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[54] **SAFETY MEANS FOR A DIFFERENTIAL PRESSURE VALVE ASSOCIATED WITH A FUEL INJECTION APPARATUS**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ....**417/307,** 123/139 E, 123/140 MC

[51] **Int. Cl.** **F04b 49/08**

[58] **Field of Search**.............417/307, 308, 302, 303; 123/139 E, 140 MC, 32 EA

[56] **References Cited**

UNITED STATES PATENTS

3,204,623 9/1965 Isley et al. ....123/140 MC

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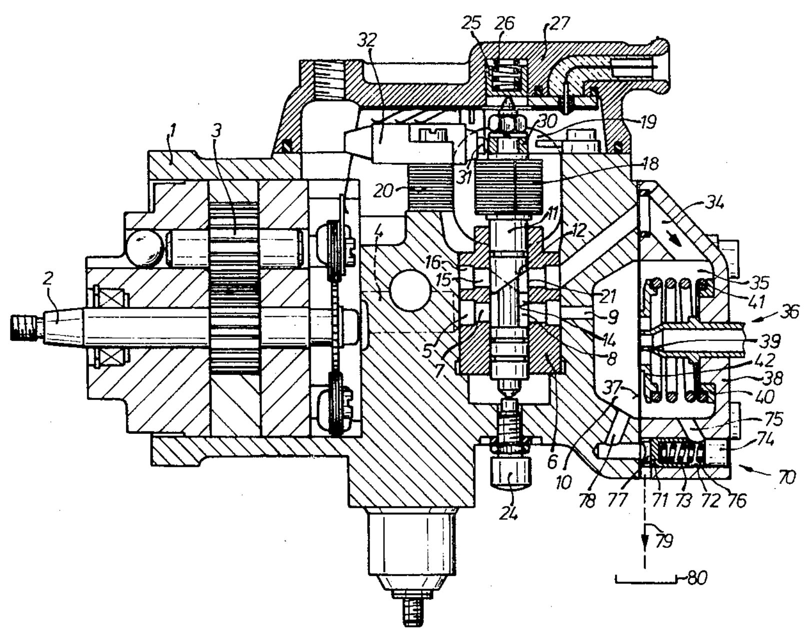
[57] **ABSTRACT**

In order to protect against excessive loads the membrane of a differential pressure valve associated with a fuel metering valve of a fuel injection apparatus, there is provided a second differential pressure valve which is connected parallel with the first-named differential pressure valve and which opens to discharge pressurized fluid therefrom when the differential pressure in the first-named valve exceeds a safe magnitude.

