Nov. 5, 1957 R. W. ROUSH, JR 2,811,958

PRESSURE-OPERATED VALVE MEANS FOR FREE PISTON ENGINES

Filed April 18, 1955 2 Sheets-Sheet 1

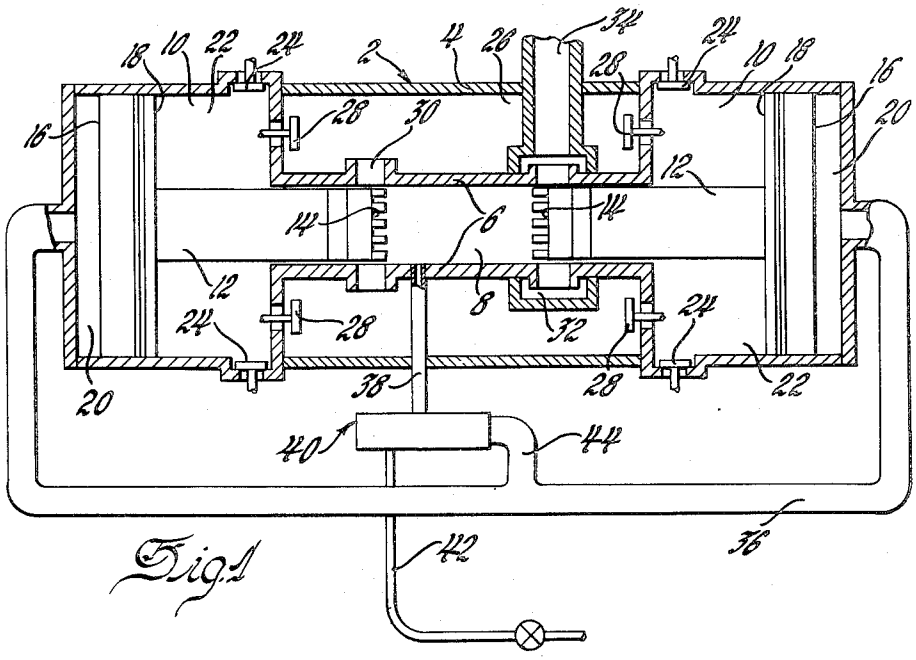

Fig. 1

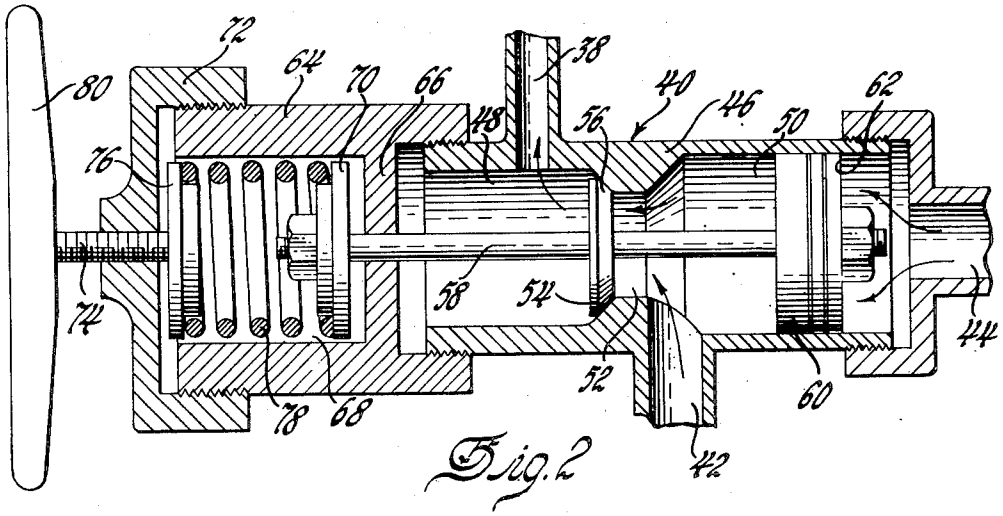

Fig. 2

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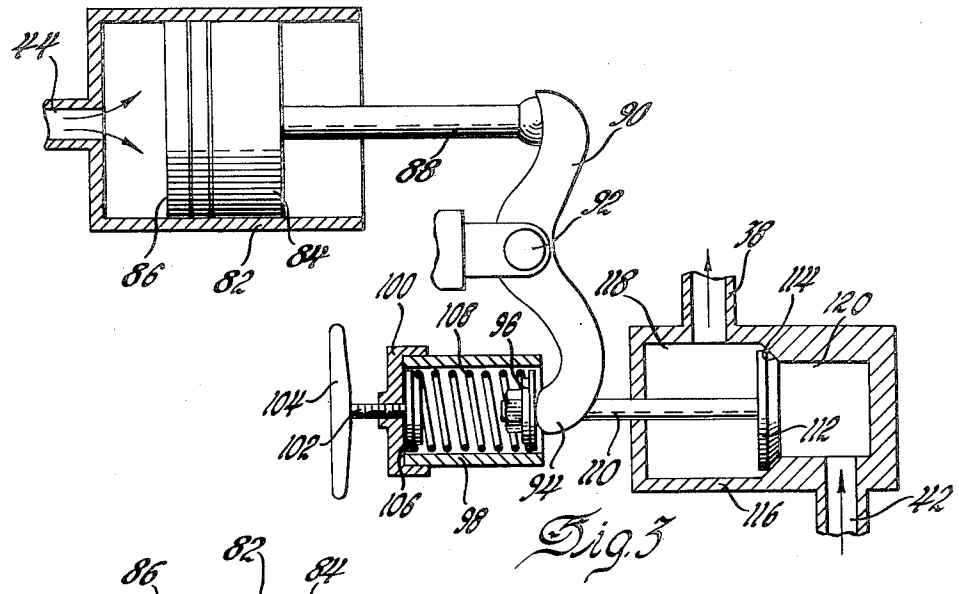

Fig. 3

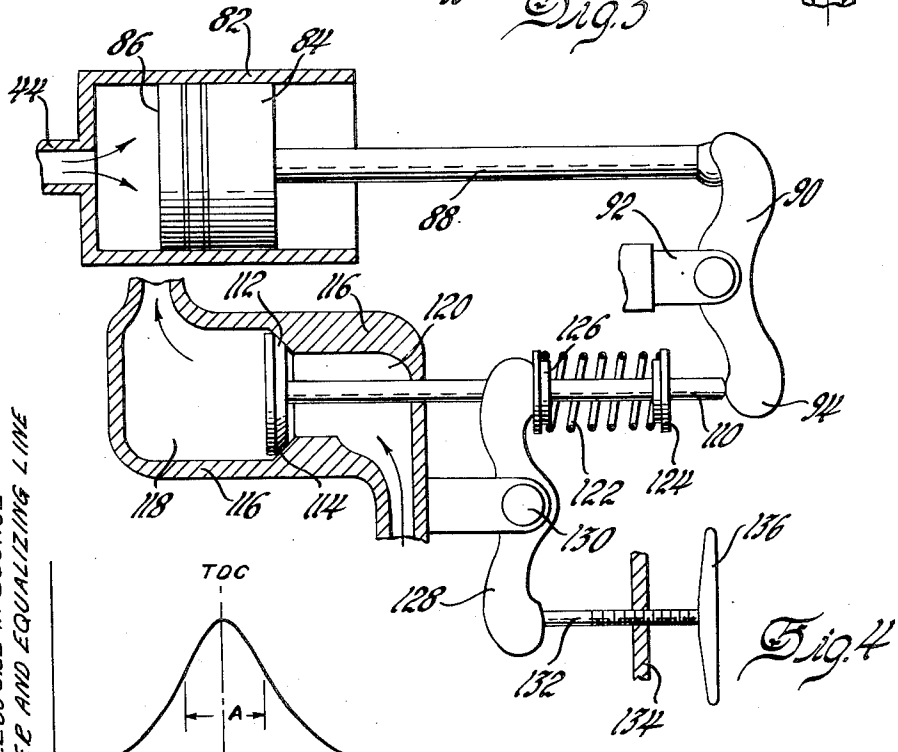

Fig. 4

Fig. 5

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PRESSURE-OPERATED VALVE MEANS FOR FREE PISTON ENGINES

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Application April 18, 1955, Serial No. 501,887

4 Claims. (Cl. 123—46)

This invention relates generally to pressure-operated valve means and more particularly to fuel valve control means for internal combustion engines.

