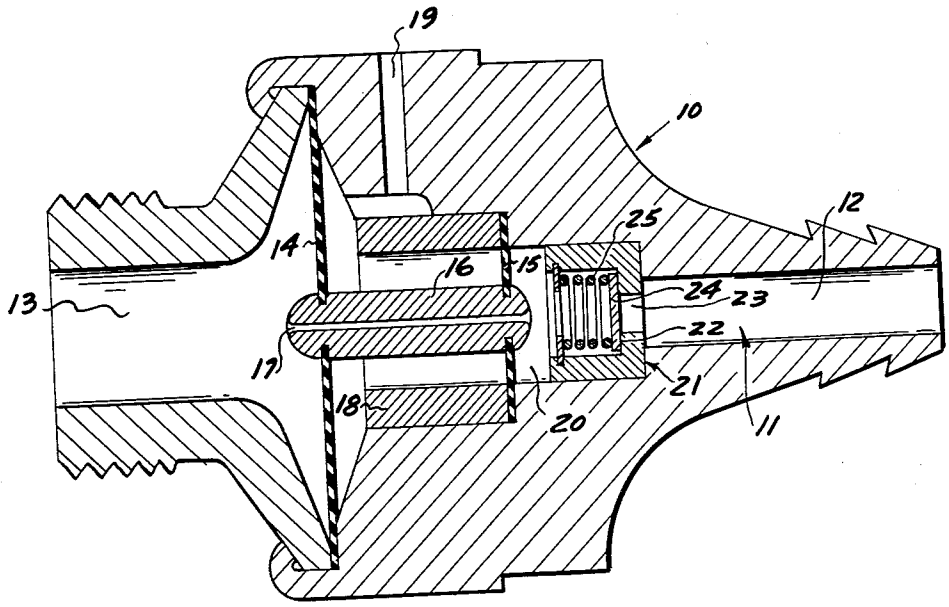
Jan. 2, 1962 R. F. WILLIAMS ET AL 3,015,325

