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FLUID PRESSURE OPERATED SWITCH

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This application is a continuation-in-part of my application Serial No. 106,383, now Patent No. 2,571,617, filed July 23, 1949, for "Fluid Pressure Operated Switch."

This invention relates to fluid pressure operated switches adapted to respond very sensitively to the influence of hydraulic or gaseous fluid pressure for making and/or breaking a circuit for apparatus actuated electrically or for bringing into and out of circuit an electrically operated warning device, controller or other apparatus. More particularly the present invention is concerned with a switch adapted to respond to very small changes in pressure and in which a diaphragm is exposed to the pressure fluid which e. g. can have an effective operative pressure as low as 0.5 inch water gauge. However the invention is applicable to other ranges of pressures, but by way of example the present switch is capable of responding effectively to pressure obtained as a signal of the immediate approach of the stalling speed of an aeroplane. For instance by predetermining the safe minimum differential of the pressure at "stagnation" point inside an aeroplane wing and the pressure at the "saturation" point on the leading edge of the wing, e. g. a differential of say .75 inch water gauge, or e. g. a stalling airspeed of 35 M. P. H., the switch can be set to give a warning signal promptly at the critical speed.

According to the present invention a fluid operated electric switch comprises a base structure formed with a compartment sealed off on one side by a flexible diaphragm of a resilient non-hygrosopic sheet material distensible from its normal flat condition by fluid pressure as low as about 0.5 inch of water gauge, said compartment having communication with an inlet for the purpose of admitting fluid pressure to the said compartment so as to deform the diaphragm for the purpose of actuating the switch, another compartment in said base structure separated and sealed off from the aforesaid compartment by the diaphragm and containing a loose disc the periphery of which is so closely related to the surrounding wall of said second mentioned compartment as to prevent deformation of the diaphragm between the said periphery and said wall, a switch actuating stud carried by said disc and slidable freely through the said base structure, and contacts, one of which is spring loaded towards said stud so as to yieldingly oppose actuation of the switch by fluid pressure upon the diaphragm, said spring loaded contact being additionally loaded by means operating in a direction which neutralises the influence of the weight of said stud and disc upon

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the spring loaded contact so that the switch operates at the same pressure when the switch occupies an inverted position such that the weight of the said stud member supplements the load due to the fluid pressure upon the diaphragm, the said spring loading of one of the contacts being effected by a leaf spring having a free end operative against the pressure transmitted to the switch via the diaphragm from the fluid pressure source and having an anchored end, an abutment engaged permanently with said leaf spring, means to adjust said abutment translatively relative to the spring to vary the yield or effective load of said spring, and means to lock said abutment in selected positional relationship with said spring.

In order that the invention may be clearly understood and readily carried into effect drawings are appended herewith illustrating an embodiment thereof, and wherein:

Figure 1 is a sectional elevation of the switch taken on the line I—I of Figure 3;

Figure 2 is a section of the line II—II of Figure 3;

Figure 3 is a section on the line III—III of Figure 2; and

Figure 4 is a detail plan view of a spring element of the switch.

Referring to the drawings the housing assembly for the switch mechanism comprises a cover cap 1, an angle section base ring 2 threaded to the cap 1 as at 3 and a cylindrical base plug 4 held in position by the annular flange of the ring 2, and a disc 5 together with a rubber sealing ring 6. All of these metal parts are preferably anodised. Gripped between the opposed faces of the plug 4 and disc 5 is a flexible diaphragm 7, which for highly sensitive operations, e. g. when the switch is to give a stall warning on aircraft is preferably made of very thin highly flexible rubber or pure latex, this diaphragm at its outer annular part being gripped between the aforesaid members 4 and 5. An annular thin plate of fibre 7a is interposed between the disc 5 and the diaphragm to obtain a good seal and for electrical insulation of the disc 5 from the base plug 4, and also to obviate distortion of the diaphragm when applying the disc 5 over the base plug 4.