An important object of the present invention is to provide means which wil enable an internal combustion engine to burn gas or gas mixed with a pilot charge of diesel fuel.

A more specific object of the invention is to provide in a free piston engine valve means between the combustion chamber and a fuel source operable in response to predetermined pressure in the equalizing conduit between the bounce cylinders of the chamber to connect the inlet to the combustion chamber with the fuel source.

A further object of this invention is to provide novel linkages for actuating the fuel control valve in response to various engine pressures.

A still further object of the invention is to provide means for varying the pressure at which the control valve will be opened in response to pressures in the free piston engine.

For a fuller understanding of the above and other objects of this invention reference may be had to the accompanying detailed description and drawings, in which:

Fig. 1 is a schematic view in section of a free piston engine with the novel valve means applied thereto.

Fig. 2 is a detail view in section of the fuel valve means indicating how it is responsive to the pressure in the equalizing conduit between the bounce cylinders of the engine.

Fig. 3 is a madification of the valve actuating and adjusting means.

Fig. 4 is a further modification of the valve actuating and adjusting means.

Fig. 5 is a diagram indicating that the fuel valve is opened in response to the pressure in the equalizing line equally before and after the piston is at top dead center.

Referring first to Fig. 1, the free piston engine indicated generally by the numeral 2 comprises a casing 4. Formed in the casing 4 by suitable wall structure 6 is a combustion chamber 8 and a pair of oppositely disposed chambers 10. Housed in the casing 4 are oppositely disposed piston assemblies 12 having piston faces 14 located in the combustion chamber 8. The piston assemblies 12 are also provided with faces 16 and 18 located in the chamber 10 which divide each of these chambers into a bounce cylinder 20 and a scavenging air compressor chamber 22. Suitable inlet valves 24 are provided leading into the chambers 10.

Leading from the scavenging air compressor chambers 22 into the scavenging air box 26 are suitable one-way valves 28. Surrounding the combustion chamber at one end thereof is an inlet manifold 30 leading from the air box 26 into the combustion chamber 8. An exhaust manifold 32 is located around the opposite end of the combustion chamber and includes a plurality of exit ports coverable and uncoverable by the end of the piston assembly 12 adjacent the piston face 14. The manifold 32 is connected to a suitable exhaust pipe 34. Connecting the bounce cylinders 20 to equalize the pressures therein is

an equalizing conduit 36. Communicating with the interior of the combustion chamber is a fuel inlet 38 leading from the combustion chamber to the fuel valve means indicated generally by a numeral 40. Also leading to the fuel valve means 40 is a conduit or pipe 42 which is connected to some suitable conventional pressurized source of fluid fuel. Connecting the valve means 40 to the equalizing conduit 36 is a conduit or pipe 44.

Referring now to Fig. 2, details of one form of the novel control valve means are shown. This valve assembly 40 includes a valve housing or casing 46 which is divided into essentially two chambers 48 and 50 by means of a valve seat restriction 52 including the valve seat 54. Adapted to be seated on seat 54 is a valve 56 which is located adjacent the restriction so that it is adapted, when the valve is open, to move into the chamber 48. The valve 56 is secured to a valve stem 58 which extends through the valve on opposite sides thereof and into the chamber 50. Secured to the stem 58 and reciprocable in the chamber 50 is a piston 60. A face 62 of piston 60 is acted on by pressure from the equalizing conduit 36 through the conduit 44 which is in communication with the end of the chamber 50. Connected to the chamber 50 by means of the conduit 42 is the pressurized source of fuel. The chamber 48, it will be observed, communicates with the inlet 38 to the combustion chamber 8. Threaded on the opposite end of the valve casing 46 is a valve housing extension 64 which includes a wall 66 enclosing the end of chamber 48. The stem 58 extends through wall 66 into a chamber 68 in the extension 64 and is provided on the end thereof with a helical coil spring seat 70. The chamber 68 is closed by a suitable cap 72 threaded on the end of the extension 64 and has suitably extending therethrough a threaded shank 74 on one end of which is mounted a second suitable spring seat 76 located in the chamber 68. Seated on the spring seats 70 and 76 are the ends of a helical coil spring 78. The initial compression of this spring to seat the valve 56 on seat 54 may be regulated by the turning of a handle 80 secured to the opposite end of the threaded shank 74.

