

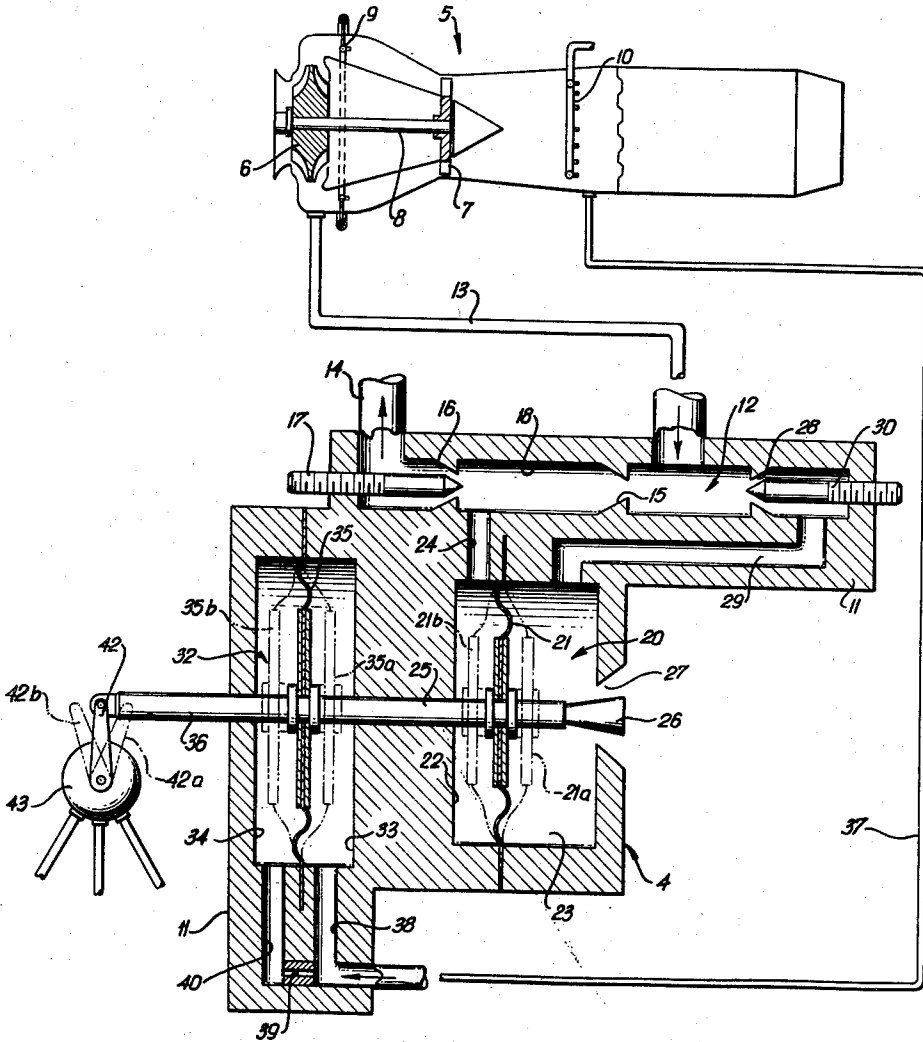
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FLUID ACTUATED TOGGLE MECHANISM

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FLUID ACTUATED TOGGLE MECHANISM

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This invention relates to a fluid actuated toggle mechanism and more particularly to a toggle mechanism for sensing sudden changes of a given magnitude in a monitored signal pressure.