FUEL INJECTOR

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Fig. 2



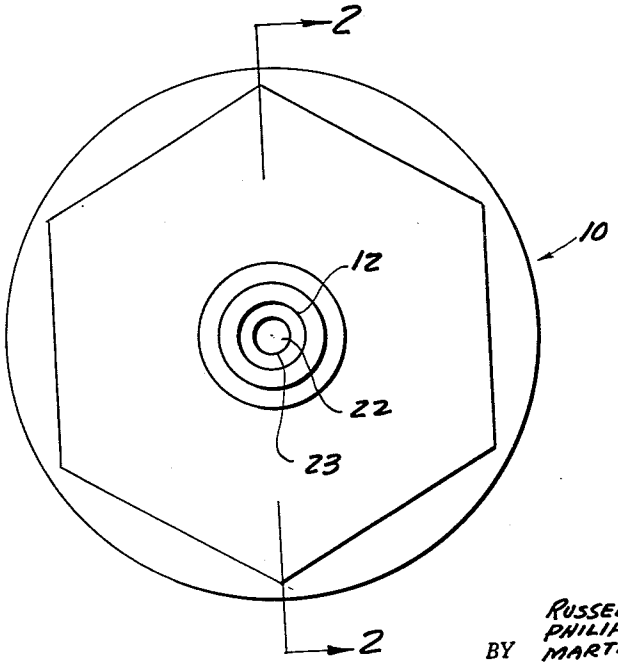


Fig. 1

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FUEL INJECTOR

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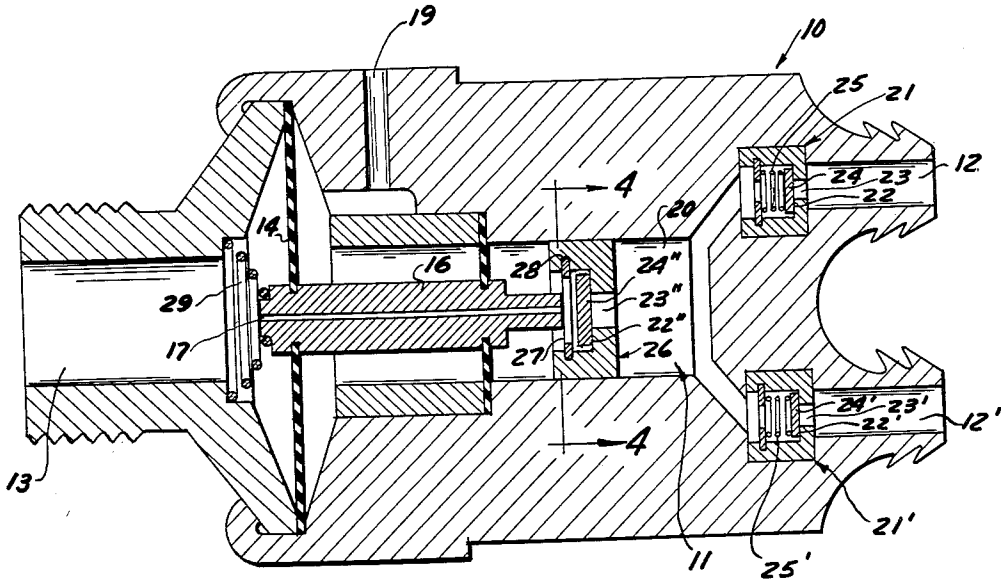


Fig. 3

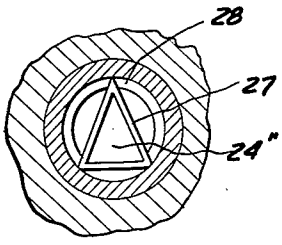


Fig. 4

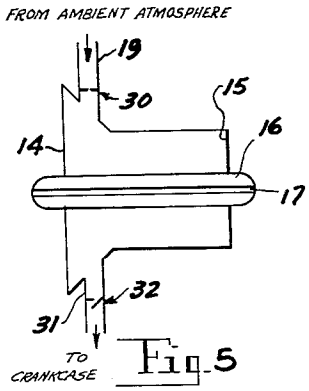


Fig. 5

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3,015,325
FUEL INJECTOR

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Filed Mar. 4, 1960, Ser. No. 12,791
7 Claims. (Cl. 123—139)

This application presents certain improvements over a prior co-pending application for "Fuel Injector" filed by Russell F. Williams and Philip R. Morgan on March 31, 1959, Ser. No. 803,145, now abandoned. In said prior application, fuel injector means were disclosed which utilized a diaphragm actuated by variations in the crankcase pressure of an engine for driving a fuel injection hollow piston into a fuel compression zone. In the present application, these features are again utilized, but in an improved manner.

This invention thus relates to fuel injectors for closed-crankcase type internal combustion engines. It is of particular value in connection with two-cycle engines, but may also be used in connection with four-cycle engines. By means of the fuel injector of the present invention, the use of a carburetor is eliminated. This results in a very substantial saving in cost, as well as eliminating the many difficulties encountered with carburetors.

The fuel injector of the present invention has the advantage of not requiring any mechanical driving means for pumping the fuel or for forming it into a spray, since it utilizes the pressure variations existing in the closed crankcase of the engine as the motive force.

A further advantage of the present invention is that it requires no tight fitting pistons or tight friction seals, as are contemplated in the aforesaid co-pending application.

Other advantages include extremely low cost, low weight, and improved fuel metering and engine performance.

If desired, a lubricant may be mixed with the fuel by incorporating individual inlets into the injector, the two fluids being automatically mixed therein during operation.

Other objects and advantages of the invention will more fully appear from the following description and drawings, wherein are disclosed preferred embodiments of the invention.