6 Claims, 2 Drawing Figures



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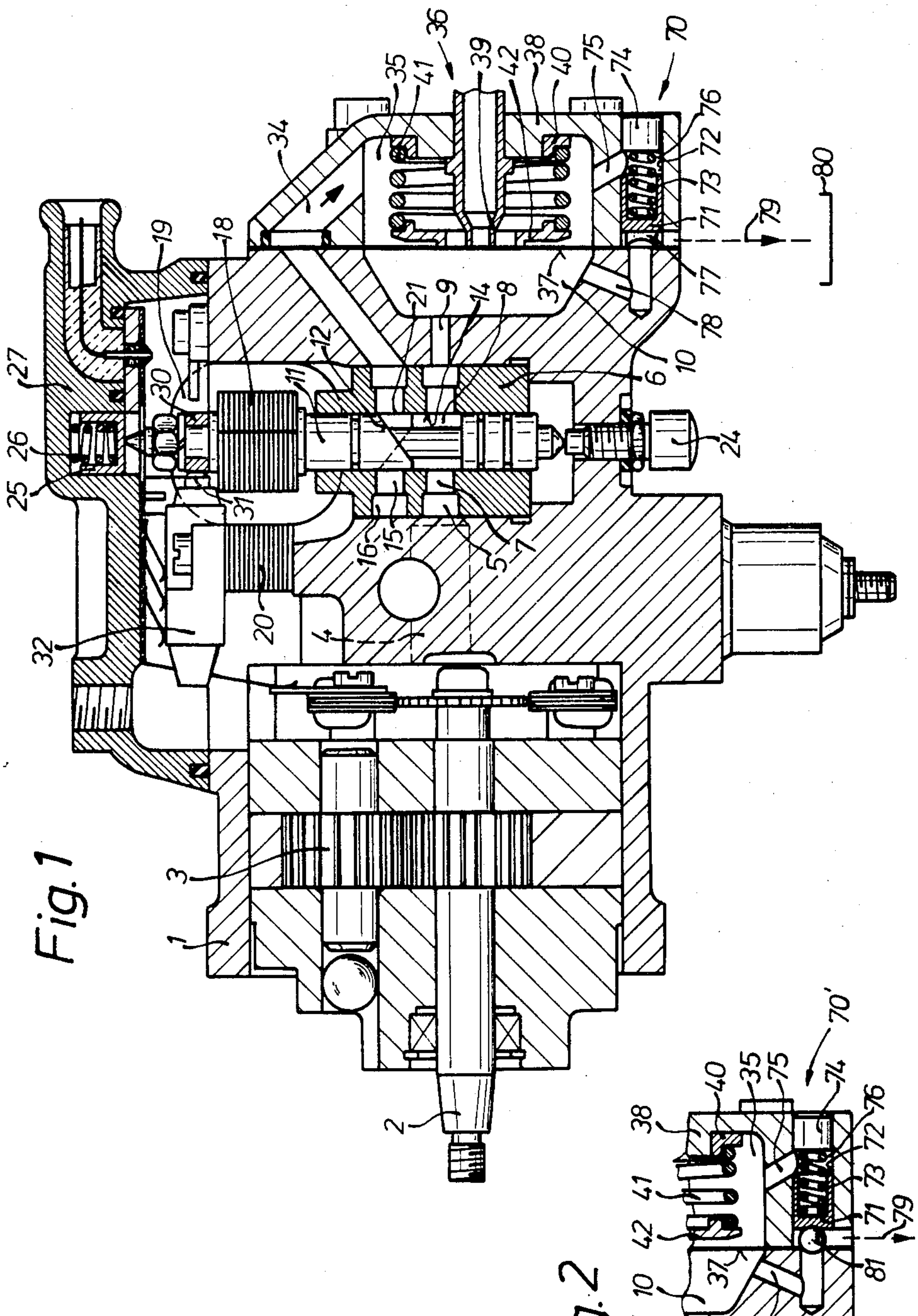

Fig.1

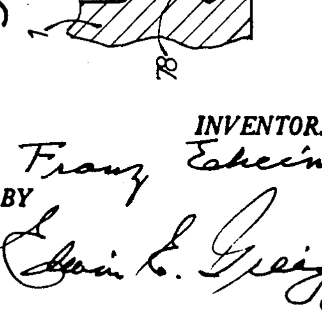

Fig.2

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SAFETY MEANS FOR A DIFFERENTIAL PRESSURE VALVE ASSOCIATED WITH A FUEL INJECTION APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a continuously operating fuel injection apparatus for vehicle-type gas turbines and is of the type which has a continuously operating fuel injection pump and control means for determining the injected fuel quantities. It further has a fuel quantity setting mechanism affecting the position of a control plunger which forms part of a fuel metering valve and which meters the fuel quantities admitted to the fuel injection nozzles. In order to ensure a constant pressure drop across the fuel metering valve regardless of the flow passage section of the latter, there is provided a differential pressure valve disposed in the fuel flow. The fuel injection apparatus is further provided with means for an rpm-dependent control of the fuel quantities, means for limiting the pressure within the hydraulic system and means for protecting against excessive rpm and excessive temperature. The fuel injection apparatus is further of the type wherein the flow passage section of the fuel metering valve is variable by means of an electromagnetic system directly connected to the control plunger. Such a fuel injection apparatus is disclosed in U.S. patent application Ser. No. 170,582, filed Aug. 10, 1971 and entitled "Fuel Injection Apparatus for Automotive Vehicles Using Gas Turbine Power Plants."