Mechanical toggle action mechanisms, such as those which incorporate springs, require a force of constant magnitude to trip the mechanism. Also, this tripping force must be continually exerted until the trip action occurs. In the present invention, different fractions of the same supply pressure act on opposite sides of a first diaphragm to provide a steady state bias for the toggle mechanism and this supply pressure can be conveniently varied to change the bias, either permanently or during operation of the mechanism. One of the pressures on the diaphragm is also a constant fraction of the supply pressure while the other pressure varies with diaphragm position from less than to greater than the constant fraction. This variation is accomplished by a needle valve controlling the area of one orifice of a pair of orifices so as to produce the variable pressure between the two orifices. The constant fraction of the supply pressure is produced between two fixed orifices which are in communication with the supply pressure. The pressure signal utilized to trip the toggle mechanism can be applied to a second diaphragm connected with the first diaphragm. It is therefore apparent that when the pressure signal exceeds in value the difference between the fixed fraction and the variable fraction pressures acting on the first diaphragm, the toggle operation will commence with movement of the diaphragms in a given direction. As the movement continues, the initial pressure difference acting against the pressure signal decreases so that the diaphragm will quickly move from one off center position to the other off center position. It is apparent that the pressure differential on the first diaphragm can be varied by simply changing the area of a fixed orifice of each pair of orifices connected with the supply pressure.

The present invention can be utilized to sense sudden changes of a given magnitude in a pressure existing within a turbojet engine. In such case, the signal pressure is introduced directly to one side of the second diaphragm and is introduced to the other side of the diaphragm through a restriction. Therefore, a force will be developed on the second diaphragm which is proportional to rate of change in pressure and which is in one direction if the pressure is increasing and in the opposite direction if the pressure is decreasing. If the signal pressure is a measure of afterburner pressure, it will reflect the increase or decrease in afterburner pressure that occurs with ignition or flameout of the afterburner, and will provide a different position of the mechanism corresponding to either of these changes. Thus, the position of the mechanism can be used to position a selector valve and thus control various other functions of the engine. The magnitude of the locking action on the mechanism is a fraction of supply pressure and in the case of a jet engine, the compressor discharge pressure can be utilized as the supply pressure. Since this pressure is a function of the

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operating point of the engine, the signal (afterburner) pressure change required to trip the unit varies with the operating point of the engine. The result is that the signal pressure change required to trip the mechanism is a constant percentage of the pressure level of the signal pressure. If a mechanical toggle mechanisms were utilized in this application, a constant magnitude signal change would be required to trip the mechanism regardless of the operating point of the engine which would destroy the sensitivity of the unit at low pressure levels and make it super-sensitive at high pressure levels, unless the mechanism were additionally biased mechanically by the signal pressure.

It is therefore an object of the present invention to provide a fluid actuated toggle mechanism in which two fractions of the same supply pressure serves to provide the biasing force for the mechanism, the magnitude of one of said fractions varying with the position of the mechanism.

Another object of the invention is to provide a fluid actuated toggle mechanism in which the force required to trip the mechanism varies with the supply pressure.

A further object of the invention is to provide a fluid actuated toggle mechanism to sense sudden changes in the magnitude of a signal pressure, such as the afterburner pressure in a turbojet engine.

These and other objects of the invention not specifically set forth above will become readily apparent from the accompanying description and drawing in which one embodiment of the present invention is shown connected with turbojet engine pressures for purpose of illustration.

The turbojet engine 5 is of standard construction and comprises compressor 6 and turbine 7 connected together by shaft 8. The fuel jets 9 are located between the compressor and turbine and the afterburner 10 is located aft of the turbine 7. The toggle mechanism 4 of the present invention comprises a casing 11 containing a first compartment 12 which is connected by passage 13 to the compressor discharge pressure of the engine 5, and this pressure serves as the supply pressure P_s for the toggle mechanism. The compartment 12 also has an outlet passage 14 connected with an exhaust pressure, such as atmospheric pressure. Two spaced orifices 15 and 16 are located between the inlet and outlet passages and the supply pressure from passage 13 is introduced to orifice 15. The orifice 16 contains a needle valve 17 threaded at one end to casing 11 for varying the throat area of the orifice and the pressure drop across the orifices will be sufficient to cause sonic velocity flow at the throats of the orifices. As described in the United States Patent Re. 24,410; the two spaced orifices comprise a pressure divider device in which the pressure in space 18 between the two orifices is a fraction of the supply pressure determined by the ratio between the throat area of orifice 15 and the throat area of orifice 16.

