

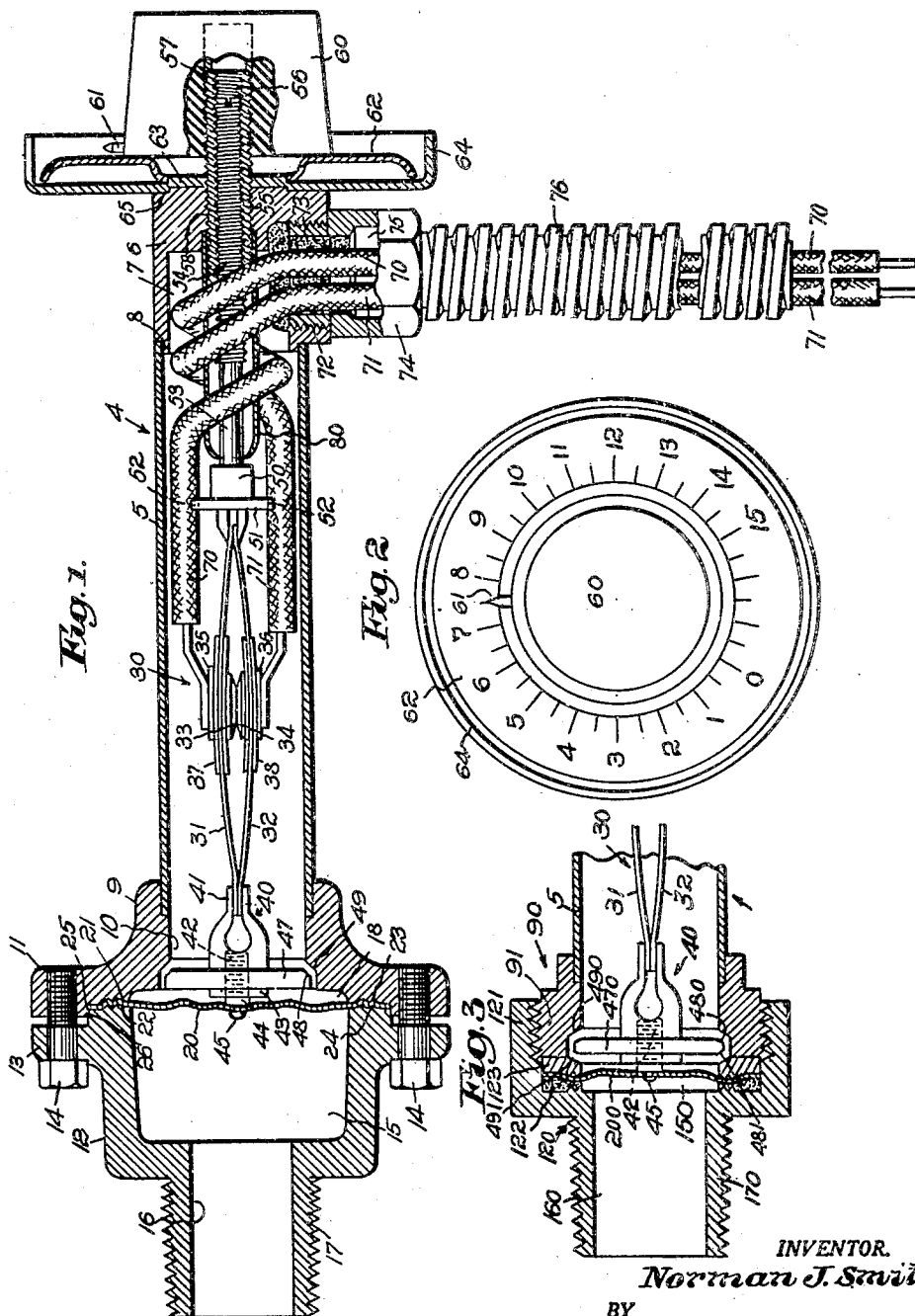
Oct. 26, 1948.

N. J. SMITH

2,452,500

PRESSURE SWITCH

Filed Jan. 18, 1945



INVENTOR.
Norman J. Smith
 BY
Emery, Booth, Townsend, Miller & Widner
 Attys

UNITED STATES PATENT OFFICE

2,452,500

PRESSURE SWITCH

Norman J. Smith, Medfield, Mass., assignor to
Fenwal Incorporated, Ashland, Mass., a cor-
poration of Massachusetts

Application January 18, 1945, Serial No. 573,322

15 Claims. (Cl. 200—83)

1

My present invention relates to electric switches, especially those for circuits to be opened or closed in response to pressure variation in a fluid or other medium. It aims to improve such devices structurally and in performance, through novel features including compensation for ambient or other temperature effects, avoidance of objectionable distortion or deformation of operating parts, retention of pressure fluid against accidental escape and possible injury thereby, together with other advantages which will be apparent from the following description and accompanying drawings.

