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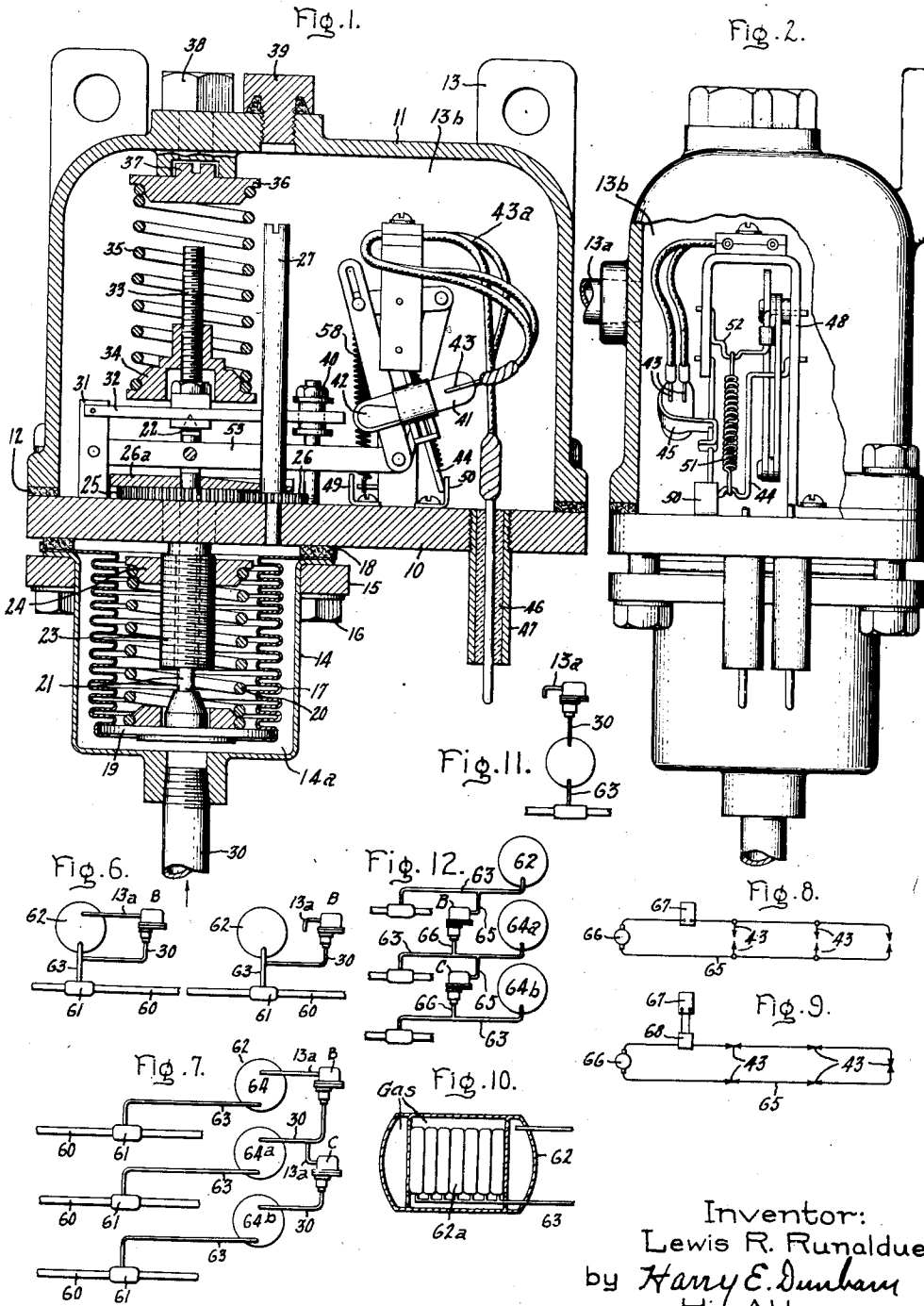
L. R. RUNALDUE

