United States Patent [19]

MacGuire

[11] **3,799,132**

[45] **Mar. 26, 1974**

[54] **VALVE DEVICE AND SYSTEM EMPLOYING THE SAME**

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[22] Filed: **Apr. 9, 1973**

[21] Appl. No.: **349,073**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 278,250, Aug. 7, 1972, abandoned, which is a continuation-in-part of Ser. No. 63,186, Aug. 12, 1970, Pat. No. 3,693,650.

[52] **U.S. Cl.**..... **123/119 D,** 137/DIG. 4, 137/480, 137/525, 137/533.11, 138/40, 138/45, 138/46, 267/153

[51] **Int. Cl.** **F02d 9/00,** F16k 15/04, F16k 15/14

[58] **Field of Search** .... 73/392; 137/516.25, 516.27, 137/516.29, 517, 540, 543, 525, 512, 533.11, 480, 533.13, 533.15, 539, 539.5, 423, 509, DIG. 4; 137/43, 40, 46, 45; 123/119 D, 97 B; 267/153

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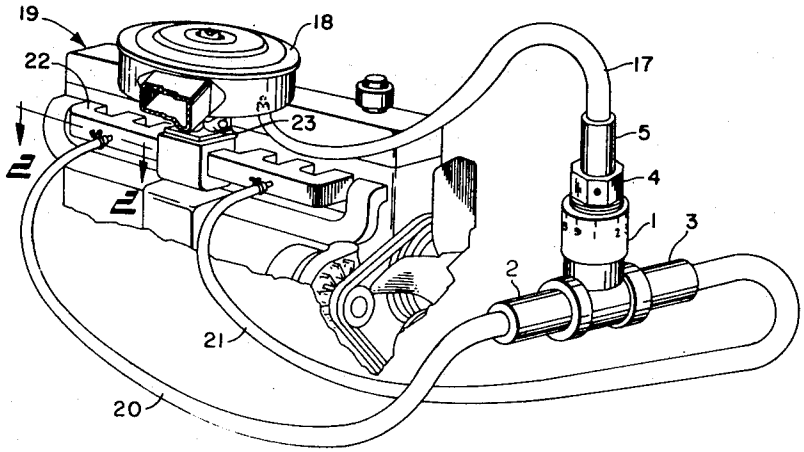
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Primary Examiner—Henry T. Klinksiek
Attorney, Agent, or Firm—Donnelly, Maky, Renner & Otto

[57] **ABSTRACT**

A fluid pressure responsive valve device and system employing the same for providing variations in air flow to the manifold of an internal combustion engine in accordance with the engine vacuum.

