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[54] MULTIFUEL COMPENSATOR
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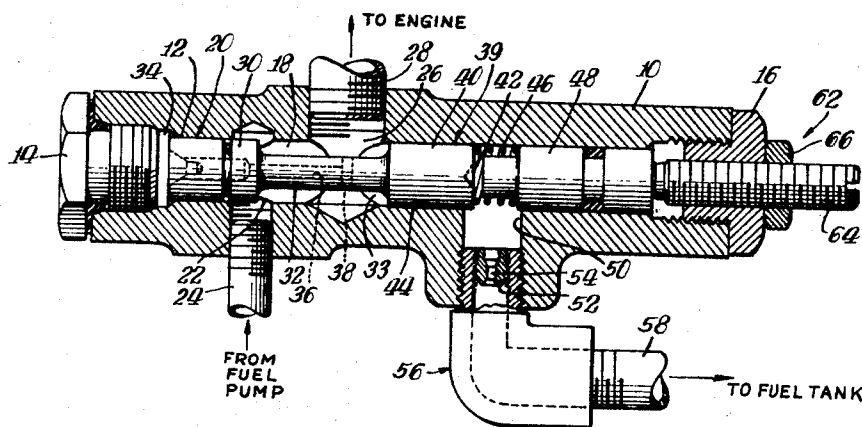
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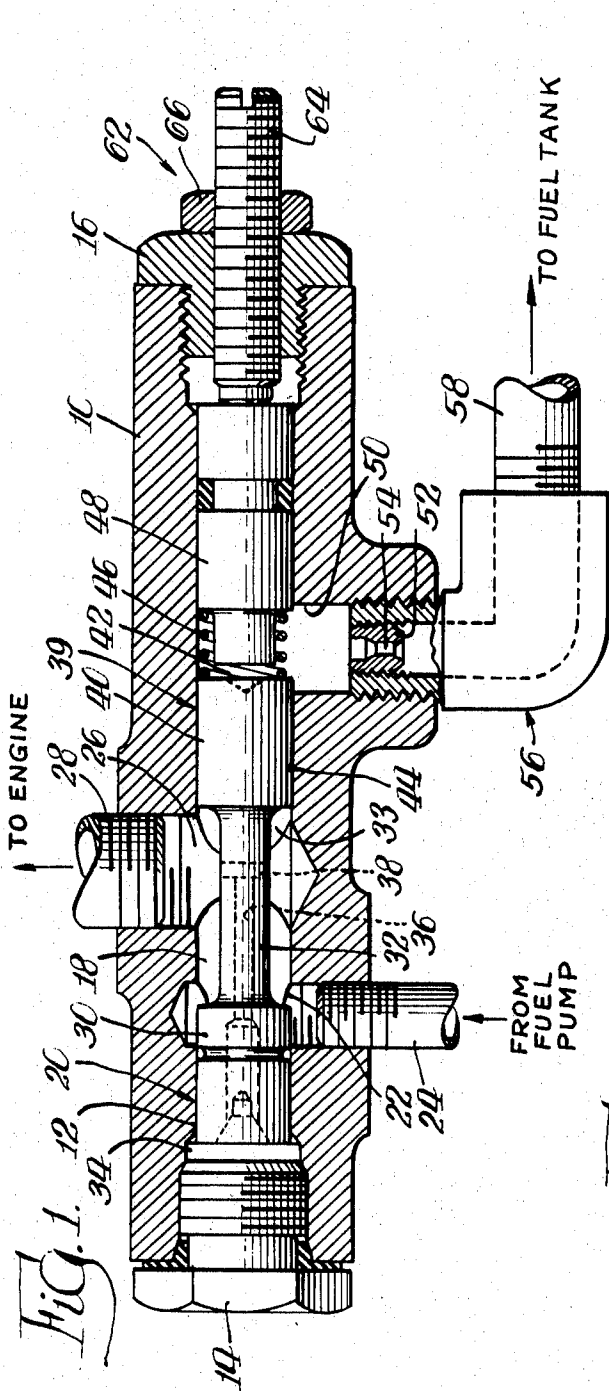
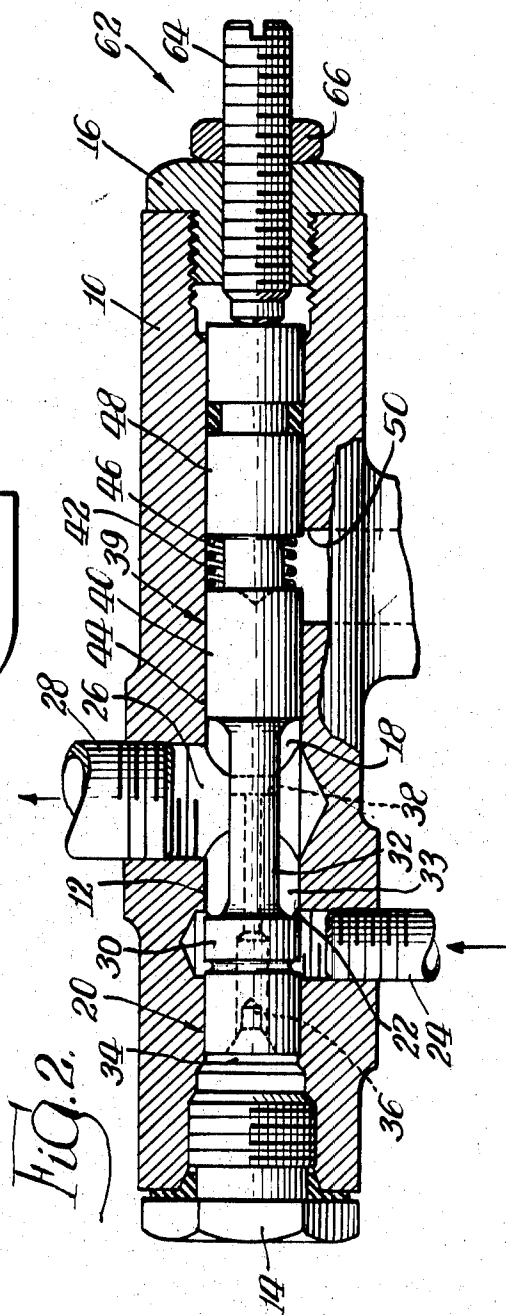
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ABSTRACT: A fuel flow compensator for automatically varying the rate of fuel flow through the compensator to an engine as a function of viscosity of the fuel to maintain a substantially constant power output from the engine when changing between high- and low-viscosity fuels while the engine is in operation.