The diaphragm 7 is exposed for deformation by fluid pressure to a shallow concentric recess 8 in the base plug 4, this recess 8 communicating via a passage 9 with a source of fluid pressure, e. g. pressure obtained from the "saturation point" at the leading edge of an aeroplane wing when the switch acts as a stall warning switch. For this purpose a union 10 can be

fitted in the plug 4 for connection by a suitable conduit to the source of fluid pressure. On the other side the diaphragm extends across a shallow concentric recess 11 in the base of the disc 5, this recess 11 accommodating the disc-like head 13 affixed by a screw 14' to a centre stud 14 slidable through the centre of the disc 5, actual physical contact of the disc 13 against the diaphragm 7 preferably being normally prevented, or the contact only being light touch contact without any weighting of the diaphragm, by the use of a flange 15 on the upper part of the stud 14 resting upon the upper face of the disc 5, when there is no pressure upon the lower side of the diaphragm, the arrangement in any event being such that the deformation of the diaphragm due to fluid pressure will have to be exceedingly slight in order to ensure effective engagement between the diaphragm and the disc-like head 13 of the stud. The head 13 is preferably an anodised aluminium disc, and in order to obviate its tendency to cling to the disc 5 e. g. through "stiction," and also to allow air to blow over the top surfaces of the diaphragm and head 13, when, as hereinafter described, air pressure is applied to the interior of the cap 1, the upper face of the head 13 is formed with a relatively narrow annular ridge 12 preferably formed with notches or transverse channels.

Also, the periphery of the disc-like head 13 has a clearance from the cylindrical wall of the recess 12 which is as small as is possible to obtain a working clearance, so that there will be no deformation of the diaphragm otherwise than that which is effective upon the base of the disc-like head 13. This manner of supporting the stud 14 with its head 13 ensures a highly sensitive response to the action of the diaphragm and relieves the diaphragm from harmful strain due to very heavy fluid pressure, so that the switch whilst being exceptionally sensitive can be employed in recording a drop in pressure in a circuit or container subjected to a very high fluid pressure. Likewise the plunger flange 15 acts as a positive stop preventing harmful deformation of the diaphragm downwardly into the recess 8 by the means, hereinafter described, which yieldably opposes the action of the fluid pressure against the diaphragm. However, as previously indicated the switch of the present invention is adapted to be sensitive and highly responsive to a wide range of variations in pressures. For example, the pressure on the diaphragm which would maintain the stud 14 raised may be air pressure against the leading edge of a wing due to the speed of an aircraft, so that when the pressure drops below a predetermined point a signal can be produced indicating that the aircraft is dangerously approaching the stalling speed of the aircraft.

In the latter connection the switch would act as a differential switch, e. g. by admitting static air pressure, e. g. air pressure inside the wing to the interior of the cap 1. This can be through a bleed hole 43' drilled in a screw plug 43 threaded in the cap 1, or via a pipe line connected to a union 44 either of which can be sealed off when necessary. This static air pressure can be transmitted to the recess 11 via a bleed hole 45 in the disc 5 and the air circulated freely over the head 13 and the upper face of the diaphragm as previously mentioned.

The top of the stud 14 is brought to spherical form as shown to make point contact with a switch lever 16 fulcrumed by a bush 17a on

a pivot pin 17 fixed by screws 19 at its ends in a pair of lugs 18' integral with a bar 18 fixed to the disc 5 by screws (not shown) threaded up through the disc 5. This lever 16 is a metal plate of substantially T configuration the centre limb part of which carries at its free extremity a split resilient blade 20 having rhodium coated contacts 21 adapted to engage a rhodium coated contact bar 22 supported across a pair of studs 23 and insulated therefrom by insulating collars 24, a terminal connector 25 (see Figure 3) connecting one end of the bar 22 to a lead 26 taken to the appropriate part of the circuit of a warning or other suitable electrically operated device. The other electrical connection is taken off the switch by a lead connected to terminal member 27 (see Figure 1) a part of the switch mechanism hereinafter described which forms electrical connection with the lever 16 and which embodies means for varying the effective pressure of a leaf spring 28 upon the lever 16 between the fulcrum 17 and the contact blade 20.

