Nov. 29, 1949 F. W. KERFOOT 2,489,419

PRESSURE RESPONSIVE SWITCH

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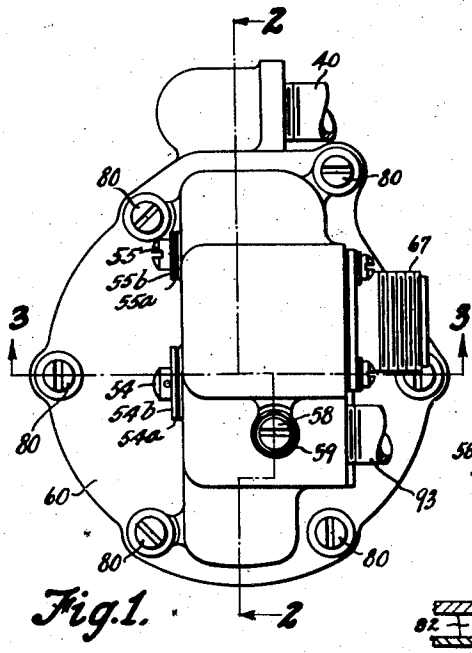


Fig. 1.

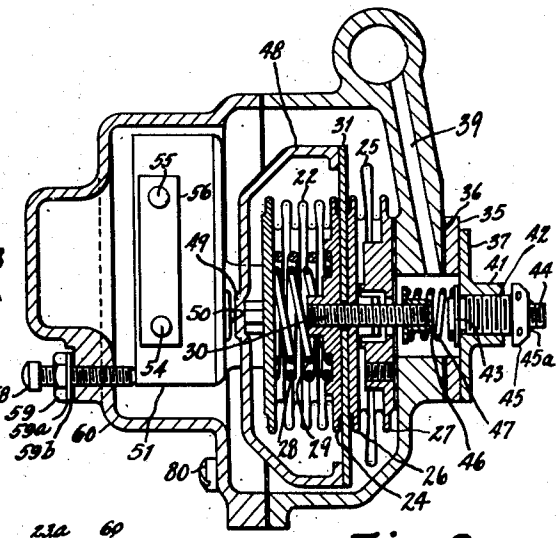


Fig. 2.

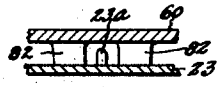


Fig. 5

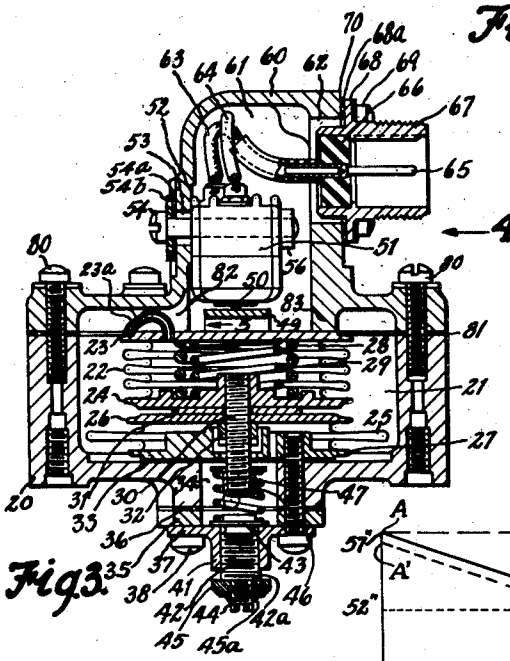


Fig. 3.