In a fuel injection apparatus of the aforenoted type, sudden changes in the load or the stoppage of the turbine may cause permanent deformations or even destruction of the membrane forming part of the differential pressure valve.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved fuel injection apparatus of the aforeoutlined type wherein the differential pressure valve is not submitted to excessive loads.

Briefly stated, according to the invention, with a first differential pressure valve which is formed as a flat seat valve and which has a membrane as the movable valve member, there is associated in parallel arrangement a second differential pressure valve.

The invention will be better understood as well as further objects and advantages become more apparent from the ensuing detailed specification of two exemplary embodiments taken in conjunction with the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal sectional view of a fuel injection apparatus incorporating the first embodiment of a second differential pressure valve and

FIG. 2 is a fragmentary sectional view of a second embodiment of the second differential pressure valve.

DESCRIPTION OF THE EMBODIMENTS

Turning now to FIG. 1, there is shown a regulator housing 1 in which there is disposed a gear pump 3 which serves as a fuel injection pump and which is driven by a drive shaft 2 and which supplies fuel through a bore 4 to an annular groove 5 of a guide sleeve 6. From the groove 5 the fuel flows through the bores 7 into an annular chamber 8 which is formed by a circumferential annular groove of a control plunger 11 and the inner bore 14 of the guide sleeve 6. The control plunger 11 is rotatably held in the bore 14 of the guide sleeve 6. The two diametrically opposite control edges 12 of the control plunger 11 and the associated control slots 15 provided in the guide sleeve 6 form a fuel metering valve, the flow passage section 21 of which is variable directly by means of a fuel quantity setting mechanism connected with the control plunger 11. The fuel quantity setting mechanism includes a magnet 18 which is rotatably held between two solenoids 19 (only one seen in FIG. 1) which, in turn, are mounted on a core 20 so that across the rotary magnet 18 and the core 20 a closed magnetic circuit may be established. The rotary magnet 18 is affixed to the control plunger 11, the axial immobilization of which is effected by means of a setting screw 24. The latter urges the control plunger 11 against a movable abutment member 25 which is resiliently supported in a closure 27 with the interposition of a spring 26.

To the control plunger 11, above the rotary magnet 18, there is keyed a cam disc 30 which, as a function of the rotation of the control plunger 11, operates an inductive transducer or position sensor 32 through a follower 31 in contact with the cam disc 30.

The fuel metered by means of the control slots 15 flows through an annular groove 16 provided in the guide sleeve 6 and a channel 34 into a first chamber 35 of a first differential pressure valve 36 which is formed as a flat seat valve and the membrane 37 of which is clamped between the regulator housing 1 and a valve housing 38 coplanar with the stationarily supported valve seat 39. The valve housing 38 is engaged, with the interposition of a ring 40, by a coil spring 41 which has a relatively flat spring characteristic. The coil spring 41 urges the membrane 37, through an interposed spring seat disc 42, in the opening direction, so that the first differential pressure valve 36 is in an open position when not in operation. From the annular groove 5 the fuel flows in an unthrottled manner through the bore 9 into a second chamber 10 of the first differential pressure valve 36. The first chamber 35 and the second chamber 10 are separated from one another by the membrane 37.

Parallel with the first differential pressure valve 36, there is arranged a second differential pressure valve 70, the movable valve member of which is constituted by a valve piston 71 which is guided in a bore 72 and which is engaged by a spring 73. At its other end, the latter is in contact with a plug 74 closing off the bore 72. A chamber 76 of the second differential pressure valve 70 communicates with the chamber 35 of the first differential pressure valve 36 through a bore 75. The valving face of the valve piston 71 is provided on a member 77 which is made of synthetic material such as fluorelastomer and which is fixedly secured to the piston 71. The second differential pressure valve 70 is urged in the opening direction against the force of the spring 73 by the fuel pressure prevailing in chamber 10. The fuel is admitted from the chamber 10 to the piston 71 through a channel 78. If the differential pressure valve 70 is in an open position, the fuel may flow from the chamber 10 through the channel 78 and a return conduit 79 into a fuel tank 80.