In the drawings illustrating by way of example certain embodiments of the invention, upon a somewhat enlarged scale:

Fig. 1 is a longitudinal section centrally through a pressure switch device, shown as having a relatively low pressure range, merely for the purposes of illustration;

Fig. 2 is an outer or right end view of the device of Fig. 1; and

Fig. 3 is a view corresponding to the left end portion of Fig. 1, showing a modification, appropriate for but not limited to operation over higher or more extensive pressure ranges.

Referring to the drawings in more detail, and first to Figs. 1 and 2, the pressure-switch device as a whole comprises a case or frame indicated generally at 4, housing and supporting a switch unit 30. Such housing herein includes a tubular shell 5, preferably cylindrical, having at one end a closing head 6 recessed as at 7 and having lapped engagement with the shell as at 8, the parts being united as by welding, brazing or the like, or they may be integrally formed. The case or housing 4 further includes at the other or inner end, integral with or secured to it in lapped seating relation, a collar 9 centrally apertured as at 10 in extension of the shell interior and having a lateral annular flange 11. The collar 9 is adapted for connection to a chambered base 12 having a corresponding flange 13, the two flanges being detachably clamped together by screws or bolts 14. This base herein completes the case or housing assembly.

The base 12 is of cup form presenting a chamber 15, herein of larger diameter than the bore of the shell 5 and somewhat flared toward the latter. The base chamber 15 has an open inlet at 16 through an externally threaded extension or neck 17, by which the device as a whole is mounted at the point of use, in closed communication with the pressure medium to which the switch is to respond.

2

The base chamber 15 together with a conformant central recess 18 at the adjacent end face of the collar 9 provide a space of substantial area transversely of the device as a whole, for the operation of a pressure receiving and transmitting element, herein a diaphragm 20 of a sheet material of a strength and flexibility as appropriate for the fluid pressures for which the given device is designed. The embodiment of Figs. 1 and 2 is represented, merely by way of example, as having an operating pressure range of from 0 to 15 p. s. i. (pounds per sq. in.), with an operating differential, as between the closed and the open status of the switch at the selected pressure within that range, of as little as 1 oz. It is constructed and arranged to afford a substantial safety factor, herein 100%; that is, the device will sustain pressures above the intended range, up to 30 p. s. i. in the particular example. A suitable diaphragm material in this instance is phosphor-bronze, e. g. Revere A or C, of about No. 20 to 22 gauge A. W. G. (approximately $\frac{1}{16}$ in.).

The diaphragm 20 is replaceably held in operative position between opposed clamping faces 21, 22 on the collar 9 and base 12 respectively and desirably having mating annular rib and groove formations 23, 24 for gripping and sealing engagement with the opposite faces of the circumferential portion of the diaphragm. The clamping faces 21, 22 are offset lengthwise with respect to the meeting plane of the flanges 11, 13, one face-carrying member, herein the collar 9, being recessed and the other, here the base 12, being correspondingly shouldered, as at 25, 26 respectively. The base 12 and the collar 9 together with the entire case 4 are accurately aligned axially, while the break-joint relation at 25, 26 further seals the diaphragm peripherally.

A distinctive feature of the invention lies in the novel combination and mutual adaptation of direct pressure-actuated mechanical means, exemplified by the diaphragm and associated parts described, and an electrical switch unit 30 of the Fenwal bowed-strut type. Such unit heretofore has generally been thermally actuated, through differential expansion or contraction as between it and a surrounding or adjacent companion element.

Switch units as here referred to comprise a pair of oppositely disposed concavo-convex flexible members, strips or struts held together at their respective ends and carrying contact points centrally between them. These flexible strips may bow in, for direct action wherein the switch closes under longitudinal compression and opens on re-

3

lease thereof, or they may bow out for inverse actuation, opening the switch under longitudinal compression and closing it when relieved or under tension lengthwise. For an example of a thermally-responsive Fenwal switch unit of the direct or in-bowed type reference is made to Patent 2,090,407 to Turenne; for the inverse or out-bowed type of Patent 2,185,433 to Fenn and Turenne; and for further disclosure of these two main types and certain features broadly common to both of them, to Turenne Patent 2,257,990.