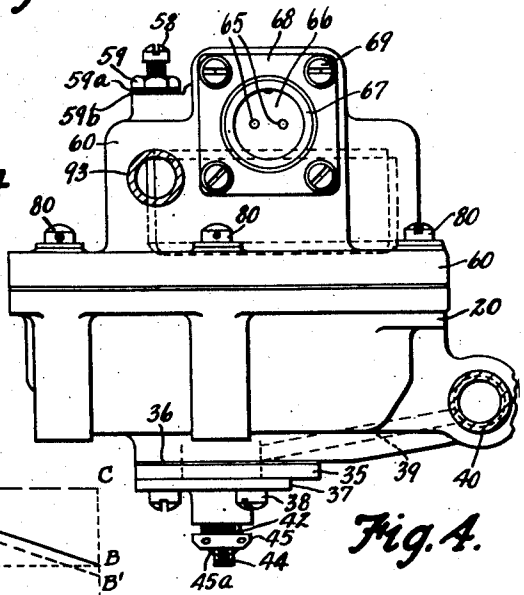
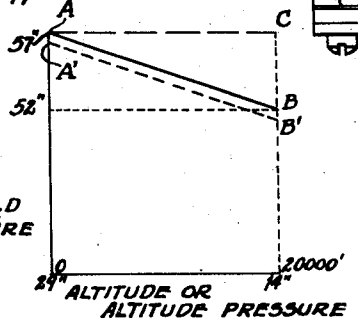


Fig. 4.



INTAKE MANIFOLD
ABSOLUTE PRESSURE

Fig. 6.

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PRESSURE RESPONSIVE SWITCH

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6 Claims. (Cl. 200—81.5)

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This invention relates to a fluid pressure responsive electric switch unit.

It is an object of the present invention to provide a switch unit comprising an electric switch and switch control means which responds to a given schedule of relations between two different pressures. A further object is to provide a facile means for modifying the schedule of the relations between the pressures.

A further object of the present invention is to provide a fluid-pressure sensitive electric switch unit of durable and economical construction which provides for the facile removal and replacement of operating parts. This object is accomplished by the provision of two subassembly units, one being a housing and a pressure sensitive device and means for adjusting it relative to an electric switch, and the other a housing, an electric switch and means for adjusting it relative to the pressure sensitive device. When the two housings are secured together to provide an enclosure the pressure sensitive device is brought into cooperative relation with the switch and its initial condition is established.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a plan view of the unit embodying the present invention.

Fig. 2 is a sectional view on line 2—2 of Fig. 1.

Fig. 3 is a sectional view on line 3—3 of Fig. 1.

Fig. 4 is a view in the direction of arrow 4 of Fig. 3.

Fig. 5 is a fragmentary sectional view in the direction of arrow 5 of Fig. 3.

Fig. 6 is a diagram illustrating the operation of the switch unit.

The unit comprises two subassemblies, one being a housing member and a fluid pressure responsive device attached thereto and the other subassembly being a housing member and an electric switch supported thereby. When the housing members are secured together, the fluid pressure responsive device of one assembly is brought into cooperative relation with the electric switch of the other sub-assembly.

One of the subassemblies comprises a housing 20 providing a chamber 21 for receiving a fluid pressure responsive device comprising an evacuated metal bellows 22 attached to end plates 23 and 24 and a metal bellows 25 attached to end

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plates 26 and 27. Springs 28 and 29 within the bellows 22 resist the collapse of this bellows under atmospheric pressure. A stud 30 threadedly engages the plate 24 and passes through a bar 31 and through the plate 26. A nut 32 threaded on the stud 30 is tightened to cause the bar 31 and the plate 26 to be clamped against the plate 24. Obviously the nut 32 is assembled before the plate 27 is soldered to the bellows 25. A gasket 33 is located between the plate 27 and the bottom wall of the housing 20 which is provided with a recess 34 closed by plates 35 and 37 which are attached to the housing 20 by screws 38 which pass through plates 37 and 35, a gasket 36, the housing 20, the gasket 33 and screw threadedly engage the plate 27. By tightening the screws 38, these parts are secured together.

The recess 34 is connected with the interior of bellows 25 between passages surrounding the rod 30 and the nut 32. Recess 34 is connected by passage 39 with a pipe 40 which may be connected with one of the pressure sources such as the intake manifold of an airplane engine. Thus the interior of bellows 25 is subjected to variation in absolute pressure within the engine manifold.

