with 65a. Further cooling will take place thus reclosing 52a—69 and this will reheat 29 and 33 thereby making another attempt at ignition. As a result, repeated ignition attempts are made. The same holds true in event an original attempt at ignition fails; that is several attempts to ignite will be made if the first effort fails.

In Figure 3 there is shown an arrangement whereby a mechanical valve may be operated by my novel control system instead of the motor or valve hereinbefore previously illustrated. The

system illustrates an elongated gas burner with a large number of burner ports **240**, with a hot wire igniter or other igniter **229** at the right end thereof. A pipe **270** has a valve **253** therein which has a stopper **254** that under normal conditions presses firmly against the right face of pipe **271** and thereby holds the valve closed. A shaft **250** has a slipping sleeve **251** and a spring **294** cooperating with it as has been previously described in connection with Figures 3 and 4. An arm **252** secured to sleeve **251** has a contact point **252***a* which normally presses firmly against the stationary contact **256**. Current is applied at wires **35** and **36** to room thermostat T and safety switch SS, the latter which may be built like is shown in casing **13** of my prior Patent 2,159,658, May 23, 1939, entitled: Control system. A heating resistor **215** is located close to strip **33** for the purpose of heating the latter. A flexible wire **202** leads current to arm **252**.

The operation of Figure 3 is described as follows. When thermostat T calls for heat, current immediately flows through heater **215**, and simultaneously it flows via the following path: **36—202—252—256—229—SS—35**. The igniter is therefore heated. The heat from heater **215** heats bimetallic strip **233** which thereupon moves stopper **254** away from the opening in pipe **271** and admits flow of gas to the elongated burner **240**. The igniter **229** will normally ignite this gas and the same will spread across the burner and provide further heating of strip **233**. As strip **233** becomes hotter, the stopper **254** will move to the left as far as it can whereupon further tension in strip **233** will result in counterclockwise rotation of arm **252** and breakage of the igniter circuit. The strip **233** will continue to be heated under the influence of two heat sources namely heater **215** and the flame. As strip **233** becomes hotter, it will move arm **252** further counterclockwise, by overcoming the friction between sleeve **251** and rod **250** and spring **294**. Should the thermostat T cease calling for heat by breaking its circuit, the heater **215** will be immediately deenergized. Since strip **233** is heated by the flame and heater **215**, and the latter source of heat has been cut off, the strip **233** will cool off somewhat, and this will result in no change in position of arm **252** at first but will cause the valve **253** and stopper **254** to move to the right. Movement of **254** to the right will either close the valve completely or close it partially. If it only closes it partially, the flame will be reduced in size and this will effect further cooling of **233** due to heat generation falling off. In any event the flame will go out, and once stopper **254** has been properly seated the strip **233** will cool further until finally contact at **252***a*—**256** is reclosed. The apparatus is then ready to be started again upon further call for heat from the thermostat T.

Other operations of the system of Figure 3 include closure of the valve upon flame failure. If the burner should ignite satisfactorily and then continue in operation indefinitely or for a long period, whereupon the gas supply should become exhausted, the first thing that will happen is a closure of the valve and subsequent reclosure of the igniter contacts **252***a*—**256**. If the gas supply is renewed in the meanwhile and begins to exert pressure in pipe **271**, it cannot flow until a substantial time has elapsed from the time it originally stopped, and not until the igniter has again been energized. When the

igniter is reenergized by thermostat T the heater **215** will heat strip **233** and reopen the valve.

In Figure 4, another form of the invention is shown in which the bulb **500** is connected by feed line **501** to the Bourdon tube **502**. The feed line **501** is a steel tube having a small hole leading from bulb **500** to the Bourdon tube **502**. The steel line **501** is supported by three bearings **503**, **504** and **513** which are nothing more than supporting members with holes in them large enough for the line **501** to pass therethrough without excessive friction. The three bearings **503**, **504** and **513** are all stationary. The lower end **514** of Bourdon tube **502** is adapted upon rotating clockwise (see Fig. 5) to push the arm **515** freely about pivot **506** until stop **507** which is fixed is engaged. The mercury switch **505** is carried by the arm **515** and has lead wires **508** which may be connected in series with the burner motor of an oil burner. The arm **515** is held against **514** due to the weight W on the right end of the mercury switch. Another mercury switch **509** is carried by an arm **516**. Normally when the bulb **500** is cool, the Bourdon tube **502** has contracted, that is tended to coil up, and the end **514** is pressed against stop **517** while arm **516** is pressed against stop **511**. The mercury switch **509** may be connected in series with the resistor **29** of Figure 4 as well as the electrical igniter. The hookup of the parts may correspond to the hookup of Figure 1 of this application or the hookup of my prior copending application S. N. 492,737, filed June 29, 1943 (now U. S. Patent 2,399,673, dated May 7, 1946 and entitled "Control system") except that switch leads **510** connect to a relay which open the igniter when the circuit at **510** is closed.