Similarly as in said Turenne Patent 2,257,990 the present invention is equally applicable to either and both the direct and the inverse switch types. For the purposes of illustration the switch unit 30 of Fig. 1 is shown as of the inverse or out-bowed type, operable to break contact at a predetermined selectable pressure lengthwise thereof. It comprises a pair of spring strips or struts 31, 32 having their concave faces mutually opposed, with their corresponding ends convergent and rigidly interconnected. Centrally at the inner faces of each strip 31, 32 is a switch point 33, 34 of suitable electrical-contact material, such as silver, on clips 35, 36 over mica, fibre glass or other insulating material 37, 38.

In accordance with the present invention, such switch unit 30 is disposed axially in the tubular case 4 and is adapted for opening and closing under the influence of longitudinal pressure, above or below the selected critical value. In the example of Fig. 1, the correlated means through which pressure acts on the switch unit includes the diaphragm 20, one surface of which is subject to the fluid pressure, or absence thereof, in the chamber 15.

Accordingly one end of the switch unit is operatively connected, rigidly in this instance, to the diaphragm. This is herein accomplished by a connective head designated generally at 40, having a forked portion 41 in which the abutted ends of the switch strips 31, 32 are secured as by welding, brazing or the like. The head 40 has a tapped aperture opposite the forked portion, receiving a screw-threaded member 42. The latter is formed with a flange 43, a rounded shoulder portion 44 engaging the adjacent face of the diaphragm 20, and a reduced pin-like extension 45 passing through a corresponding small aperture centrally of the diaphragm. The end of the pin extension 45 is turned down against the pressure-receiving face of the diaphragm, in attached sealing relation to it.

Further in accordance with the invention, safety means is provided, herein associated with the diaphragm and the attaching head 40, against accidental escape of the pressure medium, whether steam, compressed air, hydraulic liquid or other fluid, in the event of rupture or other failure of the diaphragm under some abnormal condition, or to prevent undue or permanent deformation of the parts under excessive pressure conditions. Such means as here shown comprises a valve element or safety plug 47 integral with or fixed on the head 40, between the latter and the flange 43 of the screw member 42.

This safety element 47, shown as a disc or plate having a conical seating formation 48, in effect constitutes a valve or closure plug, herein incorporated unitarily with the diaphragm and the switch unit. It has a normal inactive position substantially as in Fig. 1, and an emergency position in which it closes off the chamber 15 against escape of the pressure fluid in case of diaphragm failure. For cooperation with the valve 42-48

4

the base-attaching collar 9 of the case 4 is formed with a correspondingly inclined conical valve seat 49, concentric with and communicating between the end recess 18 and the bore 10 of the collar. Normally the spacing between the valve 47-48 and its seat 49 is such as to afford free action of the diaphragm and the switch unit throughout the entire operating pressure range for which the particular device is designed.

At the other or outer end, toward the right in Fig. 1, the switch unit 30 has rigid abutitive support in and with respect to the case 4, with capacity for adjustment relative to it for pressure setting purposes. The adjustable supporting means for this purpose may be generally similar as in the patents mentioned. The outer ends of the switch strips 31, 32, which may be semi-cylindrical as in Fenn et al. Patent 2,185,433, are confined in and secured to a tubular head 50 having a lateral flange 51.

This head 50 receives and is secured to the inner end of a pin or stud 53. Along its outer end portion the stud 53 is externally threaded as at 54 for reception in a sleeve 55 having corresponding internal threads 56. This sleeve in turn has an external thread series 57 for cooperation with a like-threaded formation 58 on the wall of an axial opening extending through the casing head 6.

It will be understood that the cooperative thread formations 57, 58 between the exterior of the sleeve 55 and the casing head 6, and the interengaging thread formations 54, 56 between the stud 53 and the interior of the sleeve 55 are respectively of a different pitch; that for the exterior threads of the sleeve desirably is somewhat lower. Rotation imparted to the sleeve 55 accordingly will effect a differential action with respect to the stud 53, for shifting the latter axially in one or the opposite directions through increments of the desired fineness and accurately proportionate to the turning of the sleeve, in a generally similar manner as in the patents mentioned.