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MULTIFUEL COMPENSATOR

DISCLOSURE

It is common practice to operate diesel engines with a fuel having a low viscosity, such as gasoline, JP fuels, CITE fuel, etc. During operation, the engine may be changed to a relatively high-viscosity fuel, such as diesel fuel. With prior fuel control apparatus it has been necessary either to accept a change in the power output from an engine or to manually adjust the fuel flow rate to provide the desired power output, when changing from a fuel of one viscosity to a fuel of another viscosity. This variation in power output from an engine when changing fuel, while maintaining a constant fuel flow rate, results from the fact that high-viscosity fuels contain more potential thermal energy per unit of volume or have a higher B.t.u. rating than do low-viscosity fuels. Consequently, when an engine is changed from a low-viscosity fuel to a high-viscosity fuel, while maintaining a constant fuel flow rate, there is a jump or increase in the power output from the engine.

The necessity of either manually adjusting the fuel flow rate or accepting variation in power output from an engine when changing from one fuel to another is undesirable. Therefore, it is an object of this invention to provide a fuel flow compensator which automatically adjusts the rate of fuel flow to an engine as a function of the viscosity of the fuel to maintain a substantially constant power output from the engine when changing from a fuel of one viscosity to a fuel of a different viscosity.

Another object of this invention is to provide a reliable apparatus which has relatively few moving parts and which automatically adjusts the rate of fuel flow to an engine to maintain a constant power output from the engine when changing between fuels of different viscosities.