2,092,559

SIGNAL MEANS FOR FLUID FILLED CABLES

Filed Dec. 8, 1934

2 Sheets-Sheet 1



Inventor:
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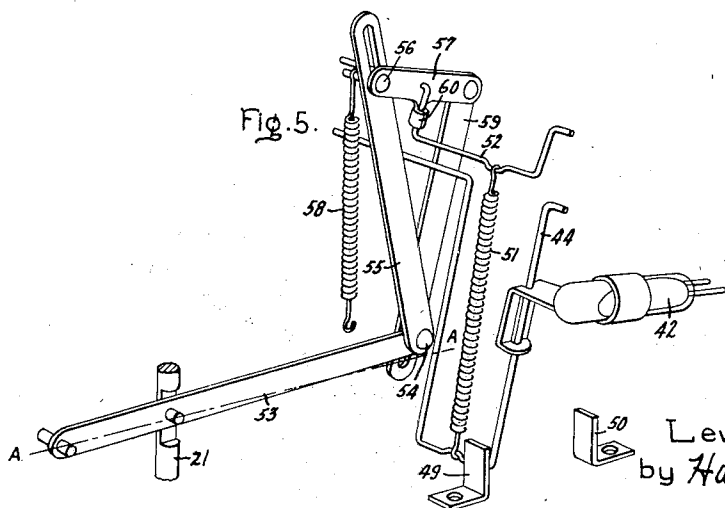
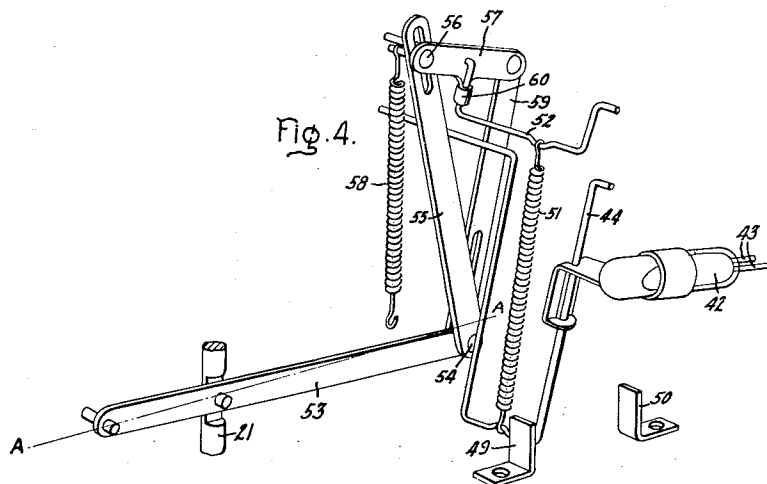
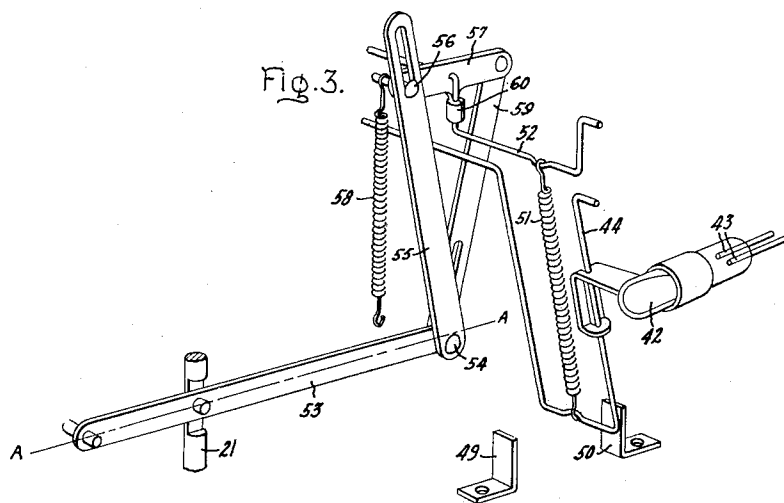
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UNITED STATES PATENT OFFICE

2,092,559

SIGNAL MEANS FOR FLUID FILLED CABLES

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Application December 8, 1934, Serial No. 756,632

15 Claims. (Cl. 200—83)

A typical fluid-filled cable system to which my improved signal means is especially applicable comprises one or more insulated conductors enclosed in an impervious sheath, there being one or more channels within the sheath containing a liquid dielectric which serves to impregnate the insulation. For a liquid, degasified oil has been found satisfactory in actual practice. Before the liquid is admitted, the cable is carefully treated to remove air and other gases and also moisture. Prior to being put into use, the entire cable with its joints and terminals is sealed with the utmost care to prevent the entrance of any foreign matter. In such a cable, whether single or multi-conductor, the temperature changes to which it is subjected cause alternate expansion and contraction of the liquid dielectric within the sheath. To prevent stretching the sheath as the volume of the liquid increases with a rise of temperature and to prevent void formation within the sheath with a fall of temperature, reservoirs are provided which are spaced along the length of the cable installation at suitable points, usually in manholes below the level of the street where they are relatively inaccessible. These reservoirs are commonly constructed comprise a casing containing numerous cellular elements having flexible walls which move in response to changes in volume of the liquid dielectric. These reservoirs are carefully designed so that the liquid pressure within the cable under normal conditions will not rise above a predetermined maximum on the one hand or fall below a certain minimum pressure on the other, said minimum pressure being above that of the atmosphere. In some installations, so-called feeding and pressure reservoirs are employed and in others only pressure reservoirs, depending upon the profile of the land on which the cable is laid. Some or all of the reservoir casings contain a suitable gas under pressure which acts on the walls of the cells whereby the desired operating characteristics may be obtained.