The plate 37 is provided with a tubular boss 41 which is tapped to receive a screw 42 having a head flange 43 and a threaded extension 44 which receives a nut 45 screwed against the shoulder 42a of the threaded portion 42 and retained thereon by soldering as indicated at 45a. Longitudinal movement of the screw 42 is limited downwardly by the engagement of the head flange 43 with the interior surface of the plate 37. Longitudinal movement of screw 42 upwardly is limited by engagement of the nut 45 with the lower edge of the tubular boss 41 of plate 37. The screw 42 is used to control the compression of a spring 47 confined between the screw-head flange 43 and a cup 46 which receives the lower end of the rod 30. The spring 47 opposes the springs 28 and 29. The opposition to springs 28 and 29 offered by spring 47 is less when the screw 42 is in the position shown in Fig. 3 and is greater when the screw 42 has been turned until the nut 45 engages the tubular boss 41. A reason for making this change in the compression of spring 47 will be explained later.

Referring to Fig. 2, the plate 31 extends a substantial distance beyond the bellows 22 and its ends are connected with a stirrup 48 having a central boss 49 and engaging the actuator 50 of a switch contained within a case 51.

The second subassembly comprises a housing 60 which provides a cover for the housing 20

and a chamber 61 for receiving the switch case 51 and an opening 62 through which wires 63 and 64 may be passed for making connection with the terminals of the switch. These wires are connected with the prongs or plugs 65 of a connector which is insulatingly supported by a disc 66 attached to a bushing 67 having a flange 68 secured by screws 69 to a plane surface 70 of the housing 60. The bushing 67 receives a connector member, not shown, having two sockets for receiving the plug 65 and having means for attaching said member to the threaded portion of the bushing 67.

The switch case 51 is secured to the plane surface 52 provided by an interior wall of the housing 60 by screws 54 and 55 passing respectively through a slot 53 and a round hole in the housing 60. Both screws pass through the switch case 51 and threadedly engage a bar 56. When screws 54 and 55 are loosened, the switch may be adjusted so as to bring its actuator 50 into the desired relation to the boss 49 of the stirrup 48 (Fig. 2). This adjustment is facilitated by a screw 58 threaded through the housing 60 and engageable with the switch case 51 and secured in the desired position by a lock nut 59 which can be screwed against a lock washer 59*a* and a plain washer 59*b*.

The adjustment of the switch case 51 is made in the following manner: Assume, for example, that the actuator 50 is too far to the right in Fig. 2. The screws 54 and 55 are loosened, the lock nut 59 is loosened, and screw 58 is screwed outwardly or toward the left relative to the housing 60 a distance estimated to be greater than necessary; and the case 51 is moved away from the housing 20 by moving the screw 54. Then screws 54 and 55 are tightened somewhat. Then screw 58 is screwed inwardly or toward the right in Fig. 2 in order gradually to move the switch actuator 50 into contact with the stirrup boss 49 so that the switch will be closed when there are predetermined pressures within the bellows 25 and surrounding both bellows 22 and 25. Then the nut 59 is tightened to lock the screw 58 in this position. Then the tightening of screws 54 and 55 is completed.

Obviously, the adjustments of the switch case 51 relative to the stirrup boss 49 are made after assembling together the subassembly comprising the housing 20 and bellows assembled therewith and the subassembly comprising the housing 60 and the switch case 51. These subassemblies are united by screws 80 passing through the housing 60 and threadedly engaging the housing 20, there being a sealing gasket 81 between them. When the two housing members are thus united the bellows assembly is confined between the bottom wall of the housing 20 and bosses 82 and 83 integral with housing 60 and having plane lower surfaces which engage the top surface of the plate 23. Thus the assembly of the housing members 20 and 60 determines the relation between the upper bellows plate 23 and the lower bellows plate 27 and places the springs 28 and 29 and the spring 47 in an initial state of compression. Thus the initial position of the stirrup boss 49 relative to the switch actuator 50 is determined.