22 Claims, 17 Drawing Figures



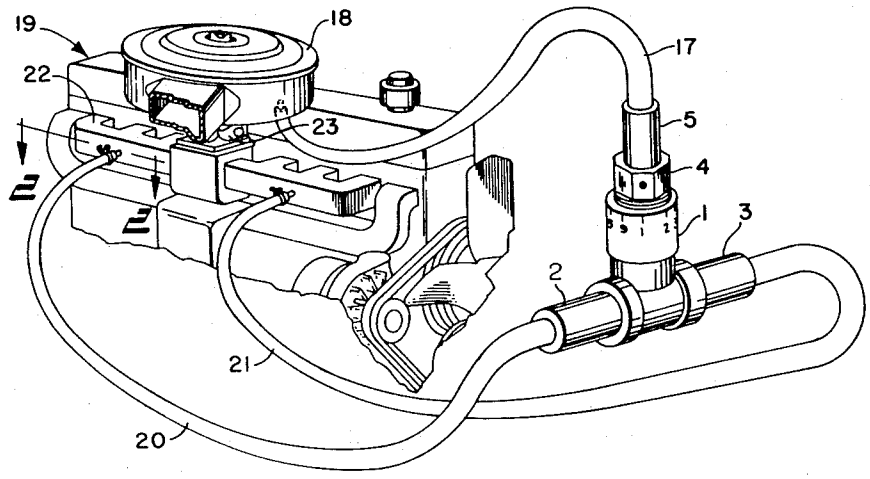


Fig. 1

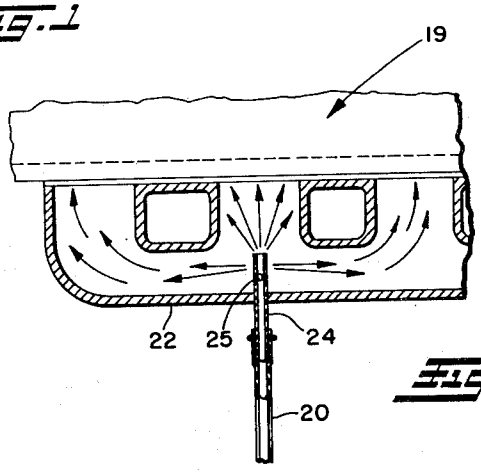


Fig. 2

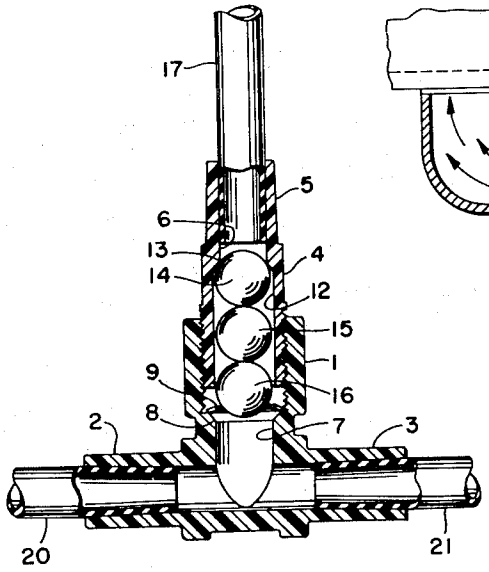


Fig. 3

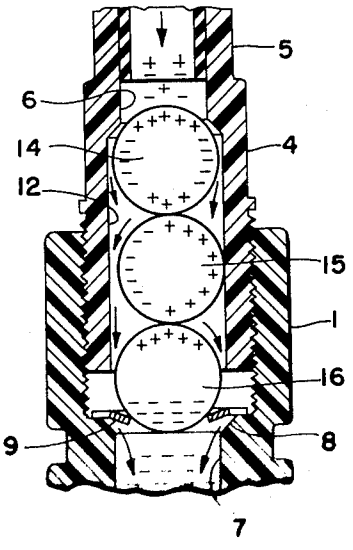


Fig. 3A

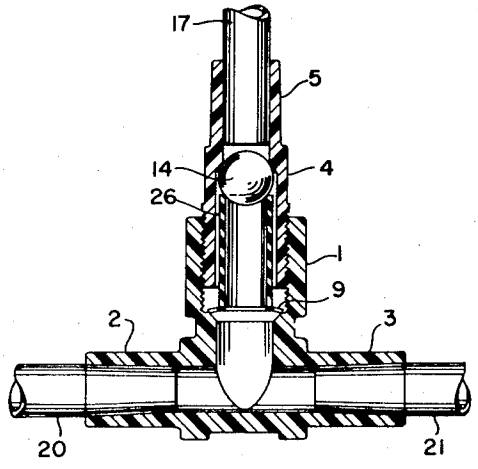


Fig. 4

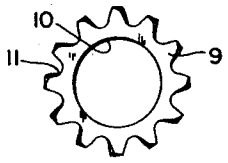


Fig. 7

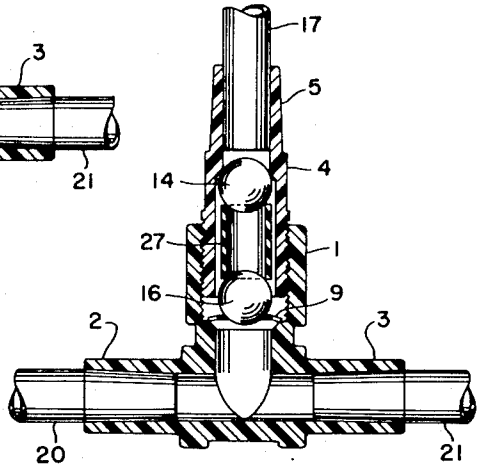


Fig. 5

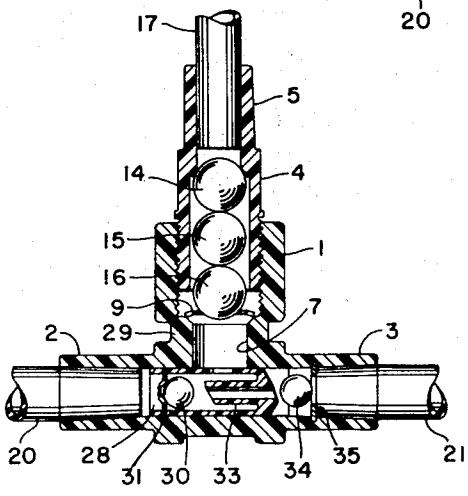


Fig. 6

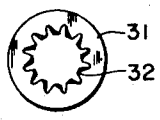


Fig. 8

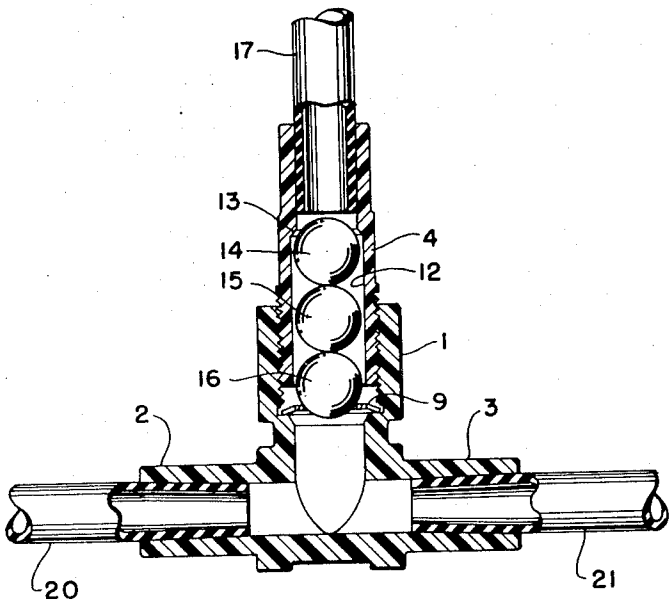


Fig. 9

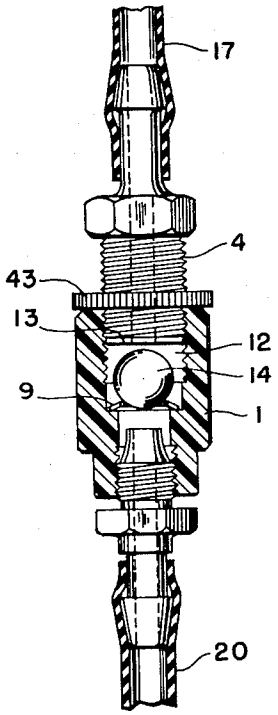


Fig. 10

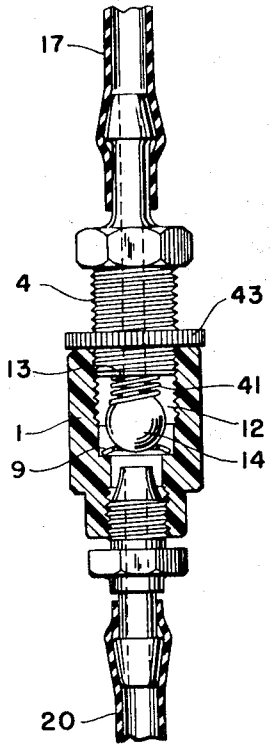


Fig. 11

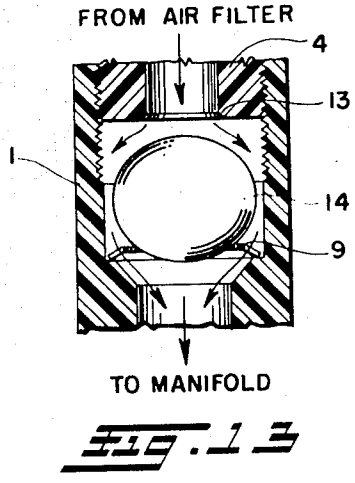