The casing 11 also contains a second compartment 20 which is divided by a flexible diaphragm 21 into spaces 22 and 23. The space 22 is connected by passage 24 to space 18 so that one side of diaphragm 21 is subject to a fraction of the supply pressure in space 18. If the supply pressure remains constant for any positions of the needle valve 17, then the pressure in spaces 18 and 22 will remain at a constant value. The magnitude of the fraction in space 18 can be varied by varying the position of valve 17 and of course, the magnitude will vary with changes in the supply pressure. Diaphragm 21 is rigidly connected with a shaft 25 slidably supported in casing 11 and one end of the shaft comprises a valve 26 movable within an orifice 27 formed in the portion of casing 11 surrounding space 23. The space 12 contains another orifice 28 which receives the supply pressure and the discharge from this orifice is connected with space 23

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through a passage 29. The throat area of orifice 28 can be varied by needle valve 30 threaded at one end to casing 11. Orifices 27 and 28 comprise the two orifices of a second pressure divider device which exhausts through orifice 27 to atmosphere so that both orifices have sonic velocity flow at their throats. Thus, the pressure determined by the ratio of the throat areas of orifices 28 and 27 and the throat area of orifice 27 will vary with the movement of shaft 25.

A third compartment 32 in casing 11 is divided into spaces 33 and 34 by a flexible diaphragm 35 rigidly connected to shaft 25 and the output end 36 of the shaft extends through the casing 11. The space 33 is directly connected to the afterburner pressure (signal pressure) of the engine through passage 37 and passage 38 in casing 11, while the passage 37 is connected to space 34 through restriction 39 and passage 40. It is therefore apparent that the pressure differential developed on diaphragm 35 will be determined by the rate and magnitude of change in the afterburner pressure and that the direction in which this differential acts will be determined by whether the afterburner pressure is increasing or decreasing.

In operation of the device, the diaphragms 21 and 35 will assume one of two extreme positions, the positions to the right being designated as 21a and 35a, respectively, and the positions to the left being designated as 21b and 35b, respectively. Also, the end 36 of output shaft 25 is connected with a lever 42 which controls a selector valve 43 of well known construction and the output of this valve can be utilized for control purposes in response to the two positions of shaft 25. The shaft 25 and the lever 42 will also assure one of two positions, the position of the lever to the right being designated 42a and the position to the left being designated as 42b.

When a rapid increase in afterburner pressure occurs upon ignition, the resulting large pressure differential on diaphragm 35 will cause diaphragms 21 and 35 to move to their extreme left positions 21b and 35b, and will cause shaft 25 to move lever 42 to position 42b. The pressure differential on diaphragm 21 will thereafter hold the diaphragms in the left position until a rapid decrease in afterburner pressure occurs upon flameout. The accompanying pressure differential on diaphragm 35 will then move the diaphragms 21 and 35 to their right positions 21a and 35a and the pressure differential developed on diaphragm 21 will thereafter hold the diaphragms in the right position until a rapid increase in afterburner pressure again occurs to move the diaphragms to their left positions.

The holding action of locking diaphragm 21 will now be described. Since the area ratio between orifices 15 and 16 is a constant value for any setting of needle valve 17, a constant fraction K_1 of the signal pressure P_s will be present in space 22. The area ratio between orifices 27 and 28, which establishes the fraction K_2 of the signal pressure present in space 23, varies from a value that is higher than K_1 when the toggle mechanism 4 is in the extreme right position to a value that is lower than K_1 when the toggle mechanism is in the extreme left position. In other words, when the mechanism is in the right position, the area of orifice 27 is large so that K_2P_s in space 23 is smaller than K_1P_s in space 22 and this pressure differential holds the mechanism in the right position. When diaphragm 35 experiences a force to overcome this differential and move the mechanism to the left, the area of orifice 27 is decreased so that pressure K_2P_s approaches and then exceeds pressure K_1P_s so that the mechanism is tripped over to its left position and thereafter is held in this position until diaphragm 35 experiences a force sufficient to move the mechanism back to the right position. Movement towards the right increases the area of orifice 27 so that pressure K_2P_s decreases to a value lower than K_1P_s causing the mechanism to trip back to the right position. Thus, once the

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shaft 25 begins to move, a smaller and smaller pressure differential on diaphragm 35 is required to keep it moving until the value of K_2 is equal to K_1 , after which point, no force is required to complete the excursion to the other extreme.