The leaf spring 28 yieldingly opposes the influence of the fluid pressure upon the stud 14 so that when the fluid pressure drops below a predetermined load the leaf spring 28 will bring the contacts 21 and 22 into engagement.

The object of making the switch lever 16 T-shaped, is to provide an easily standardised method of weighting the lever at one end, but of course, other means can be adopted for this purpose. It will be seen by reference to Figure 2 that, in what, for the purpose of explanation, might be regarded as the normal or upright position of the switch, the transverse limb 16' assists in the "lift" or "off" movement of the lever 16, but in the event of the switch being turned upside down the counterweight forming part 16' by reason of carefully predetermining its mass, will neutralise the effect of the weight of the stud 14 and its disc 13 upon the lever 16.

The leaf spring 28 lies flush upon the centre limb of a T-shaped block 30 for a part of its length and at its free end is downwardly bowed or cranked as at 28' to engage the lever 16, its other end being gripped between the transverse limb of the block 30 and the base of a rectangular U-shaped bracket 31, a pair of screws 30' securing the members 30 and 31 to the disc 5.

The leaf spring 28 (see Figure 4) is a strip of flat steel spring with its longitudinal edges converging towards its free end, its wider end being shaped, e. g. recessed as at 28a to miss the screws 30', whereby the spring may be adjusted angularly as indicated by the arrowed line, to change its point of contact with the lever 16 whereby there can be effected coarse preliminary adjustments of the effective spring pressure opposing the fluid pressure applied through the inlet 9.

The fine adjustments of the effective load of the leaf spring upon the lever 16 is obtained by translating across the upper face of the leaf spring a nut 32 having a bevelled lower edge 33 providing a line or chisel point contact with the spring. This nut is translated lengthwise of the spring by the rotation of a feed screw 34 threaded diametrically through the nut 32 which has a cylindrical periphery to make smooth low friction yet close firm contact with the opposed parallel sides of a slot 35 in a thickened or block-like end 36' of a lever 36 fulcrumed at one end by a pivot pin 37 passed through the part 36' and the vertical limbs of the bracket 31 and locked in position by a spring clip or ring, not shown.

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The other end of this lever is apertured as at 36a to fit loosely over a stud post 37 locked by a nut or nuts 37' to the disc 5. A short length of helical spring 38 is interposed between this end of the lever 36 and nuts 39 on the top of the post 37, this spring being under sufficient compression to prevent any yield of the lever 36 to the load on the leaf spring 23 due to the fluid pressure actuating the switch. Thus the nut 32 is normally a positive non-yielding stop, which by its trans-

lative adjustment by means of the feed screw 34 varies the yield or effective load of the leaf spring 23 upon the switch lever 16. The purpose of the pre-loaded coiled spring 38 is to take care of any mis-alignment or lack of concentricity of the feed screw 34 during its rotation for the purpose of traversing the nut 32, as otherwise if the feed screw 34 did not rotate concentrically about its axis it would vary the pressure of the nut 32 upon the leaf spring 28. The feed screw 34 has a concentric spigot 40 at one end journalled in the adjacent end wall of the blocklike part 36' of the lever 36, and its other end has a concentric spigot 41 journalled in a bush 42 threaded into the other end wall of the blocklike part 36'. The feed screw 34 is rotated by inserting a key through the bush 42 into a square or other suitable recess in the spigot 41, this key having a clearance from the bush 42. The purpose of the bush 42 is to provide an effective and convenient means for locking the screw 34 in selective position, this being effected by inserting a larger key in a hexagonal or other suitably shaped recess 42' in the exposed end of the bush, the other end of this bush being pressed axially against the annular ledge joining the spigot 41 with the threaded part of the screw.