Fig. 13

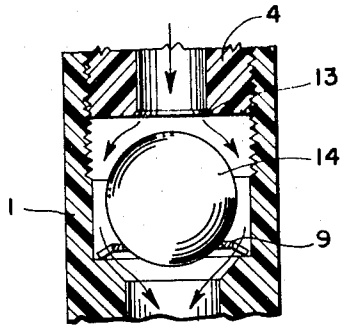


Fig. 14

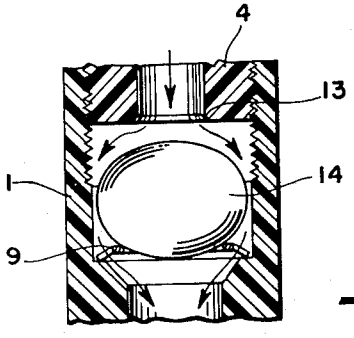


Fig. 15

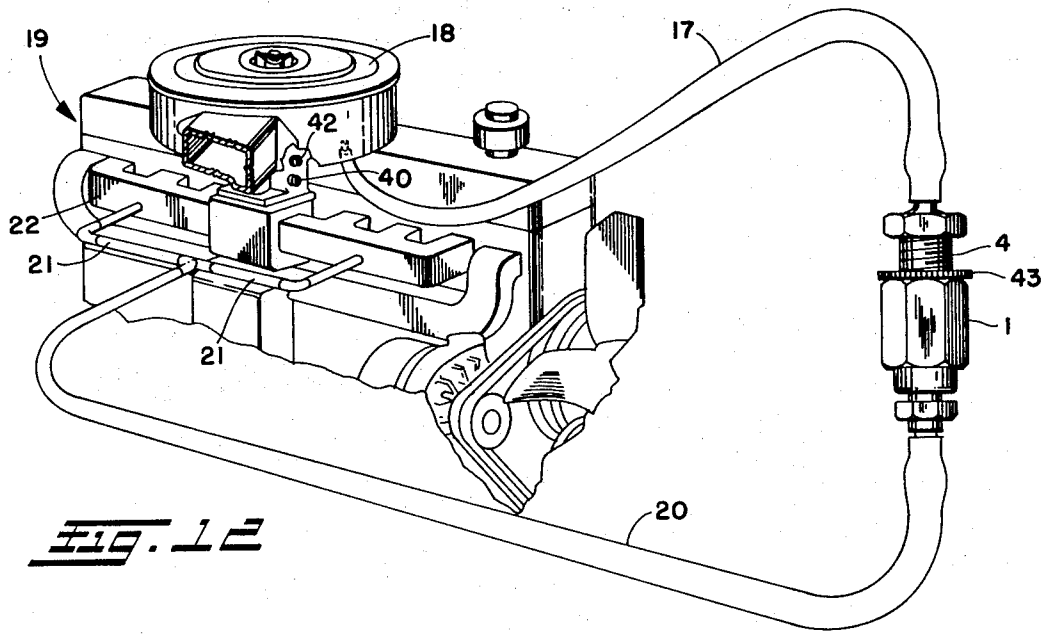

19
18
17
42
40
22
21
21
4
43
1
20

Fig. 12

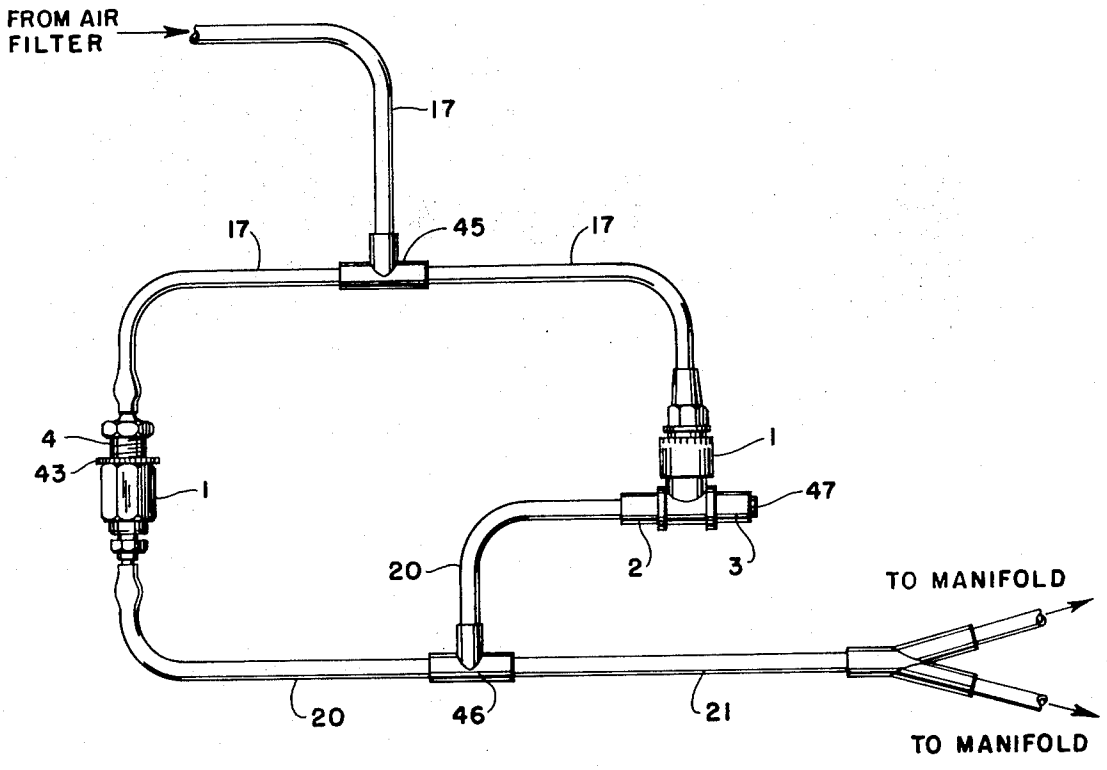

FROM AIR FILTER
17
17
45
17
4
43
1
1
47
20
2
3
TO MANIFOLD
20
46
21
TO MANIFOLD

Fig. 16

VALVE DEVICE AND SYSTEM EMPLOYING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of copending United States application Ser. No. 278,250, filed Aug. 7, 1972, now abandoned, which is a continuation-in-part application of United States application Ser. No. 63,186, filed Aug. 12, 1970, now U.S. Pat. No. 3,693,650, granted Sept. 26, 1972.