The joints between the screws 54 and 55 and the housing 60 are sealed by plain washers 54*a*, and 55*a* respectively; and these screws are secured by lock washers 54*b* and 55*b*, respectively. As stated before the joint between the connector spring 68 and the housing 60 is sealed by a gasket 68*a* and the joint between the housings is sealed by the gasket 81. Thus the interior of the switch unit and the space surrounding the bellows 22 and 25 can be made responsive to variations in another pressure such as the absolute pressure of the air within the air scoop of the air intake conduit of an airplane engine. For this purpose the housing 60 is provided with a threaded opening which receives a pipe 93 which may be connected with the air scoop or with the carburetor upper deck in some installations.

When, for example, the interior of the bellows 25 is connected with an airplane engine intake manifold and the space surrounding both bellows is connected with the airplane air scoop, the switch can be used to control the water injection apparatus which is brought into operation to prevent detonation which otherwise would occur when certain manifold pressures and altitudes are reached. It is known that, at higher altitude, the manifold pressure at which detonation begins is less than at lower altitudes. This occurs since, as altitude increases, the auxiliary supercharger (of a two-stage supercharging system) must rotate faster thereby causing such increase in the temperature of the air in the intake manifold that engine detonation begins at a manifold pressure which is lower than when operating at lower altitude.

In Fig. 6, the line A—B represents the condition under which the switch is closed. For example, at sea level, when the scoop pressure would be 29'' Hg abs., a certain engine might begin to detonate at 57'' Hg abs. manifold pressure; and, at an altitude around 20,000 ft. when the scoop pressure is 14'' Hg abs., detonation might begin at 52'' manifold pressure. The line A—B therefore represents the conditions under which closing of the switch should occur in order to cause the water injection system to operate in order to enable the engine to operate at higher pressures without detonation. As stated before, the downward slope of line A—B from left to right represents a droop in manifold pressure at higher altitude which is required because the auxiliary supercharger is required to operate faster in order to maintain the pressure and thereby the temperature of the air in the intake manifold is increased and the detonation pressure is lowered. In going from sea level to about 20,000 feet, the impact absolute pressure drops 15'' Hg and the manifold absolute pressure drops 5''. Therefore, the line A—B has a three to one slope. This is accomplished by the proper relation of the effective areas of the bellows 22 and 25. For example, let A_1 equal the effective area of bellows 25, and A_2, the effective area of bellows 22. The slope of line A—B is equal to

$$\frac{A_1 - A^2}{A_1}$$

If A_1 equals 2.88 area units and A_2 equals 1.92 area units, the above fraction equals

$$\frac{.96}{2.88}$$

which equals one-third, which is the slope of the line A—B. Line A'—B', slightly below line A—B and parallel thereto, represents the schedule of pressure relations at which the switch opens. As already explained the slope of the line A—B and A'—B' is related somewhat to the manifold air temperature increase resulting from the increase of speed of the auxiliary supercharger as the alti-

tude increases. Having determined how much the borderline detonation pressure decreases with increasing altitude for a particular supercharging system, the belolws 22 and 25 are provided with effective areas such as to give the proper slope to the line A—B. Any adjustment which is made in the position of the switch case will raise or lower the line A—B and determine the value of A at sea level. If the switch case is moved away from the stirrup boss 49, a greater manifold pressure will be reached before water injection starts; and, if the switch case is brought closer to the housing 20, water injection will start at a lower manifold pressure. This adjustment is made, of course, according to the detonation pressure of a particular engine.