Turning now to FIG. 2, the differential pressure valve 70' constituting a second embodiment differs from the differential pressure valve 70 of the first embodiment merely in that the valve piston 71 exerts a force on a valve ball 81.

The embodiments described in connection with FIGS. 1 and 2 operate in the following manner:

The fuel is supplied by the gear pump 3 to the fuel metering valve 12, 15 where the metering is effected while maintaining a constant pressure drop by means of the first differential pressure valve 36. As it is apparent from the structural description of the differential pressure valve 36, the fuel pressure prevailing upstream of the fuel metering valve 12, 15 is communicated to the chamber 10, while the fuel pressure prevailing downstream of the fuel metering valve 12, 15 is communicated to the chamber 35. Thus, the valving membrane 37 is moved as a function of the pressure drop across the fuel metering valve 12, 15. In this manner, the flow passage section 21 is a measure for the volume of the throughgoing fuel quantities.

The membrane 37 operating as the moving valve component of the first differential pressure valve 36 is exposed to very high loads. They assume a critical value particularly during rapid changes of the engine load. Thus, for example, a high dynamic pressure is generated when the flow passage section 21 of the fuel metering valve 12, 15 approaches zero and also when the turbine is stopped. In such cases the membrane 37 is exposed to the entire delivery pressure of the gear pump 3. Such loads may lead to permanent deformations and even to a destruction of the membrane 37 and thus to a total breakdown of the fuel injection apparatus.

The second differential pressure valve 70 (FIG. 1) or 70' (FIG. 2) prevents the aforenoted excessive loads from being applied to the membrane 37 of the first differential pressure valve 36.

The closing spring 73 urges the piston 71 into its closed position with a force that is predetermined based on the maximum possible pressure difference in chambers 10 and 35 and on a proper safety factor.

In normal operation, the second differential pressure valve 70 is closed, but as soon as the pressure difference in chambers 10, 35 exceeds a predetermined maximum permissible value, the pressure in chamber 10 applied to the piston 71 through channel 78 overcomes the combined force of the spring 73 and the pressure in chamber 76 and shifts the piston 71 into its open position. Thus, the differential pressure valve 70 is now open and permits fuel to flow through the bore 78 and the conduit 79 back into the fuel tank 80 until the permissible pressure difference in chambers 10, 35 is reestablished.

What is claimed is:

1. In a fuel injection apparatus of the type including (a) a pump for driving pressurized fuel for injection, (b) a fuel metering valve disposed downstream of said pump and having a variable flow passage section to control the fuel quantities to be injected into a power plant for combustion, the improvement comprising,

A. a first differential pressure valve having
   1. a first chamber,
   2. channel means for introducing the metered fuel from said fuel metering valve into said first chamber;
   3. a second chamber,
   4. channel means for introducing pressurized fuel from upstream of said metering valve into said second chamber,
   5. a flat valve seat,
   6. a membrane cooperating with said flat valve seat for varying the outflow of metered fuel from said first chamber, said membrane separating said first and second chambers from one another and being moved as a function of the difference between the pressures prevailing in said first and second chambers and

B. a second differential pressure valve having
   1. a movable valve member,
   2. means for applying the pressure in said second chamber to said movable valve member in the opening direction of said second differential pressure valve,
   3. means for applying the pressure in said first chamber to said movable valve member in the closing direction of said second differential pressure valve and
   4. discharge means communicating with said second chamber, said discharge means being controlled by said movable valve member.

2. An improvement as defined in claim 1, including means connected to said movable valve member for biasing closed said second differential pressure valve and permitting the latter to open in response to a differential pressure that is larger than the differential pressure in response to which said first differential pressure valve opens.

3. An improvement as defined in claim 2, including spring means exerting a force on the movable valve member of said second differential pressure valve in the closing direction thereof.

4. An improvement as defined in claim 1, wherein the movable valve member of said second differential pressure valve is constituted by a valve piston.

5. An improvement as defined in claim 4, wherein the valving face of said valve piston is made of a synthetic material.

6. An improvement ad defined in claim 1, wherein the movable valve member of said second differential pressure valve is formed of

A. a valve piston and

B. a valve ball displaceable by said valve piston.

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