To facilitate adjusting the switch setting in the above manner the sleeve 55 is extended outwardly beyond the casing head 6 and has detachably fixed on it a knob 60 having an index or pointer 61 for reading against a calibrated dial 62. The latter as shown is mounted concentrically with the sleeve 55, being positioned and held on a central boss 63 on a protective cupped flange 64 apertured for passage of the sleeve and secured flatwise against the head 6 of the case as at an annular shoulder 65 thereon. The switch unit as such may have an "initial," "normal" or pre-installation status in which the contacts are somewhat open and require an initial lengthwise tensioning of the strips to close them, or in which the contacts are closed under more or less initial lengthwise compression of the strips, or the contacts may initially stand closed with the strips free of either compression or tension, depending on the construction, proportioning and arrangement of the parts. Hence, to indicate switch-opening (or closing) settings over a zero to maximum range of pressure (above or below atmospheric) effective at the diaphragm, the scale, dial or other index means may be calibrated to include any appropriate plus or minus factor for the particular switch unit.

From the respective insulated switch points 33, 34 insulated conductors 70, 71 lead to the outside of the case 4, herein through a lateral opening 72 in the head 6. These conductors pass

through sealing means 73, such as impregnated asbestos packing, held in the bore of a tubular closure nut 74 threaded into the casing opening 72 and externally recessed as at 75 for attachment of flexible armoring 76 through which the leads project.

Within the case 4 the conductors may be laid through notched edge portions 52 of the flange 51 on the switch head 50. Between the latter and the opening 72 they desirably are given one or more turns about an elongated tubular sleeve or shield 80. Such shield is held in coaxial spaced relation to the threaded adjusting and switch-anchoring parts 53-58, with its outer end secured in a recess for the purpose in the casing head 6.

As a further important feature of the invention the device as a whole preferably is constructed and arranged to compensate automatically, to the desired extent, either fully or partially, for ambient and other temperature effects upon it, or to make the switch responsive either to pressure alone or to both pressure and temperature. For substantially complete independence of temperature effects, heat-subject parts including those of the housing case 4, the switch unit 30 and its supporting means are formed of materials which have substantially the same coefficient of linear expansion. In such instance, linear expansion and contraction under temperature variations being opposite and equal or substantially so with respect to the case 4 and the switch unit 30, the switch is responsive to pressure only, through its entire operating range. In other instances, where a switch response is desired which is a function of both pressure and temperature, such conjoint response can be had by selecting materials for the case 4, the switch unit 30 and the supporting means having linear expansion coefficients in appropriate predetermined ratio other than 1 to 1.

Referring now to Fig. 3, I have there shown a further embodiment of the invention, especially suitable for relatively wide ranges of operating pressure, again with adequate safety factor. For example, the switch of Fig. 3 may have a normal operating range, exclusive of the safety factor, from 0 to 100 p. s. i., or between other relatively wide-spread pressure limits, the setting means such as the scale or dial corresponding to member 62 of Figs. 1 and 2 being graduated accordingly, as from 0 to 100. While the Fig. 3 embodiment is particularly useful for extensive pressure ranges, including high pressures, it is not limited to such use. Conversely the Fig. 1 form of the invention is adaptable for other than low pressure purposes, the individual features of the two illustrative embodiments being interchangeable, with such modification of the diaphragm as to dimensions, strength and flexibility as may be appropriate for the pressures involved, with more or less spring-loading if desired.

Parts not shown in Fig. 3 may be the same as in the preceding figures, otherwise than as to the scale or dial calibration, and like parts in Fig. 3 have the same reference numerals as in Fig. 1, other parts being numbered with the addition of a zero.

In Fig. 3, the collar member indicated as a whole at 90 is formed with an externally threaded annular portion 91 while the base 120 has an oppositely extending sleeve 121 internally threaded to receive and securely hold the collar 90, the shell 5 connected thereto and the case 4 as a whole. The diaphragm 200 is firmly clamped at its circumference between gland rings 122, 123 held between

longitudinal opposed inner portions of the base and collar respectively, which are proportioned to afford the desired effective area for the diaphragm. The pressure inlet 160 in the threaded connector nipple 170 has an internal diameter calculated with reference to that of the shell 5 and the bore of the collar 90, being shown for example as somewhat less than the latter. It admits to a diaphragm chamber 150 illustrated as of relatively smaller transverse area and volume than as in Fig. 1, as suitable for higher pressures. As above noted, the embodiments of Fig. 1 and of Fig. 3 are not limited to low pressures and high pressures respectively, and in either example the diaphragm structure, proportioning and arrangement in relation to the switch case may be varied as the particular operating pressures and other use circumstances may require. As in the example of Fig. 1, the outbowed strips 31, 32 of the switch unit 30 of Fig. 3 have their ends adjacent the diaphragm secured in a head 40 provided with a screw member 42 including an end pin extending centrally through the diaphragm and having sealed engagement with it as at 45.