The operation of this engine including the novel valve control means is as follows: Assuming the engine to be turning over, as the piston assemblies 12 move outwardly away from each other the pressure in the scavenging air compressor chambers 22 is reduced and valves 24 are caused to open allowing air to enter these chambers. After the piston assemblies 12 reach top dead center and start their return stroke the valves 24 are closed and the valves 28 will be opened thereby compressing the air in chambers 22 and also in the air box 26. This compressed air enters the combustion chamber through the ports of the inlet manifold 30 when the end of one of the piston assemblies 12 uncovers the ports in the inlet manifold. At the same time the air enters the inlet manifold 30 the burnt gases are exhausted through the ports in the exhaust vent hole 32. As the pistons move outwardly toward top dead center, however, they increase the pressures in the bounce cylinders 20 and in the equalizing conduit 36. This increase in pressure acts through the conduit 44 on the face 62 of the piston 60. When the pressure in the equalizing conduit 36 reaches a predetermined amount (see Fig. 5) the piston 60 will move to the left as viewed in Fig. 2 against the action of the spring 78 unseating the valve 56. Unseating the valve 56 connects the chambers 48 and 50 and allows fuel from the pressurized source to flow through these chambers and inlet 38 into the combustion chamber 8. The valve 56 will remain unseated through top dead center of the piston assemblies 12 and for a portion of the return stroke until the pressure in the equalizing conduit 36 and against the face 62 of the piston 60 again drops to the predetermined amount at which the valve 56 was initially unseated. In this way the

combustion chamber is provided with a charge of fuel and air which is compressed and ignited on the return strokes of the piston assemblies **12**.

While any suitable type of fuel may be used and supplied in measured amounts to the combustion chamber **8** by the unique valve assembly just described the device is particularly adaptable for gaseous types of fuel or gas mixed with a pilot charge of diesel fuel.

As already mentioned, if it is desired to change the point in the stroke at which the valve **56** will be opened in response to the pressure in the bounce cylinders **20** it is merely necessary to turn the handle **80** so as to change the position of the spring seat **76** relative to the spring seat **70** when the valve **56** is closed.

From the foregoing description it will be readily apparent that the opening and closing of the valve means **40** is responsive to and proportional to the pressures in the bounce cylinders **20**, the pressures in the scavenging air compressor chambers **22** or in the combustion chamber itself. While the valve has been shown as opening predetermined amounts before and after top dead center of the piston, suitable time-delay means may be employed in combination with the valve means to cause the valve assembly to open and connect the fuel source with the combustion chamber for any preferred length of time during any particular period of the cycle in order to achieve the optimum of operation.

Referring now to Fig. 3, a modification of the valve assembly is shown. In this instance a piston and cylinder assembly comprising a cylinder **82** and a piston **84** is connected by means of conduit **44** to the pressure equalizing conduit **36** so that the pressure in the conduit **36** acts against the face **86** of the piston. Connected to the piston **84** is a rod **88** which engages by means of a suitable ball and socket joint one end of a rocker arm **90** fulcrumed intermediate the ends thereof on the support **92**. The opposite end **94** of rocker **90** abuts a spring seat **96** located in one end of a suitable spring housing **98**. The opposite end of housing **98** is provided with a cap **100** which has threaded therethrough a shank **102** provided with a handle **104** on one end thereof. On the opposite end of shank **102** is a spring seat **106** located within the housing **98** and spaced from spring **96**. Interposed between the seats **96** and **106** is a helical coil spring **108**. The spring seat **96** is suitably connected to the stem **110** of a valve **112** seated on a seat **114** located in a valve housing **116**. The valve housing **116** is divided into two chambers **118** and **120** by seated valve **112**, the first of which communicates with the combustion chamber through the inlet **38** and the second of which is connected by means of the conduit **42** to the fuel pressure source.