It is important that the quantity or pressure of liquid dielectric within each and all of the reservoirs shall not fall below a predetermined minimum or rise above a predetermined maximum for in either case it indicates an abnormal condition of the cable. Furthermore, it is important that warning of such abnormal condition be given sufficiently in advance of any actual trouble to permit of the necessary correction being made for the total or partial failure of a cable system is a serious thing affecting as it does a very large number of current consumers. The

fact that the reservoirs are usually located in relatively inaccessible places makes visual inspection an impractical thing and, even if it were possible, an abnormal condition might arise between one inspection and the next.

The object of my invention is the provision of an improved means or apparatus for fluid filled cables whereby an indication or signal is given at some selected point or station to show that an abnormal condition exists at some one of the reservoirs distant from the station and this whether the condition is due to an over or an under supply of liquid dielectric therein.

For a consideration of what I believe to be novel and my invention, attention is directed to the accompanying description and the claims appended thereto.

In the drawings which are illustrative of my invention, Fig. 1 is a view partly in section of a differentially acting mechanism for actuating the switch in a signal system; Fig. 2 is an end view of the same with a part of the casing broken away; Figs. 3 to 5 inclusive are perspective views of the switch actuating mechanism showing positions which it occupies under different operating conditions; Fig. 6 is a diagrammatic view of a fluid-filled cable and its reservoirs and relays; Fig. 7 illustrates another way of connecting the reservoirs and relays; Fig. 8 is a diagram of an open circuit relay system; Fig. 9 is a diagram of a closed circuit relay system; Fig. 10 is a view of one form of reservoir, and Figs. 11 and 12 are further illustrations of suitable arrangements or connections of the reservoirs and relays with the cable.

Referring particularly to Figs. 1 and 2, 10 indicates the bottom wall or base of the relay, and 11 the enclosing chambered cover therefor, the two being suitably united by bolts. Between the adjacent surfaces of the parts is a packing 12 to insure a fluid tight joint. The cover has one or more supporting lugs 13 by means of which it can be bolted to a support. It also has an opening to receive a pipe 13a for admitting a fluid to the chamber 13b thereof. Located below the base is a thin walled casing 14 having an outturned flange which engages and is supported by a ring 15, the latter being secured to the base by bolts 16. This casing in effect forms a part of the main casing. Inside of the casing is a bellows diaphragm 17 suitably corrugated to give it the necessary flexibility. The upper end of the diaphragm is flanged outwardly and seated on the flange of the casing. Between the flanged end of the diaphragm and the under surface of the base

is a packing 18 to insure a fluid tight joint. The lower end of the diaphragm is rolled over and firmly united to a head 19 to insure a fluid tight joint. Inside of the bellows is a coiled compression spring 20 having its lower end seated in grooves formed in the head 19. Extending upward from the head and entering the chamber in the cover is a rod 21 which terminates at its upper end in a cone 22. Loosely surrounding the rod is an enlarged member 23 having a right-hand screw thread upon which is an adjustable abutment 24. Fluid within the chamber in the cover has access to the interior of the bellows through the central opening in the member around the rod. The head and abutment, depending upon their spacing, determine the compression pressure of the spring. The effect of the arrangement described is to provide the relay with two chambers 13b and 14a with the bellows located between the two so that it is differentially acted upon by the fluids on opposite sides or surfaces thereof. These two chambers are in turn separately connected to the chambers of the reservoirs.