These and other objects and features of the invention will become more apparent upon a consideration of the following detailed description taken in connection with accompanying drawings wherein:

FIG. 1 is a longitudinal sectional view illustrating a fuel flow compensator assembly which automatically varies a rate of fuel flow with changes in viscosity of the fuel, the fuel compensator assembly being shown in FIG. 1 in an open position to provide a relatively high rate of flow of a low-viscosity fuel to an engine; and

FIG. 2 is a sectional view, similar to FIG. 1, illustrating the fuel flow compensator assembly in a partially closed position to provide a slightly lower rate of flow of high-viscosity fuel to an engine.

This invention relates to a fuel flow compensator adapted to be inserted in the fuel line to an engine. The fuel flow compensator includes a valve for varying the rate of flow of fuel through the compensator to the engine and a viscosity-responsive means for adjusting the valve to vary the fuel flow rate through the compensator to the engine as a function of the viscosity of the fuel. When a low-viscosity fuel, having a relatively low B.t.u. rating, is flowing to the engine, the valve is moved toward an open position by the viscosity-responsive means to enable fuel to flow through the compensator to the engine at a relatively high rate. When a high-viscosity fuel, having a relatively high B.t.u. rating, is flowing to the engine, the valve is moved toward a partially closed position by the viscosity-responsive means to reduce the rate of fuel flow through the compensator to the engine and to maintain the power output from the engine substantially constant. The viscosity responsive means is adjustable to accommodate different specific fuels.

The preferred embodiment of the fuel flow compensator illustrated in the drawing comprises an elongated body 10 having a longitudinally extending bore 12 which may be closed at one end, the left as shown in the drawing, by a plug 14 and at the opposite end by a plug 16 to form a cavity 18 in which a plunger member 20 is slidably mounted. The body 10, intermediate its ends, it provided with an inlet port 22 adapted to

be connected to a source of fuel under pressure as by an inlet pipe or conduit 24, and an outlet port 26 adapted to be connected to the engine by an outlet pipe or conduit 28.

The plunger member 20 is movable in the cavity 18 of the body 10 to regulate the flow of fuel from the inlet port 22 to the outlet port 26. Thus, the plunger member 20 is movable between an open position, illustrated in FIG. 1, to provide a substantially unrestricted flow of fuel through the compensator to the engine, and a partially closed position, illustrated in FIG. 2, to restrict the flow of fuel from the inlet port 22 to the outlet port 26. To this end, the plunger member 20 is provided with a head or end section 30 adapted to move across the inlet port 22 to regulate the flow of fuel therethrough. Extending from the head, the plunger member 20 has a reduced diameter intermediate portion or section 32 which provides an annular intermediate space or portion 33 within the bore 12 for the flow of fuel from the inlet port 22 to the outlet port 26. At the end of the plunger member 20 adjacent to the head 30 is a space between the plunger member and the plug 14, such space constituting a first chamber 34. To prevent any fuel leaking into the chamber 34 from being trapped therein, the plunger member 20 is provided with a relatively wide longitudinal passage 36 extending from the end of the plunger member to the space 33 around the reduced diameter portion 32 and the passage 36 is connected with said space by a relatively wide cross passage 38.

The plunger member 20 is adapted to be adjusted to vary the rate of fuel flow to the engine to maintain a constant power output from the engine when changing between fuels of different B.t.u. ratings. Since the viscosity of a fuel varies with the B.t.u. rating of the fuel, the plunger member, in the present instance is adapted to be adjusted in accordance with the viscosity of the fuel passing through the device. Thus, when a high-viscosity fuel having a relatively high B.t.u. rating is supplied to the engine, the plunger member 20 is moved to the partially closed position, and when a low-viscosity fuel having a relatively low B.t.u. rating is supplied to the engine, the plunger 20 is moved to the open position. For this purpose, the viscosity-responsive means 39 is provided. The viscosity-responsive means 39 is adapted to shift the plunger member within the body 10 to vary the amount the inlet port 22 is opened. In the present instance, when a relatively low-viscosity or light fuel flows through the device, the plunger member 20 is moved toward the open position as illustrated in FIG. 1, and when a high-viscosity fuel is used, the plunger member is moved in the opposite direction toward a partially closed position as illustrated in FIG. 2.