The operation of this valve means then is as follows: At a predetermined point in the outgoing stroke of the piston assemblies **12** the pressure in the cylinder **82** against the face of the piston **86** rises to an amount sufficient to cause the piston to move to the right as viewed in Fig. 3 against one end of the rocker arm which is biased in a counterclockwise direction by spring **108** acting on the opposite end of the rocker **90**. In other words, the rocker arm **90** is caused to turn in a clockwise direction moving its end **94** against the seat **96** so that the valve stem **110** and valve **112** are moved to the left as viewed in the figure and valve **112** is unseated thereby connecting the fuel pressure source to the inlet **38** through the chambers **120** and **118**. The valve means shown in Fig. 3 is also capable of adjustment so as to change its responsiveness to the pressure in the equalizing conduit **36** and bounce cylinders **20**. This is accomplished by turning of the handle **104** which changes the biasing effect of spring **108** on seat **96**, the end **94** of rocker **90** and, of course, the valve **112**.

A further modification of the valve means indicated generally by the numeral **40** in Fig. 1 is shown in Fig. 4. Since certain portions of this assembly are the same as those shown in Fig. 3, the same reference characters will be used in those instances. It will be noted in Fig. 4 that the rocker **90** whose one end is engaged by the rod **88** has its opposite end **94** engaging the end of the valve stem **110** and that the valve **112** is normally maintained seated by means of a spring **122** interposed between a spring seat **124** fixed to stem **110** and a seat **126** slidable on stem **110**. In the modification shown in Fig. 4, however, the biasing effect of spring **122** to maintain valve **112** seated is varied by means of a second rocker arm **128** pivotally mounted on the housing **116** and fulcrumed at **130**. The rocker arm **128** has one end engageable with the movable spring seat **126** and the opposite end in engagement with a shank **132** threaded in a fixed support **134** and turnable by a handle **136**. In this case, to effect adjustment of the bias of the spring **122** on valve **112** the handle **136** is turned so as to cause rocker arm **128** to move about its fulcrum point **130**. This will cause seat **126** to move toward or away from seat **124** as desired thus changing the biasing effect of spring **122** which tends to seat valve **112**.

What I claim is:

1. In a free piston engine including a central combustion chamber and oppositely disposed piston cushioning cylinders in which oppositely reciprocable piston assemblies are housed, a pressure equalizing conduit extending between said piston cushioning cylinders, a source of fuel under pressure, a fuel inlet to said combustion chamber, and valve means between said inlet and source responsive to predetermined pressures in said equalizing conduit to connect said inlet to said source.

2. In a free piston engine including a central combustion chamber and oppositely disposed piston cushioning cylinders in which oppositely reciprocable piston assemblies are housed, a pressure equalizing conduit extending between said piston cushioning cylinders, a source of fuel under pressure, a fuel inlet to said combustion chamber, valve means between said inlet and source responsive to predetermined pressures in said equalizing conduit to connect said inlet to said source, and means connected to said valve means adjustable to vary the predetermined pressure at which said inlet is connected to said source.

3. In a free piston engine including a central combustion chamber and oppositely disposed piston cushioning cylinders in which oppositely reciprocable piston assemblies are housed, a pressure equalizing conduit extending between said piston cushioning cylinders, a source of fuel under pressure, a fuel inlet to said combustion chamber, a valve housing, a valve in said valve housing when seated dividing said housing into first and second chambers, said first chamber being connected to said inlet, said second chamber being connected to said source, a piston in said second chamber and connected to said valve, a conduit connecting said equalizing conduit with a face of said piston thereby biasing said valve according to the pressure in said equalizing conduit, and a spring operatively connected to said valve and biasing said valve in opposition to the bias of the pressure in said equalizing conduit.

4. In a free piston engine including a central combustion chamber and oppositely disposed piston cushioning cylinders in which oppositely reciprocable piston assemblies are housed, a pressure equalizing conduit extending between said piston cushioning cylinders, a source of fuel under pressure, a fuel inlet to said combustion chamber, a valve housing, a valve in said valve housing when seated dividing said housing into first and second chambers, said first chamber being connected to said inlet, said second chamber being connected to said source, a piston in said second chamber and connected to said valve, a conduit connecting said equalizing conduit with a face of said piston thereby biasing said valve according to the pressure in said equalizing conduit, a spring operatively connected to said valve and biasing said valve in opposition to the bias of the pressure in said equalizing conduit, and means for regulating the bias of said spring on said valve.

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