The removable screw plug 43 in the cap 1 affords convenient access to the bush 42 and feed screw 34. A hole 1a is provided in the cap 1 to receive a "breeze" plug or adapter for the leads of the switch.

By means of the present invention features appropriate to the requirements of a highly sensitive switch which will respond to very slight changes in pressure to give a reliable signal, e. g. suitable for use in giving a stall warning on aircraft, are provided, viz:—

(1) A highly sensitive very flexible and yet durable thin flexible diaphragm 7, e. g. high quality thin rubber latex having a gauge of .003 to .010 of an inch,

(2) Absence of any deformation of the diaphragm 7 other than the very slight movement required to displace the stud 15,

(3) An ability to effect very fine and accurate adjustments of the spring load opposing the fluid pressure, e. g. the translative adjustment of the edge of the nut 32 upon the spring 28, and

(4) Readily accessible means for translating the nut 32 and also for locking it in selected position.

I claim:

1. A fluid pressure operated electric switch comprising a base structure formed with a compartment sealed off on one side by a flexible diaphragm of a resilient non-hygroscopic sheet material distensible from its normal flat condition by fluid pressure as low as about 0.5 inch of water gauge, said compartment having communication with an inlet for the purpose of admitting fluid pressure to the said compartment so as to deform the diaphragm for the purpose of actuating the switch, another compartment in said base structure separated and sealed off

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from the aforesaid compartment by the diaphragm and containing a loose disc the periphery of which is so closely related to the surrounding wall of said second mentioned compartment as to prevent deformation of the diaphragm between the said periphery and said wall, a switch actuating stud carried by said disc and slidable freely through the said base structure, and contacts, one of which is spring loaded towards said stud so as to yieldingly oppose actuation of the switch by fluid pressure upon the diaphragm, said spring loaded contact being additionally loaded by means operating in a direction which neutralises the influence of the weight of said stud and disc upon the spring loaded contact so that the switch operates at the same pressure when the switch occupies an inverted position such that the weight of the said stud member supplements the load due to the fluid pressure upon the diaphragm, the said spring loading of one of the contacts being effected by a leaf spring having a free end operative against the pressure transmitted to the switch via the diaphragm from the fluid pressure source and having an anchored end, a supporting member upon which said leaf spring for a portion of its length between its ends lies substantially flat, an abutment opposed to said supporting member and engaged permanently with said leaf spring, a guide member comprising a lever along one end of which said abutment is slidable, spring means loading the other end of said lever in the direction to press said abutment against said portion of the leaf spring which lies substantially flat against said supporting member, feed screw means to adjust said abutment translatively along said guide member relative to the leaf spring along the portion of the length of the leaf spring engaging said supporting member to vary the yield or effective load of said spring, and means to lock said feed screw means against rotation to maintain said abutment in selected positional relationship with said spring.

2. A switch according to claim 1 wherein the said flexible diaphragm is an imperforated piece of pure rubber latex having a gauge of approximately .003 to .010 of an inch.

3. A switch according to claim 1 wherein the said diaphragm is clamped at its annular periphery between a base member and a disc comprising the base structure of the switch, and an annular fibre or like insulating washer is gripped between the diaphragm and the said base member.

4. A switch according to claim 1 wherein the said leaf spring is adjustable angularly within the plane of its contact with the said supporting surface to vary the position of its free or operative end, the said free or operative end being engaged with a contact carrying lever engaged by the said stud, the said lever having a balancing mass on one side of its fulcrum to compensate for the weight of the said stud member when the switch is inverted.

5. A switch according to claim 1 wherein said leaf spring for a portion of its length is maintained in flat contact with a flat supporting surface of said supporting member and has a resilient operative end extending freely beyond said supporting surface, the said abutment comprising a nut with a bevelled edge pressed into engagement with the length of the leaf spring engaging the said supporting surface and having threaded therethrough a feed screw for translating the bevelled edge of the nut along the

said leaf spring to vary the terminal point of bending of the leaf spring under the influence of fluid pressure operating the switch, the said means for locking the nut in operative position comprising a bush in which rotates an unthreaded end portion of the feed screw, said bush being threaded in a support for the feed screw in the said guide member lever and being adapted to apply axial pressure to the feed screw to lock the feed screw in position, the bush being bored for the free reception of a key for turning the feed screw.