BACKGROUND OF THE INVENTION

The modern automotive internal combustion engine has been recognized as a principal contributor to atmospheric pollution and a number of different approaches have been made to the problem. Devices of various sorts have been developed to control release of crankcase emissions and others have been developed to remove harmful products from the exhaust gases. It has, however, been recognized that the basic problem would be much ameliorated if the engines could be operated under substantially ideal conditions so that only small amounts of the objectionable pollutants would be produced, as by ensuring substantially complete combustion of the engine fuel under all operating conditions. Examples of devices for such purpose are illustrated and described in Mokrzycki U. S. Pat. No. 3,039,449 and Canadian Pat. No. 590,030, as well as in Thomasson U. S. Pat. No. 1,259,317. While illustrating this general approach to the problem, such devices have not been flexible enough in operation quickly to accommodate rapid changes in engine operating conditions, such as rapid acceleration and rapid deceleration, to ensure a proper air-fuel ratio at all times and thereby achieve substantially complete combustion of the fuel, and it is accordingly a principal object of the present invention to provide a novel valve and air supply system to the manifold of an internal combustion engine which will be quickly and effectively responsive to such changes in engine operating conditions.

More particularly, the objects of this invention include the provision of such valve and system which will be effective in avoiding rough engine idle, backfiring, and unstable engine operation.

Still another object is to provide such a valve device and air supply system for supplying primary air to the engine manifold for improved engine response and acceleration over substantially the entire speed range of the engine.

Other objects include the provision of such valve and system which will ensure automatic adjustment to various throttle settings and rates of acceleration or deceleration which in the past have commonly resulted in a temporary improper fuel-air mixture.

A corollary objective is thereby to prevent the emission of excessive pollutants to the atmosphere, particularly carbon monoxide and hydrocarbon vapors.

Still another object is to provide such a valve and system which will be inexpensive of manufacture and will require little or no maintenance due to carbon build-up or the like.

Other objects of the invention will appear as the description proceeds.

DESCRIPTION OF THE DRAWING

In the annexed drawing, FIG. 1 is a semi-diagrammatic perspective view showing the device of this invention connected to an automotive internal combustion engine for use in anti-pollution control;

FIG. 2 is a fragmentary enlarged section taken on the line 2—2 on FIG. 1 through a portion of the engine manifold;

FIG. 3 is an enlarged section through the anti-pollution control valve of FIG. 1;

FIG. 3*a* is a fragmentary enlargement of a portion of the anti-pollution control valve of FIG. 3 schematically illustrating the build-up of positive and negative charges on the elastomeric balls due to pressure pulsations;

FIG. 4 is a similar section through another embodiment of such valve;

FIG. 5 is a similar section through still another embodiment of such valve;

FIG. 6 is a similar section through yet another embodiment of such valve including auxiliary flow control means;

FIG. 7 is an enlarged detailed view of the support means for the valve members;

FIG. 8 is an enlarged detailed view of an element of the auxiliary valve means of FIG. 6;

FIG. 9 is an enlarged longitudinal section through a valve similar to FIG. 3 but which has been slightly modified for use as an acceleration device in supplying primary air to an engine to increase engine response and acceleration substantially over its entire speed range;

FIGS. 10 and 11 are similar sections through still other acceleration valve embodiments;

FIG. 12 is a semi-diagrammatic perspective view showing such an acceleration valve device connected to an internal combustion engine;

FIGS. 12 through 15 are schematic diagrams showing the operation of the acceleration valve device of FIG. 10 under different engine operating conditions; and

FIG. 16 is a schematic illustration showing both an anti-pollution control device and acceleration device connected in parallel for simultaneous attachment to an internal combustion engine.

DESCRIPTION OF THE INVENTION

Referring now more particularly to said drawing, and especially to FIGS. 1–3 thereof, the anti-pollution control valve embodiment of the invention there illustrated comprises a unitary T-shape plastic body having a hollow cylindrical portion 1 in communication with the oppositely extending tubular arms 2 and 3. Threadedly adjustably received within such cylindrical body portion 1 is a tubular casing 4 having an integral extension 5 of slightly reduced inner diameter 6. Such casing 4 may have an outer hexagonal or octagonal configuration to facilitate application of a wrench thereto for the purpose of rotating casing 4 relative to body 1 and thereby axially shifting said casing relative to said body.

The diameter of the opening 7 leading from the interior of body portion 1 to communicate with the arms of the T 2 and 3 is of smaller diameter than the inner diameter of such body portion, thereby providing a shoulder 8 which supports a frustoconical serrated washer 9 (see also FIG. 7) having a circular central opening 10 and a number of outer peripheral notches

such as 11. As above indicated, the inner diameter 6 of tubular extension 5 of casing 4 is of somewhat smaller diameter than the inner diameter 12 of the casing proper, thereby affording a beveled shoulder 13 therebetween.

Received within casing 4 are three spheres or balls 14, 15 and 16 of elastomeric material and of a diameter greater than the internal diameter 6 of such extension 5 and greater than the diameter of the central opening 10 of washer 9. Also, as shown in FIG. 3, such balls are of somewhat smaller diameter than the internal diameter 12 of casing 4 so as to provide a clearance between the same and such casing. By turning casing 4 as above described, shoulder 13 (which serves as a valve seat) may be moved toward and away from washer 9 to vary the length of the chamber containing such balls and to subject the latter to a predetermined degree of compression.

As shown in FIGS. 1 and 2, the above described anti-pollution control valve assembly may be connected by means of neoprene tubing 17 with the underside of the conventional air filter 18 of an automotive internal combustion engine 19 so that air may be drawn from such filter through tubing 17, past ball 14 (when the latter is unseated), through notches 11 of washer 9, to delivery lines 20 and 21, which may likewise be of neoprene tubing, leading to engine manifold 22 with which the conventional carburetor 23 is also, of course, in communication.

As shown in FIG. 2, the ends of tubing 20 and 21 are provided with tubular metal nipples such as 24 which penetrate an appreciable distance into the manifold chamber and which, as well as being open at their ends, also have several small lateral orifices such as 25 to ensure more uniform delivery and mixing of the air thus introduced into the manifold with the fuel-air mixture delivered thereto through carburetor 23.