The operation of Figures 4 and 5 is as follows. When the burner is off the parts will assume the position of Figure 5. Upon starting, resistor **29** will heat bulb **500**, expanding the liquid therein and rotating the end **514** clockwise until it pushes **515** sufficiently to rotate the mercury switch **505** to close contacts **508** and start the burner motor which will generate much heat at bulb **500** which will in turn further rotate the Bourdon tube **502** until **515** strikes stop **507**. The next action will be a counterclockwise rotation of shaft-line **501** thus rotating mercury switch **509** to break the igniter and resistor **29** circuit at contacts **510**.

It is noted that during the rotation of arm **516**, the entire shaft-line **501** and bulb **500** are likewise rotating. After the bulb **500** should reach some high temperature, should the flame be accidentally extinguished, the Bourdon tube **502** would immediately begin to contract and first the free end **514** would move counterclockwise thus breaking the circuit at **508** stopping the motor and after still further cooling the free end **514** would engage stop **517**. Subsequent cooling of the bulb **500** would result in rotation of arm **516** clockwise until at some low temperature the contacts **510** of mercury switch **509** would be reclosed.

The arm **516** and bulb **509** must be counterbalanced for best results unless there is enough friction between shaft **501** and the supports that counterbalancing is unnecessary. A suitable counterbalance **512** is shown in Figure 5.

I claim to have invented:

1. In a lost-motion device, a stationary supporting means, a rotatable member supported thereby and frictionally engaged therewith, said frictional engagement constituting substantially the sole force opposing rotation of said mem-

ber, an expansible and contractable member having one end connected to said rotatable member, means positioned so as to be engaged by the other end of said expansible and contractable member upon change in dimension of the latter to thereby exert a force on said rotatable member, and switch means associated with the last-named means and with said other end for changing the energization and deenergization of a circuit upon engagement and disengagement of the said last-named means and said other end.

2. In a lost-motion switch, thermal means including a coil element which coils and uncoils when the thermal means is heated or cooled, a rotatable member supporting one end of said coil, stationary means in frictional engagement with and supporting said rotatable member, said frictional engagement constituting the sole restraining force between said rotatable member and said stationary means, restraining means positioned so as to be engaged by the other end of said coil upon limited movement thereof, said restraining means effecting sufficient restraint as to cause said coil to rotate said rotatable member after the coil begins exerting a force on the restraining means, a first mechanism operated when said coil exerts a force on said restraining means, and a second mechanism operated by the position of said rotatable member resulting from the rotation thereof.

3. In a lost-motion switch, thermal means including a coil which coils and uncoils when its temperature changes, a contact point rigidly connected with the first end of said coil, a rotatable member frictionally supporting the second end of said coil to permit rotation thereof against friction as substantially the entire retarding force, a complementary contact point for the first-named contact point, and means supporting said complementary point a short distance away from the first-named point and restraining motion of the complementary point by a greater retarding torque than is necessary to rotate the rotatable member.

4. The combination with a Bourdon tube of a bulb connected with a first end of the tube, means mounting said first end for unbiased rotation, and means permitting free motion of the other end of the Bourdon tube for a limited distance, and a mechanism operated by the position of said free end.

5. The device defined by claim 4 including an additional mechanism operated by said first end of said Bourdon tube.

6. The device defined by claim 4 in which said means mounting said first end for unbiased rotation is a shaft supporting both said bulb and said tube whereby they both rotate together, said shaft defining an opening therethrough connecting the bulb to said tube.

7. The device defined by claim 4 in which said means permitting free motion of said other end of the Bourdon tube for a limited distance comprises a stop on one side of the said other end and said mechanism comprises a switch on the other side, said switch constituting means for preventing further motion of said other end after a predetermined motion, the combination being so constructed and arranged with such small friction retarding rotation of the first end of said tube that as the Bourdon tube exerts pressure on the switch after further motion has been prevented that the first end of the tube will rotate to tend to relieve such pressure.

8. The device defined by claim 1 in which said switch means comprises; a rotatable element, comprising a mercury tube switch, operated by the said other end of said member to rotate said mercury tube switch.