The safety means for blocking escape of the pressure fluid in case of diaphragm failure and for preventing undue or permanent deformation of the diaphragm and other parts is in this instance double acting. With an extensive pressure range and particularly at the higher pressures abnormally reduced or negative pressure conditions may arise, such as to place undue stress on the diaphragm in the direction toward the left in Fig. 3, as well as oppositely acting excess positive pressures.

Accordingly the valve or plug element 470, again of a disc-like form and similarly mounted on the head 40 as in Fig. 1, is provided with oppositely inclined peripheral portions 480, 491. These are respectively adapted to have closed seating engagement with correspondingly inclined valve seats 490, 491, one herein on the collar 90 and the other on the adjacent clamping ring 123 of the diaphragm. The longitudinal spacing between these valve seats 490, 491, and the thickness of the valve disc 470 are relatively proportioned to afford the desired total range of free action for the diaphragm and associated switch parts. Thus it will be seen that in the event of rupture or failure of the diaphragm attendant on positive or relatively high pressures in the chamber 150, the valve 470 will be received upon the seat 490, toward the right in Fig. 3, while diaphragm failure in the presence of negative or relatively reduced pressures will effect a seating action as between the valve and the seat 491, toward the left in Fig. 3, again closing off the case 4 and relieving the switch unit from possible distortion or breakage. Also, where excess of positive or negative pressure would cause excess motion of member 40, with consequent deformation of the switch unit or of the diaphragm, this double stop acts to prevent such deformation. This double or two-directional stop feature, as well as the others of Fig. 3, may be incorporated with those of the Fig. 1 embodiment, and vice versa, as may be desired.

My invention is not limited to the particular embodiments as herein illustrated or described, its scope being pointed out in the following claims:

I claim:

1. In an electric switch device having a switch unit comprising a pair of metallic strips oppositely bowed in one direction along their working length and held together at their corresponding ends and a tubular case longitudinally housing the

switch unit, the combination therewith of an extension at one end of the case providing a pressure chamber having a fluid inlet, a pressure diaphragm transversely partitioning the chamber and the adjacent end of the switch strip pair, abutitive connecting means between said end of the strip pair and the diaphragm, and rigid connecting means between the other end of the strip pair and the corresponding end of the case whereby the switch unit is operatively subject to pressure conditions at the diaphragm.

2. A pressure-actuated temperature compensated electric switch device comprising, in combination, a tubular metallic case having a closing head and an opposite base for mounting the device in communication with a source of fluid pressure, a pressure chamber in the base presenting a flexible pressure-receiving diaphragm, an elongated switch unit comprising a contact-carrying bowed metallic strut pair operatively responsive to longitudinal forces thereon, said unit disposed lengthwise in the case, means rigidly connecting one end of the unit with the case head and the other end with the diaphragm, the case, the switch unit and said connecting means having a predetermined relation as to linear expansion properties.

3. An electric switch comprising, in combination, an elongated bowed contact unit, a supporting frame having rigid connection with one end of the contact unit, a flexible pressure-transmitting element connected to the other end of the contact unit, and means for longitudinally subjecting said element to variable fluid pressure for corresponding response by the contact unit, the frame and the contact unit being constructed and arranged for equal and opposite longitudinal expansion and contraction whereby temperature effects thereon are automatically compensated.

4. An electric switch comprising, in combination, an elongated bowed contact unit, a supporting frame having rigid connection with one end of the contact unit, a flexible pressure-transmitting element connected to the other end of the contact unit, and means for longitudinally subjecting said element to variable fluid pressure for corresponding response by the contact unit, the frame and the contact unit formed of materials having the coefficients of linear expansion in selected ratio to compensate for temperature effects to a corresponding predetermined extent.

5. In a pressure switch, in combination with an elongated tubular support presenting a fluid pressure chamber having an inlet, a diaphragm subject to pressures in the chamber, a bowed contact element extending lengthwise in the support and operatively interposed as a strut between the diaphragm and a stationary portion of the support, and plural abutment means at the face of the diaphragm adjacent the contact element and disposed respectively on the latter and on the support for opposing the contact element and diaphragm in the event of abnormal pressures effective thereon in either direction.

6. A pressure switch having, in combination, a tubular case, a bowed-strip contact unit longitudinally disposed in the case with one end rigidly held relative to it, said unit having contacts relatively movable transversely of the case for making and breaking action and a pressure-transmitting diaphragm transversely partitioning the case beyond and operatively secured to the other end of the contact unit in position to subject it to pressure lengthwise of the unit and transverse to the direction of contact making and breaking action thereof.