Another embodiment of the anti-pollution control valve of this invention is illustrated in FIG. 4 of the drawing utilizing the same valve body but with a length of elastomeric tubing 26 supporting the elastomeric ball valve member 14. An alternative embodiment illustrated in FIG. 5 is generally similar to that of FIG. 4 except that a shorter length of elastomeric tubing 27 is interposed between elastomeric ball valve member 14 and the elastomeric ball 16 which bears against serrated washer 9.

The optional modification illustrated in FIGS. 6 and 8 of the drawing may be utilized when it is desired to provide means more precisely to control the air delivered to the engine manifold during periods of extremely rapid deceleration. The device here illustrated is the same as that shown in FIG. 3 except that both hose 17 and hose 21 will now be connected to air filter 18 and only hose or tubing 20 leads to the engine manifold. A generally tubular inner plastic body 28 is tightly fitted within the bore of T portions 2 and 3, with a lateral opening 29 being in communication with outlet 7. A medium soft elastomeric ball 30 is trapped between washer 31 having outwardly turned teeth or serrations 32 and the beveled inner end of inner tubular portion 33. Another ball 34 of medium soft elastomeric material is trapped or caged between washer 35 and the outer beveled end of tubular portion 33. As will be explained in greater detail below, when excessive vacuum occurs in line 20, the suction draws ball 34 against the end of inner tube 33 and also draws ball 30 against serrated washer 31, thereby cutting off all air flow through line 21 and greatly reducing the flow of air past ball 30 coming from line 17.

The anti-pollution control valve device of this invention will preferably be installed with casing 4 extending in a vertical direction but this is not essential and the device will operate regardless of position. The valve body and casing may ordinarily desirably be of nylon and the tubing 17, 20 and 21 may likewise be of nylon or Neoprene, for example, the principal requirement of all such elements being that they should not deteriorate under warm operating conditions in the presence of oil and gasoline fumes. The valve should accordingly be mounted adjacent the engine but not in a position where it will be subjected to excessive heat. The elastomeric balls 14, 15 and 16 may desirably be of polyurethane rubber, a resiliently deformable elastomer capable of bulging laterally within the casing when ball 14 is unseated due to fluid pressure in tube 17. The flexing of these balls assists in preventing the build-up of carbon and other like deposits within the unit.

Initially, casing 4 may be rotated relative to body portion 1 so as just barely to seat valve member 14 against shoulder 13. After the engine has been started, casing 14 may then be very slightly rotated until the smoothest possible idle is obtained and the elastomeric balls are still vibrating but the noise of the vibrating balls is substantially eliminated so that they do not resinate too much. The vibration of the balls causes shock waves in the air stream which break up the fuel-air droplets passing into the manifold. The injection of additional air into the manifold also increases the turbulence of the fuel-air mixture and thoroughly mixes the required amount of air with the fuel at the critical point within the engine for improved combustion and fast response at substantially all engine speeds. The outer peripheral notches 11 in the washer 9 also create a swirling action of the air passing through the device, whereby the air enters the manifold in sonic waves combined with a swirling motion for increased turbulence.

Unless the carburetor is badly out of adjustment (e.g., affording a very high idle) it will ordinarily not be necessary to make any adjustment to the carburetor. Supplement air is admitted to manifold 22 through tubes 20 and 21 under the influence of the manifold vacuum (normally about 18 inches of mercury at idle) which serves to unseat ball 14 with consequent compression of the balls axially of the casing and corresponding lateral bulging of such balls toward the wall 12 of the valve chamber within the casing 4. It will be apparent that if ball 14 is thus unseated and moved axially within said chamber for a considerable distance under the influence of very high vacuum in lines 20 and 21 the balls would be thus laterally bulged to such an extent as to very substantially restrict the passage between the same and the chamber wall 12. The imposition of a momentary but nevertheless very high vacuum accordingly is ineffective to draw as much air through the valve assembly as would otherwise be the case.

Automotive engine carburetors are ordinarily most efficient when the vehicle is operating at a speed of approximately 50–60 mph, providing too rich a mixture at idle. By admitting supplementary air to the manifold, the system of this invention has the effect of providing a smoother idle as well as ensuring substantially complete combustion of the fuel to minimize discharge of carbon monoxide and unburned hydrocarbon.

As the engine is accelerated gradually the vacuum may drop to about 14 inches of mercury and only a little more additional air is admitted to the device through the manifold than is the case when the engine is at idle. If the engine is now accelerated to about 50 mph for example the vacuum may drop to about 2–3 inches of mercury and substantially all of the air entering the engine manifold will be derived from the carburetor. When the engine is abruptly decelerated, the vacuum may however build up to approximately 25 inches of mercury which would be expected to draw too much air through the device with consequent unstable engine operation. The anti-pollution control valve device, however, automatically eliminates such problem due to the lateral expansion of the elastomeric balls which limits the passage for the air through chamber **12**; consequently the increase in air flow to the manifold is not nearly as substantial as would be expected from the abrupt increase in manifold vacuum. It has been noted that balls **15** and **16** which support ball valve member **14** and resiliently bias the latter toward valve closing position tend thus to be laterally deformed to a greater extent than the ball valve member **14** itself. This may, however, be regulated as desired by employment of balls of varying degrees of resilience.

When the valve device illustrated in FIG. **6** of the drawing is employed, further protection is afforded against the introduction of excessive air into the engine manifold under certain operating conditions. More particularly, when the engine is operating at high speed and is abruptly decelerated the high vacuum developed in the manifold will tend to draw an excessive amount of supplementary air through the device and this may be further regulated by the provision of the ball check valves **30** and **34.** At low vacuum, both such balls drop away from the respective orofices so as not to interfere with passage of air to the latter. Under conditions of excessively high vacuum,however, ball **34** is drawn against the entrance to tubular passage **33,** blocking entry of air from tube **21,** and ball **30** is drawn against serrated washer **31** to greatly restrict the passage of air therethrough while still permitting limited movement of air through such serrations. Both balls **30** and **34** may desirably be of medium soft polyurethane rubber.