It is necessary to adjust the pressure exerted by the spring either initially or to meet a given service condition and without opening the casing. For this purpose, a portion of the threaded member 23 is made smooth to form a journal which extends through the base, the latter serving as a bearing. To the upper end of the member is secured a toothed gear 25 which meshes with a pinion 26. The upward thrust on the member and gear, due to the spring, is taken by a thrust plate 26a which is secured by screws or other means to the base. The pinion is mounted on the lower end of the spindle 27 journaled in the base and by means of which it can be turned to cause rotation of the member 23 through the gear 25 and thereby adjust the effect of the spring on the bellows diaphragm. The chamber 14a between the wall of the casing 14 and the bellows is filled with fluid under pressure supplied by the pipe 30. This fluid may be a liquid received from a cable or reservoir or it may be a gas received from a reservoir as will appear later on. Whatever be the kind or source of fluid, it tends to collapse the bellows which action is resisted by the spring and also by the pressure of the gas in the chamber 13b of the cover.

Located within the chamber of the cover and pivotally supported on a standard 31 is a stop lever 32 which has on its under side a seat for the conical upper end of the rod 22. Secured to the upper side of the lever is a rod 33 having a left-hand screw thread, said rods 22 and 33 being in axial alignment. On the rod 33 near its lower end is mounted an abutment 34 having an internal screw thread engaging the threads on the rod. The abutment forms a seat for the compression spring 35. The top of the spring is seated on a grooved head 36 which engages a tubular boss on the under side of the top wall of the cover. The head has a hub-like projection 37 which serves to center it and which is also provided with a screw-driver slot whereby the head may be rotated and with it the spring. Turning the upper head turns the abutment 34 on its threaded support and, in this manner, the spring effect can be readily adjusted. In order to give access to the screw-driver slot in the upper head, a removable screw threaded plug 38 is aligned therewith. To give access to the spring adjusting means of the lower spring, the upper end of the spindle 27 also has a screw-driver slot,

and aligned with it in the cover is a removable screw threaded plug 39. To positively limit the movements of the free end of the lever 32 both up and down, an adjustable stop 40 is provided mounted on a short rod rising from the base.

The stop 40 should be so adjusted that the spring 35 has no effect on the low pressure alarm. The conical end 22 of the rod 21 should seat or engage the lever 32 only when and just as the lever 53 which is pinned to said rod rises on its right hand end above the neutral or center line position indicated by the dotted line A—A in Figs. 3 to 5. If the pressure is high enough, rod 21 will move upward and in so doing swing the right hand end of the lever 53 upward, i. e., move said lever above its neutral position whereupon further upward movement is opposed by the springs 35 and 20. To state the matter another way, the spring 35 has no effect on the lower setting of the relay but only on the higher setting thereof. The lower setting of the relay is adjusted in the following manner: Spring 20 is so adjusted that its force opposes the resultant force due to the differential fluid pressures acting on the diaphragm. The fluid pressure in the space or chamber 14a is greater than that within the upper chamber 13b. In other words, the spring 20 is adjusted so that the forces referred to above just balance when lever 53 is in a position from which any downward movement of its right hand end would actuate the mercury switch, provided the calibrated differential pressure applied is that at which the alarm should operate.

To adjust the upper or higher alarm setting, spring 35 is so adjusted that its force plus that due to the spring 20 just balances the force due to the differential fluid pressure when the position of the lever 53 is such that upward movement from the neutral position will cause the mercury switch to again operate.

As previously indicated, an abnormal condition in a fluid filled cable installation may appear as too much fluid in a reservoir or too little, or too high or too low a pressure. To avoid undue complication, the same relay must be capable of responding to both of said conditions. Moreover, the circuit controlled device must to prevent burning of the electrical contacts act with a snap action. By the use of a properly designed switch and actuator, this is accomplished.

The electrical feature of the device will next be referred to. The circuit making and breaking device comprises an oscillating switch having an hermetically sealed glass enclosure 41 containing a body of mercury 42 and a pair of terminals 43 sealed in the glass. The enclosure is secured to its actuator 44 which is made of spring wire by a metal strap 45. As the actuator moves back and forth by a snap action, the mercury is caused to shift within the enclosure to alternately make and break the circuit at the terminals. The leads 43a to the terminals have a suitable amount of slack and are supported in any suitable manner, as by being clamped to the support for the actuating mechanism. Where oil is admitted to the chamber in which the switch is located the leads should be insulated with material which is highly resistant to deleterious action by the oil. Where the circuit wires enter the casing, each passes through and is sealed within a glass tube 46. The tube in turn is sealed within a metal tube 47 which is threaded into the base.