7. A pressure and temperature switch having, in combination, a tubular case, a bowed contact unit longitudinally disposed in the case with one end rigidly held relative to it, and a pressure-transmitting diaphragm transversely partitioning the case and operatively secured to the other end of the contact unit, the case and contact unit formed of materials having coefficients of linear expansion in selected ratio to afford predetermined relative effects of temperature thereon providing for desired switch response as a function both of pressure and temperature.

8. A pressure switch having, in combination a tubular case, a bowed contact unit longitudinally disposed in the case with one end rigidly held relative to it, and a pressure-transmitting diaphragm transversely partitioning the case and operatively secured to the other end of the contact unit, the case and contact unit formed of materials having substantially the same linear expansion coefficients and whereby temperature effects thereon are fully compensated and the switch made responsive to pressure only.

9. In a pressure switch, in combination, a case comprising a tubular shell, a closure head and a mounting base having a fluid inlet, a pressure chamber in the case in communication with the inlet, a flexible diaphragm held in and normally closing the chamber, a bowed-strip contact unit longitudinally interposed in the manner of a strut between the diaphragm and the case head, connector means between the contact unit and the diaphragm, a valve-like stop and closure element carried by the connector means at the side of the diaphragm away from the inlet, and seating means on the case cooperable with said element to oppose excessive pressures and for sealing reception of said element to prevent escape of fluid past the diaphragm.

10. In an electric switch, in combination, a case comprising a tubular shell, a closure head and a mounting base having a fluid inlet, a pressure chamber in the case in communication with the inlet, a flexible diaphragm held in and normally closing the chamber, a bowed-strip contact unit longitudinally interposed in the manner of a strut between the diaphragm and the case head, and rigid means connecting the opposite ends of the bowed-strip unit with the diaphragm and with the case head respectively, the bowed-strip unit and the shell having such relative linear expansion properties that the pressure setting of the switch is automatically compensated for temperature variation to a predetermined extent.

11. A pressure switch comprising, in combination, a tubular case having a closing head and a fluid-admitting base, a flexible diaphragm partitioning the case and subject to the fluid pressure at one face, a bowed switch unit operatively disposed lengthwise between the diaphragm and the case head, rigid means connecting the diaphragm and the adjacent end of the switch unit for longitudinal pressure variation upon the unit according to pressure of the diaphragm, a stud connected to the other end of the unit and rotative longitudinally adjustable means rigidly interconnecting the stud and the case head, said means accessible externally of the case for tensioning or relieving the switch unit thereby to set it for action at a selected diaphragm pressure within a given range.

12. A pressure switch according to claim 11 wherein the case includes a laterally extended chamber for the diaphragm, and the latter is of correspondingly enlarged surface area.

13. A pressure switch according to claim 11 wherein the effective area of the diaphragm is not greater than the approximate transverse area of the case.

14. A pressure switch comprising, in combination, a tubular case having a closing head and a fluid-admitting base, a flexible diaphragm partitioning the case and subject to the fluid pressure at one face, a bowed switch unit operatively disposed lengthwise between the diaphragm and the case head, and rotative longitudinally adjustable means rigidly connecting the end of the unit distal from the diaphragm to the case head and accessible externally of the latter for tensioning or relieving the switch unit thereby to set it for action at a selected diaphragm pressure within a given range, said adjusting means including a scale graduated in pressure units and calibrated to a minimum-maximum range of diaphragm pressures, an index movable over the scale, and a manipulating member therefor.

15. An electric switch comprising an elongate hollow body having a head at one end, a pressure chamber with a fluid inlet at the other end of the body, a fluid-pressure diaphragm transversely partitioning the chamber, a bowed-strip contact

unit extending longitudinally in the body in the manner of a strut between the diaphragm and the closure head, said unit having separable contacts having a relative opening and closing action transverse of the unit and body under longitudinally effective forces, and operative connections for the opposite ends of the bowed-strip unit with the diaphragm and the closure head respectively whereby said unit is subject to thermal expansion and contraction effects upon it and the body and is responsive to vertical pressure change upon the diaphragm.

NORMAN J. SMITH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,370,193	Crocker	Mar. 1, 1921
1,938,327	Green	Dec. 5, 1933
2,086,264	Gorschalki	July 6, 1937
2,185,433	Fenn et al.	Jan. 2, 1940
2,275,556	Rasmussen	Mar. 10, 1942