9. The device defined by claim 2 having in addition means limiting the motion of said rotatable member in both directions to a predetermined distance, stationary supporting means in frictional contact with said restraining means for permitting movement of the restraining means, said movement being retarded by friction, said friction retarding said restraining means being of such magnitude that when said restraining means is at first engaged by said coil that the restraining means will not move but the coil will rotate the rotatable element through said predetermined distance and thereafter further rotation of the coil will move the restraining means.

10. In a lost-motion device, an expansible and contractable member having first and second ends and tending to move said first end in first and second directions in response to expansions and contractions respectively of said member, restraining movement of said first end in said first and second directions, a movable element in contact with and driven by said second end, a supporting structure carrying said movable element and retarding the movement thereof to such a small extent that the force applied to said movable element by said second end due to predetermined expansions and contractions of said member will move said movable element, and control means operated by said first end for operating a mechanism in a first manner as long as said first end is tending to move said restraining means in one direction and in another manner as long as said first end is tending to move in the other direction.

11. In a lost motion device, an expansible and contractable member having first and second ends, means associated with the first end for permitting limited motion of the first end in a first direction and then restraining further motion of the first end in said first direction, a sliding mass driven by the second end of said member, frictional supporting means for the sliding mass for providing frictional forces against motion of said mass, the forces retarding said mass being sufficiently small that after said first end moves said limited distance further substantial deflection of said member will result in sliding of said mass, and control means for operating a mechanism in a manner depending on the position of said first end.

12. In lost-motion switching means, first and second sliding masses respectively mounted for sliding motion and each including frictional retardation to such sliding with the second mass having considerably greater friction against sliding than the first, means for limiting the extent of sliding of the first of said masses, an expansible and contractable member for driving said sliding masses against their frictional forces which upon expansion and contraction of the member drives the first mass to its limit of sliding and then drives the second mass to relieve further stress in said member, a first switching means to hold open a circuit when the first mass is tending to slide in one direction and to hold closed the circuit when the first mass is tending to slide in the other direction, and a second switching means to hold open a circuit when the second mass is sliding in one direction and to hold closed

such circuit when the second mass is moving in the other direction.

13. In a lost-motion device, an expansible and contractable member having first and second ends arranged to deflect relative to each other in response to expansions and contractions, means cooperating with the first end for permitting the first end to move to relieve stress in the member comprising a mass restrained from motion substantially wholly by friction and tending to be driven by said first end in opposite directions respectively in response to expansions and contractions of said member, means for limiting the extent of motion of said mass within predetermined close limits, additional means cooperating with the second end of said member for permitting the second end to move to relieve stress in the member comprising a second mass restrained against motion substantially wholly by friction and to a greater degree than the first mass and driven in opposite directions respectively in response to expansions and contractions of said member, whereby in response to expansion of the member the first mass will slip first to the extent of its limited motion and thereafter in response to further expansion the second mass will slip, one of said masses including supporting means for said member to carry the latter, a first mechanism operated in a manner depending on the position of the first mass, and a second mechanism operated in a manner depending on the direction of motion of the second mass.

14. The device defined by claim 10 including additional means for controlling a mechanism depending on the position of said movable element.

15. The device defined by claim 14 in which the control means is a valve which is moved to a first position when said first end is tending to move the restraining means in one direction and which is moved to a second position when said first end is tending to move in the other direction.

16. In the device defined in claim 4: said means mounting said first end for unbiased rotation comprising a shaft supporting both said bulb and said tube whereby they both rotate together, said shaft defining an opening therethrough connecting the bulb to the tube, said means permitting free motion of the other end of said Bourdon tube for a limited distance comprising a stop on one side of said other end, said mechanism comprising a switch on the other side of said other end, said switch constituting means for preventing further motion of said other end after a predetermined motion, and an additional mechanism controlled by rotation of said shaft, the combination being so constructed and arranged with such small friction retarding rotation of said first end of said tube that as the Bourdon tube exerts pressure on the switch after further motion has been prevented that the first end of the tube will rotate and operate the second mechanism as well as tend to relieve said pressure.

17. The device defined in claim 11, in which said expansible and contractable member comprises a spiraled bimetallic strip, in which said sliding mass comprises a rotatable element supporting the inner end of said spiraled bimetallic strip, and in which said control means for operating a mechanism includes an electric switch actuated by motion of said first end.

WILLIAM D. HALL.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,503,259 April 11, 1950

William D. Hall

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 24, claim 10, after the word and comma, "member," insert -- restraining means --.

Signed and sealed this 31st day of May 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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