The switch actuator is of U-shape and is pivoted at its ends in a frame 48. Its lower end is

arranged to move between two fixed stops 49 and 50 secured to the base. To give the actuator a snap action, a tension spring 51 is employed having its lower end connected to the bottom end of the actuator and its upper end in a second U-shaped member 52 made of spring wire that is also pivotally supported at its ends in the frame 48. The pivots of the two U-shaped members are spaced a substantial distance apart so that when the upper one is swung, say to the right, it causes the axis of the spring 51 to cross the dead center of the pivots of the actuator 44 and thus insure a snap action. The reverse action takes place when the member 52 is moved in the opposite direction. Stated another way, the axes of pivots on the two U-shaped members are in spaced eccentric relation, in this case one above the other.

The primary actuator for the switch is the lever 53 which is pivoted to the standard 31 on the base and is suitably connected to the lower rod 22. Referring more especially to the perspective views Figs. 3 to 5 inclusive, 53 indicates the main actuating lever and to its free end is pivotally connected by a pin 54, a link 55 having a slotted upper end in which is located a pin 56 carried by a rocking lever 57, thus forming a lost motion connection. The left-hand end of the lever tends to move downwardly at all times under the influence of the tension spring 58. This has the effect of tending at all times to move the switch to the position shown in Figs. 1 and 3. To the right-hand end of the rocking lever is pinned a link 59 having a slotted lower end arranged to slide on the pivot pin 54, thus forming a lost motion connection. The rocking lever is connected to the upper U-shaped member by the clamp 60 so that as it is tilted in one direction or the other the member is moved and with it the upper end of the tension spring 51. As the axis of this spring crosses the dead center of the pivots of the lower U-shaped member 44, it causes the latter to snap from stop 49 to 50 and vice versa. In the position shown in Fig. 3, the body of mercury 42 has moved to the left to open the circuit of the terminals 43. This is the normal or neutral position of the parts when the device is operating in a signal system where the closing of the circuit at the terminals 43 gives a signal at some selected point. If used in a system where the circuit is normally closed and its opening gives a signal, the position of the switch will be such that with the other parts in the position shown, the circuit will be closed by the mercury. In other words, the switch will be tilted in the opposite direction. The center line A-A indicates the same position of the main actuating lever 53 as in Fig. 1. In Fig. 4, the rocking lever 57 is shown in another of its positions with the circuit at the switch closed, i. e., with its free end depressed. The closing of the circuit in this figure is due to the fact that the differential fluid pressure acting on the bellows diaphragm has decreased below a predetermined value and has forced the free end of the lever 53 downward.

In Fig. 5, the circuit at the switch is also closed by the mercury but this closing was brought about by a condition different from the abnormal one which closed it before. In this case, the differential pressure on the bellows is assumed to have been increased above the predetermined value with the result that the rod 21 has been raised from the normal or neutral position of Fig. 3 where the center line of the lever 53 is

horizontal or approximately so and with it the free end of the lever. In Fig. 4, the closing action is brought about by the pin 54 engaging the bottom of the slot in the link 59 and pulling it down in a manner to rock lever 57. In Fig. 5, the closing action is brought about by raising the link 55 until the lower end of its slot engages the pin 56 and pushing the left-hand end of the rocking lever 57 upwardly. This rocking causes no action by the link 59 because the pin 54 at its lower end merely rides in the slot thereof. To state the matter in another way, the rocking lever 57 while it is capable of tilting in two directions, both serving to actuate the mercury switch through the medium of the upper and lower U-shaped members and the spring 51, is tilted by two different links, 55 and 59, one acting as a pushing means on one end of the lever and the other as a pulling means on the opposite end. To prevent any adverse action of the admitted fluid on the parts within the relay, they may advantageously be chromium plated.

The relay can be connected to the reservoir and cable in a variety of ways to meet the operating conditions which may differ in different installations. As an illustration but not as a limitation, oil or other liquid may be admitted from a reservoir in a manner to act on the external surface of the bellows and gas from the reservoir admitted in a manner to act on the inside thereof or vice versa. Or, liquid from a reservoir may be caused to act on the exterior of the bellows and air on the inside, the latter being admitted through a pipe such as 13^a. An alternative is to cause gas from a reservoir to act on the outside of the bellows and air on the inside. As a further alternative, a relay may be connected to the gas chambers of two reservoirs, one to one side of the bellows and the other to the other side.