The location of lines A—B and A'—B' is higher in winter than in summer since, as outside temperature decreases, the temperature of the manifold air will not be as high. To facilitate making the adjustment for winter and summer conditions, the screw 42 is turned in order to shift the screw longitudinally. When the screw 42 is in the position shown in Fig. 3 the switch is conditioned for winter operation because the spring 47 is under less stress; therefore, a greater intake manifold pressure is required in order to raise the stirrup pad 49 to a point where it causes the switch to close. In summer, the screw 42 is turned so as to cause it to raise until the nut 45 engages the lower end of the boss 41. This increases the compression of the spring 47 and tends to raise the stirrup pad 49; therefore, a lower value of intake manifold pressure will cause the switch to close.

As shown in Fig. 2 the stirrup is so shaped as to accommodate a bellows 22 having larger diameter so that if required the effective area of bellows 22 could be made as great as the effective area of the bellows 25. In that case the switch would close at the same pressure as represented for example, by line A—C in Fig. 6. A switch having such operation might find use in an installation where means are provided to cool the air entering the intake manifold in proportion to the extent of heating the air by increased rate of operation of the auxiliary supercharger.

The present switch is easily adapted for use in a system where the relation of the two controlling pressures is represented by a line which slopes upwardly from left toward right instead of downwardly as shown in Fig. 6. In such case the effective area of the bellows 22 would be larger than the effective area of bellows 25.

The part 23*a* between the lugs 82 (Fig. 5) is the sealed stem of bellows 22 through which this bellow had been evacuated.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. A switch unit comprising an electric switch having an actuator, means responsive to a predetermined schedule of relations of the pressure values of two different pressure sources and comprising an aneroid bellows, a bellows connected interiorly with one pressure source, a housing enclosing both bellows and connectible with another pressure source, and a member actuated by both bellows in accordance with a schedule of relations between the values of the pressures of the two sources depending on the relation of the effective areas of the two bellows

for operating the switch actuator to open and close the switch in response to pressure variations.

2. A switch unit according to claim 1 having means for increasing or decreasing the values of the schedule of relations of the pressures of the two sources.

3. A switch unit comprising an electric switch having an actuator, pressure responsive means for operating the switch actuator and comprising two bellows in tandem relation with remote ends fixed and adjacent ends connected, one of the bellows being evacuated, means for connecting the other bellows with a pressure source, a housing enclosing both bellows and connectible with another pressure source, and a member for transmitting motion from the connected adjacent ends of the two bellows to the switch actuator whereby the switch is closed in accordance with a schedule of relations between the values of the pressures of the two sources depending on the relation of the effective areas of the two bellows.

4. A switch unit according to claim 3 having a spring for opposing or aiding movement of said member and means for adjusting the force of said spring.

5. A switch unit comprising two sub-assemblies, one of which comprises a housing, a pressure sensitive device therein comprising a pair of pressure responsive elements responsive to different fluid pressures, a member the position of which is controlled by said elements and transmits movement from the device to a switch actuator, and the other of which comprises a housing which provides a cover for the first mentioned housing and a switch in the second mentioned housing having an actuator for engagement by said member of the first sub-assembly, the assembling of the housing causing said member of the first subassembly to be operatively associated with the switch of the second sub-assembly.

6. A switch unit comprising two sub-assemblies, one of which comprises a housing, a pressure sensitive device comprising two bellows in tandem relation with their remote end walls fixed and their adjacent end walls movable together, one of the bellows having its fixed end wall attached to a wall of the housing and connected therethrough with a passage in the housing providing a connection with a pressure source, the other bellows being evacuated, a spring within the evacuated bellows to resist collapse by pressure in the housing surrounding the bellows, and a member for transmitting motion from the movable adjacent end walls of the two bellows to a switch actuator, the other of the subassembies comprising a housing which provides a cover for the first mentioned housing and which provides surfaces for engaging the immediately adjacent wall of the evacuated bellows, and a switch in the second mentioned housing having an actuator for engagement by said member of the first sub-assembly, the assembling of the housings causing said member of the first subassembly to be operatively associated with the switch of the second sub-assembly, and also determining the initial condition of the pressure sensitive device by virtue of the engagement of said surfaces of second housing with the immediately adjacent end wall of the evacuated bellows.

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