While balls of elastomeric material have previously been employed in various types of valves as disclosed, for example, in U. S. Pat. Nos. 3,077,204, 3,343,566, and 3,447,564, I am not aware of any such device where multiple elastomeric balls are utilized in the manner illustrated in FIGS. **3** and **6** of the present application or, indeed, where an elastomeric valve member is caused to bulge laterally when unseated from the valve inlet opening. It has been found that the valve of the present invention is capable of very precise adjustment and is also delicately responsive to relatively small changes in fluid pressure, thereby rendering it particularly useful for the metering of supplemental air to an internal combustion engine manifold. It will be appreciated, however, that the valve of this invention may be employed for a wide variety of different purposes.

While polyurethane rubber has been found to be especially suitable for balls **14, 15** and **16,** such balls may also be of natural or synthetic rubber, of foamed polyurethane, or Neoprene, and may be in the form of hollow inflated spheres. In a typical installation for the purpose described, such balls may be one-half inch in diameter and the inner diameter of chamber **12** in casing **4** may be only several hundredths of an inch greater. Despite the tendency of such balls to bulge laterally as the valve opens more and more, such bulging will not ordinarily be to an extent sufficient entirely to close off the passage for fluid flow through chamber **12,** there being an automatic self-compensating effect whereby the force tending to open the valve is diminished gradually as such passage becomes more and more restricted.

It is desirable that all the principal parts of the valve assembly, including the tubing connecting the same to the air filter and manifold, be of plastic rather than metal so as to avoid stripping negative charges from the air delivered to the manifold. Also, because the various parts of the valve assembly are made of plastic, when pressure pulsations are applied to the elastomeric balls, the force of the pressure drives the electrons from one side of the balls to the other whereby positive and negative charges are built up on opposite sides of the balls as schematically shown in FIG. **3***a*. In addition, the friction of the air passing over the elastomeric balls and the friction of the balls rubbing against each other produce small electrical charges on the surface of the balls. The negative charges are bled off the balls by the metal spring washer **9** which concentrates the electrostatic charges and has points thereon to facilitate charge bleed-off to the air passing through the washer into the engine. The air rushing past the negative side of the balls also bleeds off negative charges from the balls, and such air passes through the insulated passages **20, 21** into the engine under control at all times.

The advantage in charging the air passing into the engine is that there is ordinarily a lack of negative charges in the fuel. Also, under high temperature the fuel may lose one or more electrons, and these electrons are introduced back into the fuel with the air which also causes the air to more intimately mix with the fuel vapor for more complete combustion. This results in decreased detonation during hot start acceleration and elimination of engine knock.

The valve assembly should of course be fully insulated from the engine and other metal parts to avoid stripping of negative charges from the air delivered to the engine manifold, and rubber or other insulating coating may be used on the metal nipples **24** for the air lines **20, 21** from the valve assembly to the manifold. The valve assembly allows pulsations of air to enter the engine manifold carrying a small negative charge that replaces one or more electrons lost from the fuel either by heat or other reason. It has also been found advantageous to locate the valve assembly and the air intake therefor out on the front bulkhead or in a cool section of the engine compartment to minimize the loss of electrons due to heat.

The construction is such that operation is not affected by engine or road vibration. The assembly is light in weight, inexpensive, and easily installed and provides a degree of protection against the dangers of a faulty exhaust system since discharge of lethal carbon monoxide may be much diminished thereby. If desired, instead of being connected directly with the engine manifold, the device may be connected to a positive crankcase ventilation line, or one outlet of the T-shape member may connect directly to the manifold and the

other connect to such positive crankcase ventilation line.

The valve of this invention may employ a metal ball valve member supported by the resiliently deformable elastomeric balls although it will generally be preferred to employ a plastic valve member for reasons indicated above. With balls one-half inch in diameter, the cylindrical chamber containing the same may be about one-sixteenth of an inch greater in diameter, more or less depending on the size of passageway desired therebetween. The chamber must not, of course, be of such a large relative diameter that the balls are not retained in general alignment and become wedged in use.

In the various embodiments of the invention previously described, each of the fluid pressure responsive valve devices admits supplementary air to the manifold in varying amounts in accordance with the manifold vacuum providing a smoother idle and ensuring substantially complete combustion of the fuel to minimize discharge of carbon monoxide and unburned hydrocarbon as aforesaid. Moreover, with slight modification such valve devices may also be used as acceleration devices by supplying the air to the manifold **22** which is normally supplied by adjustment of the idle mixture screw **40** on the carburetor **23**, schematically shown in FIG. **12**. This requires that the idle mixture screw **40** be tightened to substantially completely close off the idle jets of the carburetor so that the air which is normally admitted with fuel through the idle jets is eliminated and instead is obtained through a modified fluid pressure responsive valve device in a manner to be subsequently fully described.

The advantage in obtaining such air through a fluid pressure responsive valve device rather than through the idle jets of the carburetor is that such valve device will cause the air flow to vary automatically with changes in the engine vacuum to provide the desired fuel-air mixture for quick response and rapid acceleration as desired over substantially the full range of engine speeds. This is not possible with a normal carburetor setting since the idle mixture screw is normally fixed and will not vary the air supply to suit the demands of the engine in the same manner as a fluid pressure responsive valve.

If the valve devices previously described are to be used for primary air flow in lieu of the carburetor idle jets, the casing **4** should be unscrewed sufficiently to eliminate the slight preloading or compression of the ball **14** previously applied so that the valve is initially open as shown for example in FIG. **9** to allow primary air to pass therethrough even at very low vacuum pressures such as occurs during rapid acceleration of the engine. This may have some reduced effect on the performance of the valve device in minimizing the discharge of carbon monoxide and unburned hydrocarbon but will provide for marked improvement in engine response and acceleration throughout substantially the entire speed range of the engine. Otherwise, the modified valve devices for use as acceleration devices may be substantially the same as the valve devices previously described, except that they should desirably be made somewhat smaller to provide for less air flow therethrough.

It has also been found that even greater response and acceleration performance can be obtained utilizing a single ball **14** in the valve chamber **12** as shown in FIG. **10**, with a slight clearance being provided between the ball **12** and valve seat **13** to permit the ball to in effect float within the chamber so that the valve remains open even when the engine is off or the engine is running and the vacuum produced is only sufficient to draw the ball against the serrated washer **9** for substantially unrestricted passage of air through the valve to the engine manifold.