Referring to Fig. 6, 60 indicates lengths of a fluid filled cable and 61 joints through which fluid such as oil may be admitted or discharged. The cable has one or more channels for fluid as is the ordinary practice. To receive fluid from the cable as it expands and feed it back as it contracts, reservoirs 62, Fig. 10, are provided at spaced intervals and connected by pipes 63 with the cable. The reservoirs contain a liquid such as oil in the several cells and a gas in the casing under determined pressure. For some installations it will be found desirable to reverse this arrangement and have the gas in the cells and oil from the cable in the casing around the cells. At the left in Fig. 6, oil from the cable and reservoir is admitted by the pipe 30 to the chamber of the relay B outside of the bellows and gas is admitted to the chamber within the relay by the pipe 13^a. At the right in Fig. 6, oil is admitted to the relay by the pipe 30 and air is afterwards sealed. These two arrangements in some cases may be used on the same section of cable. The reservoirs are of usual construction, each comprising a casing 62, and a plurality of sealed cells 62^a connected to a common manifold. The chamber within the casing not occupied by the cells is filled with gas. It may be a neutral gas in some cases and atmospheric air in others, depending upon the kind of installation. In any event, the oil and gas are separately maintained.

In Fig. 7 is shown three independent cables 60, each having a single conductor and forming a part of a three phase system of electrical distribution. In this instance, three reservoirs are pro-

vided, one for each cable but only two relays. The oil supply in reservoir 64 is connected by a pipe 63 to the cable, and the gas chamber thereof to the gas chamber in the relay by the pipe 13^a. The gas chamber of the reservoir 64^a is connected by pipe 30 to the chamber 14^a in the relay B, in which the bellows is located, and by pipe 13^a to the upper gas chamber 13^b of the relay C. The gas chamber of reservoir 64^b is connected by pipe 30 to the chamber 14^a in which the bellows of relay C is located. In this figure, it will be observed that the relays respond to differences in gas pressure within the reservoirs of the three cables instead of being responsive to differences of pressure between liquid and gas as in the previous illustrations.

Fig. 8 illustrates an open circuit signal system in which 43 indicates the terminals of the mercury switch 41, 65 the circuit wires, 66 a source of current and 67 a signal device which may be a lamp or bell located at a selected station and which is actuated when the circuit is closed.

Fig. 9 illustrates a closed circuit system in which the terminals 43 of the mercury switch are normally closed, 65 the circuit wires, 66 a source of current, 67 a signal device of suitable construction, and 68 a magnetic relay which when the circuit is opened at any one of the pairs of terminals 43 causes the circuit of the signal device to be energized and a signal given.

In Fig. 11 is illustrated a modification of the arrangement shown at the right in Fig. 6. The liquid containing chamber of the reservoir is connected to the cable by the conduit 63 as before while the gas chamber thereof is connected by the conduit 30 to the chamber 14^a outside of the bellows diaphragm between it and the wall of the casing 10. The chamber 13^b in the relay on the opposite side of the diaphragm is initially open to atmosphere through the conduit 13^a and subsequently sealed.

In Fig. 12 is shown a variation of the arrangement shown in Fig. 7. In this figure, the liquid containing chamber of each reservoir is connected by a conduit 63 to a cable as before but instead of utilizing the differential action of the gases in the reservoirs to actuate the switches in signal circuits of the relays, the differential action of the liquids in the reservoirs is employed. This is accomplished by connecting the chambers 13^b and 14^a of each relay by separate conduits to the liquid containing chambers of a pair of reservoirs as by conduits 65 and 66. The connections as a matter of simplicity are made to the conduits 63 to avoid making additional openings in the casings of the reservoirs but such openings may be made when desirable. In this arrangement, assuming that reservoir 64^a loses a certain abnormal portion of its liquid while the others do not, the bellows in both relays B and C will cause the main levers thereof to actuate the switches and cause an alarm to be given. An abnormal increase of liquid in any one of the reservoirs will likewise cause the signal to be actuated. In both Figs. 7 and 12, it is to be understood that the gas chambers of the reservoirs are sealed and contain gas under a determined pressure. In all cases suitable valves will be provided whenever necessary.

At the time the cable and signal wire circuit is installed, careful measurements of the resistance of signal wires between the station and each of the several relays are made, and from the data thus obtained a chart is prepared. Upon receipt of a signal at the station, the attendant

by suitable electrical measuring devices determines the resistance of the circuit between the station and the relay which has operated, and by comparing the data thus obtained with the chart, is able to locate which of the relays has acted and instruct the service men accordingly.

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

1. A device of the character described comprising a casing having a pair of chambers containing fluids under different pressures, an elastic diaphragm located between the chambers acted upon differentially by the fluids therein, spring means acting in opposition to certain movements of the diaphragm, a lever actuated by the diaphragm, an oscillating switch having fixed terminals therein and containing mobile conducting material for opening and closing an electric circuit at the terminals as it moves therein with oscillations of the switch, a support for the switch, a pivot for the support, a rocking lever for actuating the support, and means actuated by the diaphragm lever for tilting the rocking lever and moving the pivoted support and the switch.