FIG. 1 shows an end view of a preferred embodiment of the present invention;

FIG. 2 shows a cross-sectional view taken along the lines 2—2 of FIG. 1;

FIG. 3 shows a cross-sectional view of a second embodiment of the invention;

FIG. 4 shows an end view of a portion of the injector of FIG. 3; and

FIG. 5 shows schematically a second means of maintaining a desired pressure range between the diaphragms of the injector of the present invention.

Referring now to the drawings in detail, wherein similar numerals represent similar parts, FIGS. 1 and 2 show a preferred embodiment of the present invention. The injector comprises a generally cylindrical injector body 10 having a longitudinal passage 11 extending therethrough, defining at opposite ends a fuel inlet 12 and a fuel outlet 13. Mounted in fluid-tight manner transversely across said longitudinal passage 11, at an enlarged section thereof adjacent said fuel outlet 13, is a large-area flexible pressure-responsive diaphragm 14. Similarly mounted, at a section of somewhat reduced area, closer to said fuel inlet 12, is a small-area flexible pressure-responsive diaphragm 15. A hollow piston 16, having a longitudinal passage 17 extending therethrough is affixed to and freely suspended from said diaphragms 14 and 15 so as to cause

said diaphragms 14 and 15 and said piston 16 to undergo joint longitudinal motion in response to variations in differential pressure across diaphragm 14. A removable bushing 18 may be used to maintain diaphragm 15 in position, as shown in FIG. 1.

Fuel outlet 13 is adapted to be attached to the closed crankcase of an engine (not shown). Thus, the pressure on the outer face of diaphragm 14 (i.e. the face closest to the fuel outlet 13) will vary with the variations in crankcase pressure during the engine cycle, as described in said prior co-pending application. The space between diaphragms 14 and 15 will at the same time be maintained at a pressure intermediate the maximum and minimum crankcase pressures. This may, for example, be accomplished, as shown in FIG. 1, by venting said space to the ambient atmosphere through vent 19. A fuel compression zone 20 is provided intermediate said diaphragm 15 and said fuel inlet 12; and a pressure-responsive check valve indicated generally at 21 is provided between said fuel inlet 12 and fuel compression zone 20, adapted to close when the pressure in said fuel compression zone reaches a predetermined pressure in excess of that in said fuel inlet 12 (which may be substantially atmospheric). Said check valve 21 may comprise, as shown, a valve seat 22 defining a valve port 23, a disc 24 adapted to seat against said valve seat 22 so as to close said valve port 23, and spring loading means 25 urging said valve disc toward its closed position.

In operation large-area diaphragm 14 is urged inwardly (to the right in FIG. 1) when the crankcase pressure is high. Piston 16 transmits this force to small-area diaphragm 15, moving it also to the right, thereby creating an increased pressure in the fuel compression zone 20. This in turn aids spring loading means 25 to close check valve 21. The pressure in said fuel compression zone reaches a value in excess of that in the crankcase, because of the amplifying effect of the pistons 14, 15 of different area, the flexibility and relative areas of said diaphragms being suitably selected in known manner to accomplish this result in a particular case. Fuel trapped in said fuel compression zone 20 is thus forced out (to the left in FIG. 1) through the longitudinal passage 17 extending through piston 16, and thence into the crankcase of the engine. Since gas is flowing from the crankcase toward diaphragm 14 at this time, fuel leaving passage 17 is broken up into a fine spray, thus obviating the need for special spray-forming means at this point. Nor is it necessary to provide a check valve at the fuel outlet side of passage 16, since when the pressure in fuel outlet 13 is high, it is even higher in passage 20; and when it is low in fuel outlet 13, it is even lower in passage 20, because of the amplifying effect of the two diaphragms of different area.

When the pressure in the crankcase of the engine reaches a low value, diaphragms 14 and 15, and piston 16 are moved to the left in FIG. 1, creating a reduced pressure in fuel compression zone 20. This causes check valve 21 to be moved into open position, allowing fuel to enter said fuel compression zone 20 through fuel inlet 12.

Thus, this type of fuel injector requires no tight-fitting piston or tight friction seals, requires no outlet check valve, requires no feed pump, and requires no drive mechanism or energy other than that provided by variations in crankcase pressure.