The plunger member 20 is moved between the open and partially closed position by opposing pressure forces exerted on opposite end portions of the plunger 20. Therefore, the plunger member 20 includes a head or end section 40 which cooperates with the cavity 18 to provide a second chamber 42 at the other end of the plunger member from the first chamber 34. The chamber 42 is connected by a long narrow annular passage 44 to the space 33 to enable the fuel to flow from the space 33 into the chamber 42 to exert fluid pressure against the head 40 of the plunger member 20. The pressure in the chamber 42 tends to urge the plunger member 20 toward the open position of FIG. 1. This pressure force in the chamber 42 is opposed by the pressure force in the chamber 34. The pressure force in the chamber 34 is exerted against the head 30 of the plunger 20 by fuel flowing from the space 33, through the passages 36 and 38 into the chamber 34.

The fluid pressure force exerted by the fuel in the chamber 42 against the head 40 is augmented by a force from a spring 46 which is mounted in the chamber 42 between the head 40 of the plunger 20 and a stop member 48. The spring 46 tends to urge the plunger member 20 toward the open position in opposition to the fluid pressure force from the fuel in the chamber 34. Thus, there are two forces tending to move the plunger member 20 toward the normally open position, that is a fluid pressure force exerted by the fuel in the chamber 42 against the head 40, and a spring force exerted against the

head 40 by the spring 46. These two forces are opposed by a fluid pressure force exerted by fuel in the chamber 34 against the head 30. When the sum of the forces exerted against the head 40 exceeds the pressure force against the head 30, the plunger member 20 is moved to the open position of FIG. 1. However, when the fluid pressure forces against the head 30 exceed the sum of the spring force and fluid pressure force against the head 40, the plunger member is moved toward the partially open position of FIG. 2.

The fluid pressure force exerted against the head 40 by fuel in the chamber 42 is less than the pressure force exerted against the head 30 by fuel in the chamber 34 by an amount corresponding to a pressure loss or drop incurred by fuel in flowing from the space 33 through the relatively long narrow passage 44 to the chamber 42. The relatively long narrow passage is formed by a slight space or diametral clearance between the head 40 and the bore 12. The relatively long narrow configuration of the passage 44 is perhaps best illustrated by a consideration of the dimensions of one embodiment of the invention in which the head 40 has an axial length of approximately 0.5 of an inch and a diameter of approximately 0.3710 of an inch. The cavity 18, in this illustrative embodiment of the invention, has a diameter of approximately 0.3750 of an inch. Thus, the passage 44 is approximately 0.5 of an inch long axially with a maximum radial width of approximately 0.004 of an inch in the illustrative embodiment of the invention. It should be understood, of course, that the preceding dimensions are given merely to illustrate the relatively long narrow configuration of the passage 44 and are not to be considered as limiting the scope of the invention to the dimensions given.

The long narrow configuration of the passage 44 provides a relatively large resistance to a flow of high-viscosity fuels from the space 33 in the cavity 18 to the chamber 42. Consequently, when high-viscosity fuels are being conducted to the engine through the fuel conduits 24 and 28, the fuel incurs a relatively large pressure drop or loss in flowing from the space 33 through the passage 44 to the chamber 42. Therefore, with a high-viscosity fuel there is a relatively low pressure in the chamber 42 and a relatively small pressure force is exerted against the head 40 to urge the plunger 20 toward the open position. The sum of this relatively small pressure force and the force from the spring 46 is less than the force exerted by the fuel in the chamber 34 against the head 30. Consequently, the relatively large fluid pressure force in the chamber 34 moves the plunger member 20 toward the partially closed position of FIG. 2.

When a low-viscosity fuel is being conducted to the engine through the fuel conduits 24 and 28, the low-viscosity fuel will flow through the passage 44 to the chamber 42 with a relatively small pressure drop or loss. Therefore, a relatively large fluid pressure force will be exerted against the head 40 by the low-viscosity fuel in a chamber 42. The sum of this relatively large fluid pressure force and the force exerted by the spring 46 against the head 40 will be greater than the opposing fluid pressure force exerted against the head 30 by fuel in the chamber 34. Consequently, the plunger member 20 will be moved toward the open position by the forces exerted against the head 40 when a low-viscosity fuel is being used with the engine.