The setting of the pressure divider devices can be varied by needle valves 17 and 30 to provide for a higher or lower tripping value in pressure for one direction than the other. For instance, if the area of orifice 16 is reduced by needle valve 17, a higher differential pressure on diaphragm 35 would be required to trip the mechanism to the left position and a lower pressure differential would be required to trip the mechanism to the right. Also, adjustment of needle valve 30 will vary the position at which, during movement of the mechanism, the pressures K_1P_s and K_2P_s become equal. In addition, the contour of needle valve 26 or of orifice 27 can be varied to give different sensitivities for any particular set of operating conditions.

Since the force on the diaphragm 21 is equal to the area times the differential between K_1P_s and K_2P_s , the value of P_s determines the force required to trip the unit. Thus, if the value P_s is always at a value that corresponds to the reference level of the signal pressure, the transient change required in the signal pressure to actuate the mechanism is a constant percentage of the signal pressure level. Since the compressor discharge pressure P_s and the afterburner pressure (signal pressure) are always at the same reference levels, the signal pressure change required to trip the mechanism is a constant percentage of the pressure level of the signal pressure.

It is apparent that both compressible and non-compressible fluids can be utilized to produce the toggle action. In the example given, the pressure divider devices receive a compressible fluid and sonic flow exits at the orifice throats. However, even though the orifices are not choked, a similar functioning of the mechanism will result since the compressible fluid flowing across each orifice of both pressure dividers provides a pressure drop, the total of these two pressure drops being equal to the difference between the supply pressure P_s and exhaust pressure. Also, the pressure drop across each orifice will be determined by the area of the orifice so that the pressure in space 23 will vary inversely with the size of orifice 27. An incompressible fluid, such as a hydraulic fluid, will also provide a pressure drop in space 23 which will vary inversely with the size of orifice 27 so that an incompressible fluid can also be utilized in the mechanism.

By the present invention, a novel fluid actuated toggle mechanism is provided which utilizes a diaphragm and two pressure divider devices in place of mechanical linkages and springs. The mechanism is simpler and less subject to wear than a mechanical device, and under conditions where the pressure of the fluid supply varies with the force available to shift it, a flexibility is provided that is not attained by mechanical mechanisms. The device is particularly suitable for sensing ignition and flameouts of afterburners since the compressor discharge pressure, which varies with afterburner reference pressure, can be utilized as the supply pressure.

It is understood that any force producing means, other than diaphragm 35 and restriction 39, can be utilized to apply a tripping force to the toggle mechanism and that the tripping force must exceed the reaction force acting on diaphragm 21 until the force on diaphragm 21 reverses in direction to provide the tripping action. Also, various control devices, other than valve 43, can be utilized to sense the position of shaft 25 for control purposes. Various other modifications are contemplated by those skilled in the art without departing from the spirit and scope of the invention as hereinafter defined by the appended claims.

What is claimed is:

1. A fluid actuated toggle mechanism comprising a source of fluid at a supply pressure, means for obtaining a first fraction of said supply pressure, pressure differential means movable from one extreme position to another, means for introducing said first fraction to one side of said differential means, means responsive to the position of said differential means for obtaining at the other side of said differential means a variable fraction of said supply pressure which is larger than said first fraction when said differential means is in one extreme position and smaller than said first fraction when said differential means is in the other extreme position, and means for applying a force to said differential means to initiate movement of said differential means towards either one of the extreme positions.

2. A fluid actuated toggle mechanism as defined in claim 1 wherein said force applying means comprises means connected with a signal pressure and responsive to sudden changes in said signal pressure, said supply pressure being continually at the reference level of said signal pressure so that the transient change in said signal pressure required to initiate movement of said differential is a constant percentage of the signal pressure level.