Preferably, a light spring **41** is interposed between the valve seat **13** and ball **14** as shown in FIG. **11** to maintain the ball away from the valve seat and in light pressure engagement with the serrated washer **9** even when the engine is off. The spring **41** assists in keeping both the ball and serrated washer in place and prevents undesirable fluttering and vibration of the ball during fluctuations in vacuum pressure. Also, the spring facilitates installation of the valve device in any position. Without the spring, the acceleration valve device should desirably be mounted so that the axis of the valve chamber is vertical with the serrated washer **9** located at the bottom.

In use, such acceleration valve devices may be connected with the under side of the air filter **18** as by means of Neoprene tubing **17** as schematically shown in FIG. **12** to permit air to be drawn through the filter into the valve chamber **12** past the ball **14** for delivery to the engine manifold **22** through one or more delivery lines **20** connected to the lower end of the valve assembly. During the initial installation of the acceleration device the curb idle screw **42** of the carburetor **23** should be adjusted to increase the RPM of the engine while running to about 2,500 RPM to permit tightening of the idle mixture screw **40** to close off the idle jets of the carburetor without causing the engine to stall. At that point, the modified valve assembly will operate to supply primary air to the engine in place of the carburetor idle jets which automatically varies with engine operation as described hereafter. Next the curb idle screw **42** should be readjusted to return the engine RPM to normal. For some later model cars it has also been found desirable or necessary to back open the idle mixture screw **40** a mere fraction to obtain proper engine idle. Also if necessary, slight adjustment of the valve assembly may then be made by rotating the casing **4** relative to the valve body **1**, and a lock nut **43** may be provided on the valve casing **14** for locking the same in adjusted position as shown in FIGS. **10** and **11**.

With the idle jets of the carburetor closed off, additional fuel will be drawn from the speed and main jets of the carburetor and injected into the manifold at increased velocity, which increases the turbulence. The injection of additional air into the manifold by any one of the acceleration valve devices will also increase the turbulence of the fuel-air mixture and thoroughly mix the required amount of air with the fuel at the critical point within the engine for improved combustion and fast response at substantially all engine speeds.

In operation with the engine running at idle, the engine vacuum is approximately **17** to **18** inches of mercury, which is adequate to cause some deformation of the ball **14** of the acceleration valve device against the adjacent member, which in the case of the modified acceleration valve of FIG. **9** is the adjacent ball **15**, and in the case of the acceleration valves of FIGS. **10** and **11** is the serrated washer **9**, etc. This results in some lateral expansion of the ball **14** toward the wall of the chamber **12** as schematically illustrated in FIG. **13** to somewhat restrict the flow of air through the device

and thereby obtain the desired fuel-air mixture for substantially complete combustion of the fuel during idle. As the engine is accelerated, the engine vacuum will drop proportionally to the rate of acceleration thereby reducing the compressive force acting on the ball **14** and allowing the ball to substantially return to its normal round shape for increased air flow therepast as schematically shown in FIG. **14** during acceleration.

At cruising speeds of between 60 and 70 mph, the engine vacuum will again increase to approximately 17 inches of mercury which causes the ball **14** to expand laterally once again to the FIG. **13** condition thereby reducing the amount of air flowing past the ball to support proper combustion during cruising. During deceleration, the engine vacuum will increase in proportion to the rate of deceleration causing extensive deformation and lateral expansion of the ball **14** which substantially restricts the air flow through the valve as schematically shown in FIG. **15** once again to suit the demands of the engine. When the engine is turned off, the ball **14** will resume its normal round shape and is free to float within the chamber **12** or is pressed lightly against the serrated washer **19** by the light spring **41** which maintains the ball slightly spaced from its seat **13.**

From the foregoing, it will now be apparent that when the carburetor **23** is adjusted to close off the idle jets as previously described, the various disclosed acceleration valve devices will provide for automatic variable control of air to the engine manifold which automatically varies with engine operation for improved response and engine performance. In actual practice, it has been found that such acceleration devices improve engine performance over substantially the complete speed range of the engine, permitting quick response and rapid acceleration at both low and high speeds as well as at intermediate speeds without the drastic drop in manifold vacuum previously experienced. This may be especially important when a vehicle is ascending a sharp ramp and entering fast moving traffic on a throughway, or when a vehicle has to quickly pass another vehicle or take other diversionary action. The various described acceleration valve devices also greatly improve performance of engines which were heretofore found to be quite sluggish due to the smog control devices with which they were required to be fitted.

The acceleration valve devices also have some beneficial effect in reducing engine pollution, particularly during acceleration. However, more effective pollution control can be obtained by also fitting the engine with one of the various anti-pollution control valve devices shown in FIGS. **3** through **6** of the drawings as by connecting an anti-pollution control valve device in parallel with an acceleration valve device as schematically shown in FIG. **16.** To make the necessary connections, the tubing **17** extending from the entry ends of the valve devices may be connected to the oppositely extending tubular arms of a Tee **45** with the perpendicular arm of the Tee connected to the air filter **18** by still another piece of tubing **17.** The outlet ends of the valve devices may be connected directly to the manifold **22** or connected together prior to connecting to the manifold through another Tee **46** as shown, and one of the two outlets of the anti-pollution valve device may also be plugged as shown at **46** in FIG. **16.**

While it is essential that the idle jets of a conventional carburetor be closed off for effective operation of the acceleration devices, it will be apparent that the carburetor itself could be modified to eliminate the idle jets altogether if specifically designed for use with such acceleration devices, and it will also be apparent that such acceleration devices could be built directly into the carubretor in lieu of the idle jets if desired.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In combination with an internal combustion engine having an intake manifold and carburetor, pressure responsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, said valve means comprising a valve chamber having an inlet and an outlet, a resiliently deformable elastomeric valve member within said chamber intermediate said inlet and outlet, and support means for supporting said valve member within said chamber, said resiliently deformable elastomeric valve member being deformable by fluid pressure to cause lateral bulging of said valve member toward the surrounding wall of said chamber to reduce the clearnace between said valve member and wall and thereby increasingly restrict the flow of fluid around said valve member as the fluid pressure increases, said chamber being dimensioned to afford a small amount of clearance for said valve member even when the latter is compressed axially of said chamber by fluid pressure as aforesaid.