FIG. 3 shows a second embodiment of the invention, wherein certain additional optional features are shown, similar numerals representing similar parts. In this embodiment, a pair of inlets 12 and 12′ are provided, as an optional feature, instead of a single fuel inlet 12. Inlet 12′ represents an inlet for lubricant, to be mixed with the fuel. It is common to blend some lubricant with fuel in two-cycle engines, for lubrication of the moving parts in

the crankcase. This blending can be accomplished automatically by the operation of the injector shown in FIG. 3, the blending occurring in fuel compression zone 20. Each inlet 12, 12' is equipped with an individual check valve 21, 21'. An advantage of this feature is that if the oil reservoir should run dry, air will be pulled into inlet 12', stopping the operation of the engine. Thus there is no danger of an oil-less run.

Another optional feature shown in FIG. 3 is a piston-operated shut-off valve indicated generally at 26. This valve operates in a manner similar to that described in connection with the check valve 21, except that it is not spring-loaded, but is moved into closed position by the direct pressure of the end of piston 16. Retaining means 27 housed in groove 28 prevent valve disc 24'' from falling out of valve 26 when it is open; said restraining means are designed in known manner so that said valve disc 24'' does not form a fluid-tight seal with said restraining means 27 when said valve 26 is in open position. For example, restraining means 27 may comprise a triangular wire, as shown in FIG. 4, so that round disc 24'' cannot form a fluid-tight seal against it. A light spring 29 holds piston 16 against disc 24'' when the engine is not running, but offers only minor resistance during operation. The object of spring 29 and valve 26 is to prevent seepage of fluid from the fuel compression zone 20 into the engine during shut-down. When this feature is employed, substantial gravity heads on the fuel and lubricant feeds may be permitted, without causing seepage into the engine during shutdown, and without requiring the use of excessive spring loadings on check valves 21, 21'' which might interfere with feeding during operation of the engine.

FIG. 5 shows schematically an alternative means of regulating the pressure between diaphragms 14 and 15. Vent line 19 is provided with a restriction 30. An inlet line 31 to the space between disphragms 14, 15 leads to the crankcase, and is provided with a check valve 32. Check valve 32 and restriction 30 cause the pressure in the space between diaphragms 14, 15 to remain below ambient pressure. Air is evacuated from said space to the crankcase when the latter is under suction, but cannot return subsequently because of check valve 32. A limited amount of air is permitted to enter said space through restriction 30, insufficient to allow the pressure in said space to reach ambient pressure. Thus, a limited negative pressure is maintained in said space. This has the effect of providing increased motive power of the diaphragm 14 in pressurizing the fuel.

While we have thus shown and described preferred embodiments of our invention, it is understood that various other modifications may also be made in the details of construction without departing from the spirit of the invention, the principal novel features of which are set forth in the claims below.

We claim:

1. A fuel injector for a closed crankcase type internal-combustion engine, comprising: an injector body having a longitudinal passage extending therethrough, defining at opposite ends a fuel inlet and a fuel outlet; a first flexible pressure-responsive diaphragm mounted in fluid-tight manner transversely across said longitudinal passage adjacent said fuel outlet; means for exposing the surface of said first diaphragm facing said fuel outlet to the varying pressure of said crankcase; a second flexible pressure-responsive diaphragm of smaller area than the first diaphragm, mounted in fluid-type manner transversely across said longitudinal passage at a position closer to said fuel inlet; a hollow piston having a passage extending therethrough, and being affixed to and freely suspended from both of said diaphragms so as to cause said diaphragms and said piston to undergo joint longitudinal motion in response to variations in crankcase pressure; means for maintaining in the space between said diaphragms a pressure intermediate the maximum and minimum crankcase pressures; a fuel compression zone intermediate the ends of the aforesaid longitudinal passage extending through said injector body, intermediate said second diaphragm and said fuel inlet; and pressure-responsive check valve means located at the junction between said fuel inlet and said fuel compression zone, adapted to close when the pressure in said fuel compression zone reaches a predetermined pressure; the flexibility and relative areas of said diaphragms being so selected as to cause said piston and diaphragms to move from an initial position in the direction of said fuel inlet and to create in said fuel compression zone a fuel pressure substantially in excess of the crankcase pressure when the latter is at its maximum positive value and at least equal to the aforesaid predetermined pressure required to close said pressure-responsive check valve means, and a sufficient reduction in pressure when the crankcase pressure is at its maximum negative value to cause the opening of the aforesaid check valve and to return said piston and said diaphragms to their initial position, without requiring the aid of spring loading to assist said motions and pressure changes in said fuel compression zone.