A passage 50 extends from the chamber 42 to drain fuel from the chamber 42 to allow for a continuous flow of fuel from the space 33, through the long and narrow passage 44 to the chamber 42. An orifice plug 52 having an orifice 54 is mounted in a fitting 56 threaded into the passage 50. The orifice 54 has a smaller effective area than the passage 44 to maintain a relatively low predetermined rate of flow of fuel through the passage 50 and to thereby enable fluid pressure to be built up in the chamber 42. A pipe or conduit 58 conducts the fuel from the fitting 56 to the fuel tank. The continuous flow of fuel into the chamber 42 and through the orifice 54 provides a continuing response of the fuel flow compensator to changes in viscosity of the fuel.

In one illustrative embodiment of the invention, the orifice 54 was sized to have a diameter of approximately 0.020 of an inch to provide a fuel flow of approximately 530cc. per minute at a pressure of 240p.s.i. Of course, the size of the orifice can be varied to provide different fuel flow rates from the chamber 42 as long as the fuel flow rate from the chamber is lower than the fuel flow rate through the passage 44 to enable pressure to be built up within the chamber 42 to urge the plunger member 20 toward the open position when a low viscosity of fuel is used with the engine.

It is desirable to provide a minimum flow of fuel through the inlet aperture 22 when the plunger member 20 is in the partially closed position. Therefore, the stop member 48 is engaged by the head 40 to halt the movement of the plunger member 20 at the partially closed position with the head 30 only partially blocking the inlet port 22. An adjustment assembly 62 is provided for varying the relationship of the head 30 to the inlet port 22 when the plunger member 20 is in the partially closed position to provide a desired minimum flow of a high-viscosity fuel through the inlet port 22 to the outlet port 26. The adjustment assembly 62 includes a screw 64 which extends through the plug 16 to engage the stop member 48. The setting of screw 64 is the stop setting for the particular maximum flow rate desired from the high-viscosity fuels. This stop can be adjusted to give the exact quantity of fuel delivery required to maintain a constant power output of low- to high-viscosity fuels as the desired operating end points. The screw 64 is held in adjusted position by a jam or locknut 66 once the flow through the inlet port 22 has been adjusted.

In operation, the fuel flow compensator maintains a substantially constant power output from an engine when changing between fuels of different viscosities and B.t.u. ratings by varying the flow rate of the fuels as a function of their viscosities. Before the engine is started, the plunger member 20 will be urged against the plug 14 by the biasing spring 46, since there is no fuel pressure acting on the plunger member at such times. As the engine is started with a low-viscosity fuel having a relatively low B.t.u. rating, the pressure of such fuel will be applied to the fuel in the chamber 34 through the passages 36 and 38 and the latter will apply a pressure force against the head 30 tending to move the head 30 toward closing relationship with the inlet port 22. However, at the same time the relatively light or low-viscosity fuel will flow through the long narrow passage 44 into the chamber 42 to apply an opposing pressure force on the head 40 to augment the force of the spring 46. The pressure force and spring force on the head 40 will tend to move the head 30 toward the open position of FIG. 1 in opposition to the pressure force exerted by the fuel in the chamber 34 against the head 30.

The pressure force exerted by the fuel in the chamber 42 on the head 40 will be smaller than the pressure force exerted by the fuel in the chamber 34 on the head 30 by an amount which is a function of a pressure loss or drop caused by resistance to fuel flow in the relatively long narrow passage 44. With a relatively low-viscosity fuel, a relatively low pressure loss or drop will be incurred by the fuel in flowing from the space 33 through the passage 34 to the chamber 42. Consequently, a fluid pressure force only slightly smaller than the pressure force on the head 30 will be applied by the fuel in the chamber 42 to the head 40 to urge the plunger member 20 toward the open position. The pressure force against the head 40 will be augmented by the spring force against the head 40. The sum of the pressure force and spring force against the head 40 will be greater than the pressure force against the head 30 and the plunger member will be urged toward the open position to maintain a relatively large flow of low-viscosity fuel from the inlet conduit 24 to the outlet conduit 28 and to the engine.