3. A fluid actuated toggle mechanism comprising a source of fluid at a supply pressure, a first passage connected with said fluid and containing a first pair of spaced orifices, a second passage connected with said fluid and containing a second pair of spaced orifices, pressure differential means receiving on one side thereof the pressure existing between said first pair of orifices and receiving on the other side thereof the pressure existing between said second pair of orifices, means connected with said differential means for increasing the area of one orifice of said second pair upon movement of said differential means in one direction and for decreasing the area of said one orifice upon movement of said differential means in the opposite direction so that at the extreme position in said one direction the pressure on said one side is greater than on said other side and at the extreme in said other direction the pressure on said one side is less than on said other side, and means for applying a force to said differential means to trip said differential means from one extreme position to the other.

4. A fluid actuated toggle mechanism as defined in claim 3 wherein said means connected with said differential means comprises a contoured needle valve positioned within said one orifice of said second pair and connected with said differential means for axial movement along said one orifice to vary the area thereof.

5. A fluid actuated toggle mechanism as defined in claim 3 having means for adjusting the area of one of the orifices of said first pair in order to modify the pressure acting on said one side of said differential means.

6. A fluid actuated toggle as defined in claim 3 wherein said force applying means comprise means connected with said differential means and responsive to sudden change in a sensed pressure.

7. A fluid actuated toggle mechanism comprising a source of compressible fluid at a supply pressure, a first pressure divider means comprising first and second orifices spaced along a first fluid passage and having a fixed ratio between their throat areas, means for introducing said fluid at the supply pressure to one of the orifice of said first pressure divider means, a second pressure divider means comprising third and fourth orifices spaced along a second fluid passage, means for introducing said fluid at the supply pressure to one of the orifices of said second divider, pressure differential means having first and second spaces on opposite sides thereof, means for introducing the pressure existing between said first and second orifices to said first space and for introducing the pressure existing between said third and fourth orifices to said second space, valve means connected with said dif-

ferential means for continually reducing the throat area of said fourth orifice upon movement of said differential means in one direction and for continually increasing the throat area of said fourth orifice upon movement of said differential means in the opposite direction, said throat area of said fourth orifice being large enough at one extreme position of said differential means to provide a pressure in said second space exceeding the pressure in said first space and being small enough at the other extreme position of said differential means to provide a pressure in said second space smaller than the pressure in said first space, and means for applying a force to said differential means to move said differential means against the pressure differential acting thereon and thereby trip said toggle mechanism.

8. A fluid actuated toggle mechanism as defined in claim 7 wherein said force applying means comprise a second pressure differential means connected with said first differential means and having third and fourth spaces on opposite sides thereof, a source of fluid at a signal, pressure means for introducing said signal pressure directly to said third space and for introducing said signal pressure to said fourth space through restriction means, said second differential means producing a tripping force upon a sudden change of given magnitude in said signal pressure.

9. A fluid actuated toggle mechanism as defined in claim 8 wherein said source of supply pressure and said source of signal pressure are continually at substantially the same level so that the change in signal pressure required to trip said mechanism is a substantially constant percentage of the signal pressure level.

10. In a turbojet engine having a compressor, a turbine and an afterburner, means for sensing the compressor discharge pressure, means for obtaining a first fractional pressure of said discharge pressure, first pressure differential means movable from one extreme position to another, means for introducing said first fraction to one side of said differential means, means responsive to the position of said differential means for obtaining at the other side of said differential means a variable fractional pressure of said discharge pressure which is larger than said first fraction when said differential means is in one extreme position and smaller than said first fraction when said differential means is in the other extreme position, means for obtaining the afterburner pressure, a second pressure differential means connected with said first differential means, means for introducing said afterburner pressure directly to one side of said second differential means, restriction means for introducing said afterburner pressure to the other side of said second differential means, said second differential means being responsive to sudden changes in afterburner pressure upon ignition and flameout to produce a tripping force on said first differential means, and control means responsive to the position of said first differential means.

11. In a turbojet engine as defined in claim 10 wherein said means for obtaining said first fractional pressure comprises a passage containing a pair of spaced orifices connected with said discharge pressure and means for sensing the first fraction at a location between said orifices of said first pair, said means for obtaining said variable fractional pressure comprising a second passage containing a second pair of spaced orifices connected with said discharge pressure, means for sensing the variable fraction at a location between said orifices of said second pair, and means connected with said first differential means for varying the area of one orifice of said second pair in accordance with the position of said first differential means.

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