2. The fuel injector set forth in claim 1, wherein said means for maintaining pressure between said diaphragms comprises venting means communicating with the ambient atmosphere.

3. A fuel injector for a closed crankcase type internal-combustion engine, comprising: an injector body having a longitudinal passage extending therethrough, defining at opposite ends a fuel inlet and a fuel outlet; a first flexible pressure-responsive diaphragm mounted in fluid-tight manner transversely across said longitudinal passage adjacent said fuel outlet; means for exposing the surface of said first diaphragm facing said fuel outlet to the varying pressure of said crankcase; a second flexible pressure-responsive diaphragm of smaller area than the first diaphragm, mounted in fluid-type manner transversely across said longitudinal passage at a position closer to said fuel inlet; a hollow piston having a passage extending therethrough, and being affixed to and freely suspended from both of said diaphragms so as to cause said diaphragms and said piston to undergo joint longitudinal motion in response to variations in crankcase pressure; means for maintaining in the space between said diaphragms a pressure intermediate the maximum and minimum crankcase pressures; a fuel compression zone intermediate the ends of the aforesaid longitudinal passage extending through said injector body, intermediate said second diaphragm and said fuel inlet; and pressure-responsive check valve means located at the junction between said fuel inlet and said fuel compression zone, adapted to close when the pressure in said fuel compression zone reaches a predetermined pressure; the flexibility and relative areas of said diaphragms being so selected as to create in said fuel compression zone a fuel pressure substantially in excess of the crankcase pressure when the latter is at its maximum positive value and a sufficient reduction in pressure when the crankcase pressure is at its maximum negative value to cause the opening of the aforesaid check valve, also provided with a second inlet adjacent the aforesaid fuel inlet and leading to said fuel compression zone, and provided also with means for feeding a lubricant thereto and with pressure-responsive valve means located at the junction between said lubricant inlet and said fuel compression zone, adapted to close when the pressure in said fuel compression zone reaches a predetermined pressure in excess of that in said lubricant inlet.

4. A fuel injector for a closed crankcase type internal-combustion engine, comprising: an injector body having a longitudinal passage extending therethrough, defining at opposite ends a fuel inlet and a fuel outlet; a first flexible pressure-responsive diaphragm mounted in fluid-tight manner transversely across said longitudinal passage adjacent said fuel outlet; means for exposing the

surface of said first diaphragm facing said fuel outlet to the varying pressure of said crankcase; a second flexible pressure-responsive diaphragm of smaller area than the first diaphragm, mounted in fluid-type manner transversely across said longitudinal passage at a position closer to said fuel inlet; a hollow piston having a passage extending therethrough, and being affixed to and freely suspended from both of said diaphragms so as to cause said diaphragms and said piston to undergo joint longitudinal motion in response to variations in crankcase pressure; means for maintaining in the space between said diaphragms a pressure intermediate the maximum and minimum crankcase pressures; a fuel compression zone intermediate the ends of the aforesaid longitudinal passage extending through said injector body, intermediate said second diaphragm and said fuel inlet; and pressure-responsive check valve means located at the junction between said fuel inlet and said fuel compression zone, adapted to close when the pressure in said fuel compression zone reaches a predetermined pressure; the flexibility and relative areas of said diaphragms being so selected as to create in said fuel compression zone a fuel pressure substantially in excess of the crankcase pressure when the latter is at its maximum positive value and a sufficient reduction in pressure when the crankcase pressure is at its maximum negative value to cause the opening of the aforesaid check valve, also provided with a piston-operated shut-off valve intermediate said piston and said check valve means, adapted to be closed by contact pressure from said piston when the latter has been moved towards said fuel inlet under the force of increased crankcase pressure, thereby closing said fuel passage in said piston at that time; also provided with a spring biasing said piston against said shut-off valve for closure thereof when the pressures on both sides of said first diaphragm are equal.