When the engine is switched to a higher viscosity fuel having a relatively high B.t.u. rating, the fluid pressure in the chamber 34 will remain substantially equal to the fluid pressure in the space 33. However, the fluid pressure in the chamber 42 will be decreased by a relatively large pressure drop or loss which will occur when the high-viscosity fuel

flows through the relatively long and narrow passage 44 to the chamber 42. This pressure drop or loss will result in a relatively large pressure differential between the chambers 34 and 42. The sum of the pressure force and spring force on the head 40 will be less than the pressure force on the head 30. Therefore, the plunger member 20 will be forced toward the partially closed position. As the plunger member 20 moves toward the partially closed position, the head 30 will partially block the inlet port 22 to reduce a flow of high-viscosity fuel from the inlet port 22 to the outlet port 26. In this manner, the rate of fuel flow to the engine is varied as a function of the viscosity and B.t.u. rating of the fuel to maintain a substantially constant power output from the engine with fuels of different viscosities.

The continuous flow of fuel, at a relatively low rate, through the orifice 54 provides for a continuous flow of fuel through the long narrow passage 44 so that the fuel compensator will be continuously responsive to changes in viscosity in the fuel flowing to the engine. Of course, if a change were made from a high-viscosity fuel to a low-viscosity, the pressure loss encountered by the fuel flowing through the passage 44 would be reduced and the pressure in the chamber 42 would be increased. This increase in pressure would force the plunger member 20 toward the open position to move the head 30 and thereby increase the flow of fuel from the inlet port 22 to the outlet port 26.

The viscosity of the fuels used with the engine will vary somewhat with the temperature of the fuels. However, the difference in viscosity between the two fuels will be substantially greater than any range of variation in viscosity with changes in temperature of the fuels. Thus, the range of variation of viscosity of the fuels with normal changes in temperature will be insufficient to cause the ranges in the viscosities of the two fuels to overlap.

In view of the foregoing description it is apparent that we have provided a fuel flow compensator which varies the rate of flow of fuel to an engine to maintain a substantially constant power output from the engine when changing between fuels of different viscosities. In the present instances, the fuel flow compensator utilizes the plunger member 20 to vary the flow of fuel through the compensator to the engine as a function of the viscosity of the fuel. The position of the plunger 20, and the flow of fuel through the compensator being varied in accordance with the rate of fuel flow through the relatively long narrow passage 44 and the pressure in the chamber 42.

We claim:

1. A fuel flow compensator for varying the flow rate therethrough of any one of a plurality of fuels of different viscosities as a function of the viscosity of the one fuel, said compensator comprising a body, movable valve means in said body for regulating the rate of flow of fuel through said fuel flow compensator, and movable viscosity-responsive means in said body rigidly connected to said movable valve means and defining, with said body, a narrow passage for fuel from said valve means and responsive to pressure dependent on said viscosity for moving said valve means to vary said rate of fuel flow through said fuel flow compensator as a function of the viscosity of the fuel flowing therethrough to maintain substantially constant the power output of an engine receiving fuel from said fuel flow compensator when changing from a fuel of one viscosity to a fuel of a different viscosity.

2. A fuel flow compensator as set forth in claim 1 wherein said narrow passage leads to a chamber the pressure in which effects movement of said valve means, said narrow passage connecting said chamber with said valve means, said passage providing a resistance to flow which varies as a direct function of the viscosity of the fuel flowing through said passage into said chamber to vary the pressure in said chamber in accordance with the viscosity of the fuel, and an orifice through which fuel flows from said chamber, said viscosity-responsive means moving said valve means in one direction to increase the flow of fuel through said compensator when a fuel of a relatively low viscosity flows through said passage and a rela-

tively high fluid pressure occurs in said chamber and moving said valve means in the opposite direction when a relatively high-viscosity fuel flows through said passage and a relatively low fluid pressure occurs in said chamber.