6. A switch according to claim 5 wherein the leaf spring is clamped between one end of a block and a U-shaped bracket in the side limbs of which is pivotally supported the said slotted lever carrying the feed screw and nut.

7. A switch according to claim 5 wherein the guide member lever is pivoted adjacent the point of support of the feed screw means and is free at its other end, its latter end being engaged by a compression spring which normally does not yield to fluid pressure transmitted through the leaf spring and nut, but which yields to compensate for any eccentricity of the screw in order to maintain solid or positive contact of the said nut or abutment against the leaf spring.

8. A switch according to claim 5 wherein said nut has a cylindrical periphery sliding in and engaging the longitudinal walls of a slot formed in the said lever, the feed screw being supported for rotation at its ends in the end walls of the said slot, one end wall receiving the said threaded bush.

9. In a fluid pressure operated switch of the kind in which making and breaking of opposed contacts is effected by changes in fluid pressure operating against a very thin flexible diaphragm in opposition to a variable spring load and in which a stud with a disc head making substantially co-planar surface contact with one face of the diaphragm transmits to one of the contacts movement due to the deformation of the diaphragm derived from the fluid pressure whilst only permitting of exceedingly slight uniform deformation of the diaphragm for all loads against the diaphragm, a leaf spring providing the said spring load, feed screw and nut means for selectively varying the said spring load by translative displacement of the nut thereof along one face of the leaf spring due to rotation of the feed screw, a cover enclosing the switch, an opening in said cover aligned axially with said feed screw and affording access to one end of the feed screw by a tool for rotating the feed screw, locking means with said latter mentioned end of the feed screw to lock it against rotation, said locking means also being adapted to be actuated rotatably by a tool insertable through said opening and comprising a rotary locking

member and a support therefor in which the rotary member is threaded and is displaceable axially by reason of its being rotated, its axial displacement in one direction applying an axial compression load on the feed screw to lock the screw against rotation, said latter end of said feed screw being unthreaded and received in said rotary locking member.

10. In a fluid pressure operated switch of the kind in which making and breaking of opposed contacts is effected by changes in fluid pressure operating against a very thin flexible diaphragm in opposition to a variable spring load and in which a stud with a disc head making substantially co-planar surface contact with one face of the diaphragm transmits to one of the contacts movement due to the deformation of the diaphragm derived from the fluid pressure whilst only permitting of exceedingly slight uniform deformation of the diaphragm for all loads against the diaphragm, a leaf spring providing the said spring load, feed screw and nut means for selectively varying the said spring load by translative displacement of the nut thereof along one face of the leaf spring due to rotation of the feed screw, a cover enclosing the switch, an opening in said cover aligned axially with said feed screw and affording access to one end of the feed screw by a tool for rotating the feed screw, locking means with said latter mentioned end of the feed screw to lock it against rotation, said locking means also being adapted to be actuated rotatably by a tool insertable through said opening and comprising a rotary locking member and, a lever arm, means at one end of said lever arm pivotally supporting it, a lengthwise disposed guide slot in said end of the lever arm, unthreaded ends to said feed screw, a bore in said arm in prolongation of one end of said slot in which rotates one of said ends of the feed screw, a threaded bore in the said lever arm at the other end of said feed screw in which is threaded the said rotary locking member, said rotary locking member freely receiving the other unthreaded end of said feed screw, said latter end of the feed screw and an end of said rotary locking member being shaped for the reception of the tools to actuate them, and a compressible abutment engaged by the end of the lever arm remote from said guide slot yieldable only for the purpose of compensating for any eccentricity of the screw.

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