5. A fuel injector for a closed crankcase type internal-combustion engine, comprising: an injector body having a longitudinal passage extending therethrough, defining at opposite ends a fuel inlet and a fuel outlet; a first flexible pressure-responsive diaphragm mounted in fluid-tight manner transversely across said longitudinal passage adjacent said fuel outlet; means for exposing the surface of said first diaphragm facing said fuel outlet to the varying pressure of said crankcase; a second flexible pressure-responsive diaphragm of smaller area than the first diaphragm, mounted in fluid-type manner transversely across said longitudinal passage at a position closer to said fuel inlet; a hollow piston having a passage extending therethrough, and being affixed to and freely suspended from both of said diaphragms so as to cause said diaphragms and said piston to undergo joint longitudinal motion in response to variations in crankcase pressure; means for maintaining in the space between said diaphragms a pressure intermediate the maximum and minimum crankcase pressures; a fuel compression zone intermediate the ends of the aforesaid longitudinal passage extending through said injector body, intermediate said second diaphragm and said fuel inlet; and pressure-responsive check valve means located at the junction between said fuel inlet and said fuel compression zone, adapted to close when the pressure in said fuel compression zone reaches a predetermined pressure; the flexibility and relative areas of said diaphragms being so selected as to create in said fuel compression zone a fuel pressure substantially in excess of the crankcase pressure when the latter is at its maximum positive value and a sufficient reduction in pressure when the crankcase pressure is at its maximum negative value to cause the opening of the aforesaid check valve, wherein said means for maintaining pressure between said diaphragms comprises: admission means communicating, through a suitable restriction, with the ambient atmosphere; exit means communicating through a check valve to the crankcase of said engine, said check valve being oriented so as to permit flow of air only from the space between said diaphragms to said crankcase; said restriction being sized so as to maintain a desired negative pressure range in said space between diaphragms, intermediate the maximum and minimum crankcase pressures.

6. In a fuel injector for a closed crankcase type internal-combustion engine, which injector is provided with a flexible pressure-responsive diaphragm being exposed on a first face to the varying pressure of said crankcase, the improvement comprising: exit means communicating between the space adjacent the second face of said diaphragm and said crankcase through a check valve so oriented as to permit flow of air only towards said crankcase; and inlet means communicating between said space adjacent said diaphragm and the ambient atmosphere through a restriction so sized as to maintain a desired negative pressure range in said space, intermediate the maximum and minimum crankcase pressures.

7. A fuel injector for an internal-combustion engine, comprising: a flexible pressure-responsive diaphragm; means for impressing a varying differential pressure across said diaphragm equal to the difference between the pressure of the ambient pressure and the pressure at a predetermined position in the inlet means to said engine so selected as to be responsive to pressure variations created by relative motion of the working parts of said engine; a fuel inlet port; a fuel compression chamber, into which said fuel inlet port leads; valving means actuated in response to the movement of said diaphragm and adapted to close and open said fuel inlet port as the aforesaid pressure varies between positive and negative, and to exert compression on fuel contained in said fuel compression chamber when said fuel inlet port is closed; and exit means from said fuel compression chamber leading to said inlet means to said engine; the flexibility and area of said diaphragm being so selected as to allow said diaphragm to move back and fourth in a fuel pumping stroke in response to said varying differential pressure without requiring the aid of spring loading to assist said motions.

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