2. In combination with an internal combustion engine having an intake manifold and carburetor, pressure responsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, said valve means comprising a valve member within said chamber, an inlet to said chamber providing a seat for said valve member, an outlet from said chamber, and support means for supporting said valve member within said chamber in slightly spaced relation from said valve seat, said valve member being made of a resiliently deformable elastomeric material.

3. The combination of claim **2** wherein said valve member is generally spherical when subjected to relatively low pressures and is deformable when subjected to relatively high pressures to cause lateral bulging of said valve member toward the surrounding wall of said chamber to reduce the clearance between said valve member and wall and thereby increasingly restrict the flow of air around said valve member as the pressure increases.

4. In combination with an internal combustion engine having an intake manifold and carburetor, pressure responsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, said valve means comprising a valve chamber, a valve member within said chamber, an inlet to said chamber providing a seat for said valve member, an outlet from said chamber, and support means for supporting said valve member within said chamber in slightly spaced relation from said valve seat, said support means comprising a serrated washer which permits flow of air therepast when contacted by said valve member.

5. In combination with an internal combustion engine having an intake manifold and carburetor, pressure re-

sponsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, said valve means comprising a valve member within said chamber, an inlet to said chamber providing a seat for said valve member, an outlet from said chamber, and support means for supporting said valve member within said chamber in slightly spaced relation from said valve seat, said support means comprising at least one spherical member of elastomeric material.

6. The combination of claim 5 wherein said support means comprises two spherical members of elastomeric material.

7. In combination with an internal combustion engine having an intake manifold and carburetor, pressure responsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, said valve means comprising a valve member within said chamber, an inlet to said chamber providing a seat for said valve member, an outlet from said chamber, and support means for supporting said valve member within said chamber in slightly spaced relation from said valve seat, said support means comprising a length of resiliently deformable elastomeric tubing of smaller internal diameter than said valve member and in axial alignment therewith.

8. The combination of claim 5 wherein said support means further comprises a serrated washer engaged by the end of said length of tubing remote from said seat.

9. The combination of claim 7 wherein said support means further comprises a spherical member of elastomeric material at the end of said chamber opposite said seat, said length of tubing being axially supported against said spherical member.

10. In combination with an internal combustion engine having an intake manifold and carburetor, pressure responsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, said valve means comprising a valve chamber having an inlet and an outlet adjacent opposite ends thereof, a resiliently deformable elastomeric valve member within said chamber, and support means for supporting said valve member within said chamber, said inlet to said chamber being connected to the atmosphere, and said outlet being connected to said intake manifold.

11. The combination of claim 10 wherein said valve means is responsive to the engine vacuum to vary the air flow therethrough inversely proportional to such engine vacuum.

12. The combination of claim 10 wherein said inlet to said chamber provides a seat for said valve member, said valve member being free to float within said chamber.

13. The combination of claim 10 wherein said inlet to said chamber provides a valve seat for said valve member, and said support means supports said valve member within said chamber in slightly spaced relation from said valve seat.

14. The combination of claim 13 further comprising a light spring interposed between said valve seat and valve member for maintaining said valve member against said support means and out of engagement with said valve seat.

15. The combination of claim 10 wherein said carburetor has idle jets and an idle mixture screw, said idle mixture screw being set to close off said idle jets, whereby the additional air which is normally supplied to said engine manifold through said idle jets is required to be supplied through said valve means.

16. The combination of claim 10 wherein said valve member is generally spherical when subjected to relatively low pressures and is deformable when subjected to relatively high pressures to cause lateral bulging of said valve member toward the surrounding wall of said chamber to reduce the clearance between said valve member and wall and thereby increasingly restrict the flow of air around said valve member as the pressure increases.

17. In combination with an internal combustion engine having an intake manifold and carburetor, pressure responsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, and a second pressure responsive valve means in parallel with the first-mentioned pressure responsive valve means, said first-mentioned pressure responsive valve means being open at relatively low pressures to permit air flow therethrough which decreases with substantially increased pressures, and said second valve means being closed at relatively low pressures to prevent air flow therethrough and open at increased pressures to permit air flow therethrough which decreases with substantially increased pressures.

18. The combination of claim 17 wherein both said first and second valve means comprise a valve chamber, a resiliently deformable elastomeric valve member within said chamber, and support means for said valve member, each said valve member being deformable by pressure to cause lateral bulging of said valve members toward the surrounding walls of said chambers to reduce the clearance between said valve members and walls and thereby increasingly restrict the flow of air around said valve members as the pressure increases.

19. In combination with an internal combustion engine having an intake manifold and carburetor, pressure responsive valve means for supplying auxiliary air to said manifold in varying amounts in accordance with the pressure acting on said valve means, said valve means comprising a valve chamber, a valve member within said chamber, an inlet to said chamber providing a seat for said valve member, an outlet from said chamber, and a serrated washer contained within said chamber axially spaced from said inlet, said inlet to said chamber including means for connection to the atmosphere and said outlet including means for connection to said intake manifold, all of the parts of said valve means except for said serrated washer being made of plastic to avoid stripping negative charges from the air delivered to said manifold.

20. The combination of claim 19 further including a support member for said valve member within said chamber, said valve and support members being made of plastic as aforesaid and being responsive to the engine vacuum to cause said valve and support members to vibrate resulting in shock waves in the air stream which break up the fuel-air droplets passing into said intake manifold and increase the turbulence of the fuel-air mixture to thoroughly mix the air and fuel in said intake manifold.

21. The combination of claim 20 wherein the pressure pulsations acting on said valve and support members drive the electrons from one side of said valve and support members to the other, whereby positive and negative chagres are built up on opposite sides of said valve and support members, and the negative charges are bled off by said serrated washer which concentrates such negative charges for bleed-off to the air passing through said washer into said intake manifold.

22. The combination of claim 19 wherein said valve member comprises a resiliently deformable elastomeric valve member within said chamber intermediate said inlet and outlet, said resiliently deformable elastomeric valve member being deformable by fluid pressure to cause lateral bulging of said valve member toward the surrounding wall of said chamber to reduce the clearance between said valve member and wall and thereby increasingly restrict the flow of fluid around said valve member as the fluid pressure increases, said chamber being dimensioned to afford a small amount of clearance for said valve member even when the latter is compressed axially of said chamber by fluid pressure as aforesaid.

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