2. A device of the character described comprising a casing having a pair of chambers containing fluids under different pressures, a diaphragm located between the chambers and acted upon differentially by the fluids therein, spring means acting in opposition to certain movements of the diaphragm, a lever actuated by the diaphragm, an oscillating switch having fixed terminals and containing mobile conducting material for opening and closing an electric circuit at the terminals as it moves therein with oscillations of the switch, a pivotal support for the switch, a pivotally supported member having its pivots in spaced eccentric relation to those of the support, a tension spring connecting the support and member, a rocking lever for moving the member, and links actuated by the diaphragm actuated lever for moving the rocking lever to actuate the switch.

3. A device of the character described comprising a casing having a pair of chambers containing fluids under pressures which independently vary with operating conditions, a bellows diaphragm located between the chambers and acted upon differentially by the fluids, a spring located within the bellows, an abutment for the spring, a screw threaded support for the abutment, gearing for turning the support to change the effective action of the spring, a rod moved by the diaphragm, a lever actuated by the rod, a chambered oscillating switch having contacts therein, a pivotal support therefor, a body of mercury in the chamber, a rocking lever for moving the support on its pivots in a manner to tilt the switch and cause movement of the mercury therein, and slotted links moved by the rod actuated lever for tilting the rocking lever first in one direction and then in the other.

4. A device of the character described comprising a casing having a pair of chambers containing fluids under pressures which vary independently under operating conditions, a diaphragm located between the chambers and differentially acted upon by the fluids, an adjustable spring for loading the diaphragm, a lever actuated by the diaphragm, an oscillating switch, a pivotal support therefor, a pivotal member, the pivots of the support and member being in spaced relation, a spring uniting the support and member to cause the switch to move with

a snap action, a rocking lever, a link pinned to the diaphragm lever and having a lost motion connection with the rocking lever for tilting the latter in one direction to actuate the switch, a second link pinned to the rocking lever and having a lost-motion connection with the diaphragm lever for tilting the rocking lever in the opposite direction to actuate the switch.

5. A device of the character described comprising a casing having a pair of chambers containing fluids under pressure which vary independently under operating conditions, a diaphragm located between the chambers and differentially acted upon by the fluids, a two position oscillating switch, a two position pivotal support therefor, a rocking lever for moving the support from one of its positions to the other, a lever actuated by the diaphragm which when in its neutral position permits the switch to remain in one of its two positions, a means connecting the lever to the rocking lever on one side of its pivot to cause actuation of the switch when the lever moves in one direction from its normal position, and a second means connecting the lever to the rocking lever on the opposite side of its pivot to cause actuation of the switch when said lever moves in the opposite direction from its normal position.

6. A device of the character described comprising a base, a chambered cover therefor, a conduit for admitting fluid thereto, a chambered casing secured to the base, a bellows diaphragm mounted in the casing, a conduit for admitting fluid to the casing outside of the diaphragm, a compression spring located inside of the diaphragm, an adjustable abutment for the spring, a screw threaded member supporting the abutment, gearing located within the cover for adjusting the position of the abutment, a rod moved by the diaphragm, a lever actuated by the rod, a second adjustable spring acting on the rod, a stop means for limiting the longitudinal movements of the rod in both directions, a two position oscillating switch, a tilting support for the switch, actuating means for tilting the support and the switch, and means moved by the lever for moving the actuating means.

7. A device of the character described comprising a base, a chambered cover therefor, a casing attached to the base, a bellows diaphragm mounted therein and separating the chamber of the cover from that of the casing, a compression spring mounted in the diaphragm for distending it, an abutment for one end of the spring, a screw threaded hollow member journaled in the base upon which the abutment is mounted, gearing located within the casing for turning the member to adjust the abutment and the spring, a rod seated at one end on the diaphragm and extending through the hollow member into the casing, a lever actuated by the rod, a second spring aligned with the first and also acting on the rod, a stop means engaging an end of the rod, a screw threaded rod and adjustable abutment on the stop means for adjusting the action of the second spring, a head upon which the inner end of the second spring is seated, means for rotating the head and spring to adjust the last-named abutment, an oscillating switch within the chambered cover, and a tilting support for the switch which is actuated by the lever as it is moved in response to action of the diaphragm.