3. A fuel flow compensator as set forth in claim 1 wherein said compensator further includes a cavity in said body, and said viscosity-responsive means includes a member slidably mounted in said cavity with said narrow passage between said member and said body leading to said cavity, the portion of said cavity adjacent one end of said member constituting a chamber into which fuel flows through said narrow passage at a rate which is a function of the viscosity of the fuel, said member being moved in one direction in said cavity when a fuel having a low viscosity flows through said narrow passage at a relatively high rate and a relatively high fluid pressure occurs in said chamber to operate said valve means to increase the rate of fuel flow through said compensator, said member being moved in the opposite direction in the cavity when a fuel having a high viscosity flows through said narrow passage at a relatively low rate and a relatively low fluid pressure occurs in said chamber to operate said valve means to decrease the rate of flow of fuel through said compensator.

4. A fuel flow compensator as set forth in claim 1 wherein said compensator member includes a body having a cavity, a member movably mounted in said cavity, said body further having inlet and outlet ports through which fuel flows, said member having one portion cooperating with at least one of said ports to control the effective size thereof and being movable in one direction to reduce said effective size to reduce the rate of fuel flow through said compensator, and said member being movable in a second direction to increase said effective size to increase the rate of fuel flow through said compensator, said viscosity-responsive means including a chamber and a second portion of said member wherein said narrow passage is formed between said second portion and said body to enable fuel to flow through said narrow passage into said chamber at a rate which is a function of the viscosity of the fuel, said member being moved in said one direction to reduce the rate of fuel flow through said compensator to the engine when there is a relatively small flow of high-viscosity fuel into said chamber, and said member being moved in the second direction by fluid pressure in said chamber to increase the rate of fuel flow through said compensator to the engine when there is a relatively large flow of low-viscosity fuel into said chamber.

5. A fuel flow compensator as set forth in claim 4 wherein said viscosity-responsive means further includes means for engaging said member to urge said member in the second direction.

6. A fuel flow compensator as set forth in claim 4, further including stop means mounted in said body for limiting the movement of said member in said one direction and preventing said member from completely closing said one port to provide a minimum rate of fuel flow to the engine.

7. A fuel flow compensator as set forth in claim 6, further including means for adjusting the position of said stop means to vary the minimum rate of fuel flow to the engine.

8. A fuel flow compensator as set forth in claim 1 wherein said body has a cavity with inlet and outlet ports through which fuel flows, said valve means includes a member slidably mounted in said cavity, said member including one section movable relative to said inlet and outlet ports by said viscosity-responsive means to vary the effective size of at least one of said ports and the rate of fuel flow through said compensator as a function of the viscosity of the fuel, said member further including a second section having a relatively small transverse dimension to enable fuel to flow from said inlet port to said outlet port through a portion of said cavity adjacent to said second section.

9. A fuel flow compensator as set forth in claim 8 wherein said member has a third section constituting a part of said viscosity-responsive means, said third section at least partially defining said narrow passage through which fuel flows from

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said portion of said cavity at a rate which is a function of the viscosity of the fuel.

10. A fuel flow compensator as set forth in claim 1 wherein said compensator includes a body having a cavity, a member slidably mounted in said cavity, said member including one end section constituting a part of said valve means and forming a first chamber at one end of said cavity, said first chamber being connected to a source of fuel under pressure, said member including a second end section constituting a part of said viscosity-responsive means and forming a second chamber at the other end of said cavity, said second chamber being connected to a source of fuel under pressure by said narrow passage through which fuel flows to provide a fluid pressure in said second chamber which is a function of the viscosity

ty of the fuel flowing through said narrow passage, and biasing means engaging said member for urging said member toward said one end of said cavity, said member being moved toward said one end of said cavity by said biasing means and the fluid pressure in said second chamber to increase the rate of fuel flow through said compensator when a fuel having a low viscosity is flowing through said narrow passage and a relatively high fluid pressure occurs in said second chamber, said member being moved toward said other end of said cavity by fluid pressure in said first chamber to decrease the rate of fuel flow through said compensator when a high-viscosity fuel is flowing through said narrow passage and a relatively low fluid pressure occurs in said second chamber.

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