8. A device of the character described comprising a chambered casing, a diaphragm dividing

the chamber into two parts, a pair of springs within the casing acting on the diaphragm to change its operating characteristics, a rotary member for adjusting the abutment of one of the springs, a rotatable head for turning the other of the springs to adjust its abutment, means for turning the member and head which are accessible from the outside of the casing, a means moved by the diaphragm, and a switch in an electrical circuit moved by the means.

9. A device of the character described comprising a chambered casing, a diaphragm dividing the chamber of the casing into two parts, each of which contains fluid, the fluids acting differentially on the diaphragm, springs acting in opposition to certain movements of the diaphragm, a rod moved by the diaphragm, a main lever moved by the rod, a second lever also moved by the rod, an adjustable stop for the second lever, an oscillating two-position switch, a rocking lever for tilting the switch, and means acting on the rocking lever in response to a movement of the main lever from either side of its neutral position to move the switch.

10. A device of the character described comprising a casing containing two chambers, a diaphragm between the chambers, a switch in an electrical circuit, a pivotal support therefor, a pivotal member for moving the support, a spring uniting the support and member to cause the support to move with a snap action, a two-position rocking lever for actuating the member, a spring tending to move the lever to one of its positions, a main lever moved by the diaphragm and independent means acting on the ends of the rocking lever to tilt it, each of said means including a lost motion connection.

11. In a device of the character described, the combination of a controller having circuit controlling contacts and a mobile body of conducting material, said controller having two positions, a movable support for the controller, a device tending at all times to move the support and the controller to one of its two positions, a primary lever having a neutral position and movable to positions on either side thereof, a means actuated by the primary lever as it moves in one direction from its neutral position to move the support and the controller against the action of the device to one of its two positions, a second means also actuated by the primary lever as it moves in the opposite direction from its neutral position to move the support and controller against the action of the device to move the controller to the same said position, and means for moving the primary lever with respect to its neutral position.

12. In a device of the character described, the combination of a controller having relatively movable circuit controlling contacts, said controller having two positions, a movable support for the controller, a device tending at all times to move the support and the controller to one of its two positions, a primary lever having a neutral position and movable to positions on either side thereof, a means actuated by the primary lever as it moves in one direction from its neutral position to move the support and controller against the action of the device to one of its two positions, a second means also actuated by the primary lever as it moves in the opposite direction from its neutral position to move the support and controller against the action of the device to move the controller to the same said position, a lost-motion connection between the

primary lever and each of the means permitting it to actuate one means without affecting the other, and means for moving the primary lever with respect to its neutral position.

5 13. A device of the character described comprising diaphragm means movable in response to two opposing fluid forces, a lever actuated by the diaphragm which occupies a neutral position
10 when the opposing forces acting on the diaphragm means are substantially equal and is moved to one side or the other of its neutral position when the equality of said forces is upset, a switch for controlling an electrical circuit,
15 which has an active and an inactive position, the latter corresponding to the neutral position of the lever, and means moved by the lever whenever it departs in either direction from its neutral position for moving the switch from its inactive to its active position.

20 14. A device of the character described comprising diaphragm means movable in response to two opposing fluid forces, a lever actuated by the diaphragm which occupies a neutral position
25 when the opposing forces acting on the diaphragm means are substantially equal and is moved to one side or the other of its neutral position when the equality of said forces is upset, a switch for controlling an electrical circuit,
30 which has an active and an inactive position, the latter corresponding to the neutral position of the lever, a rocking actuator for the switch, and

two lost motion connections between the lever and the actuator for moving the latter, one of said connections being used when the lever moves in one direction from its neutral position and the other when the lever moves in the opposite direction, both of said connections causing similar
5 movements of switch and rocking actuator.

15 15. A device of the character described comprising diaphragm means movable in response to two opposing fluid forces, a lever actuated by the diaphragm which occupies a neutral position
10 when the opposing forces acting on the diaphragm means are substantially equal and is moved to one side or the other of its neutral position when the equality of said forces is upset,
15 a switch for controlling an electrical circuit, which has an active and an inactive position, the latter corresponding to the neutral position of the lever, a rocking actuator for the switch, two
20 lost motion connections between the lever and the actuator for moving the latter, one of said connections being used when the lever moves in one direction from its neutral position and the
25 other when the lever moves in the opposite direction, both of said connections causing similar movements of switch and rocking actuator, a stop-lever also acted upon by the diaphragm means, and stops which are engaged by the stop-lever to limit the movements of the first mentioned lever on both sides of its neutral position.
30

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