March 2, 1948. W. O. LUM 2,436,815

PRESSURE OPERATED VALVE

Filed March 15, 1944

Fig. 1.

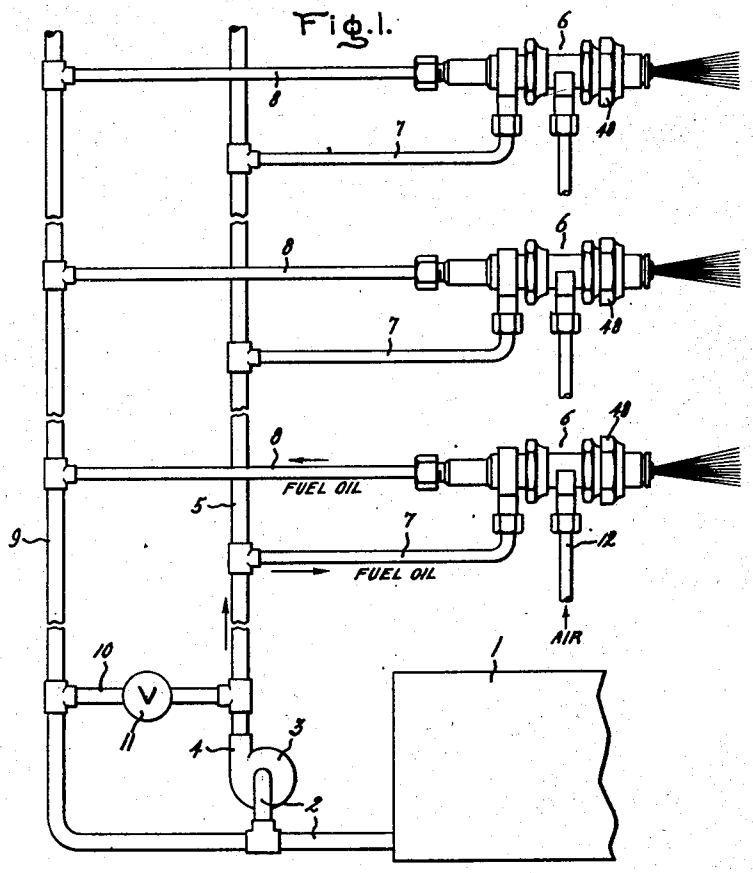
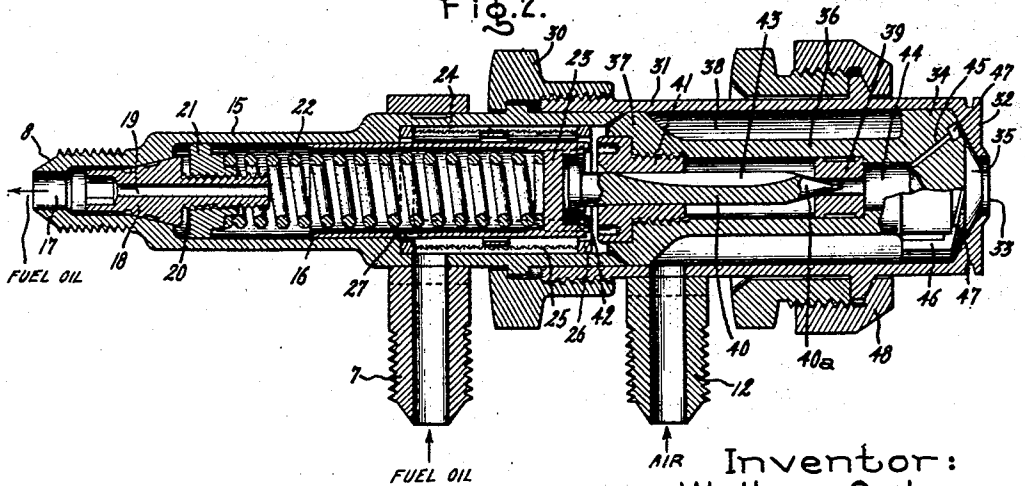


Fig. 2.



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PRESSURE OPERATED VALVE

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4 Claims. (Cl. 137—153)

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For certain applications, it is required that a number of fuel nozzles, each supplying fuel to a separate combustion chamber, be connected in parallel to a common fuel header and that during the operation equal amounts of fuel over a wide range of operation from no load to full load be supplied from the header to each fuel nozzle. It is further required that upon changes in load, the fuel supply to all the fuel nozzles be varied evenly, promptly and simultaneously. Such an application is met with, for example, in the case of gas turbine power plants wherein a number of relatively small combustion chambers (for example as many as 12 or more) arranged in a circle supply gas to a turbine wheel, each combustion chamber supplying gas to a small arc of the wheel. In such an application, it is important that the wheel be equally loaded throughout its circumference which means that each combustion chamber at all loads must supply equal temperatures of gas to the nozzles of the turbine. It is also necessary that fluid fuel be metered very accurately to the combustors over an extremely wide range of flow rates.

The object of my invention is to provide an improved fuel distributing system and an improved fuel nozzle for use therein for meeting the foregoing requirements, and for a consideration of what I believe to be novel and my invention, attention is directed to the following specification and to the claims appended thereto.

In the drawing, Fig. 1 is a diagrammatic view of a system embodying my invention, and Fig. 2 is a longitudinal sectional view through one of my improved fuel nozzles.

Referring to the drawing, 1 indicates a fuel tank connected by a pipe line 2 to the inlet of a suitable fuel pump 3 which has its discharge side 4 connected to a fuel header 5. In the case of an installation wherein a number of combustion chambers are arranged in a circle, header 5 may be in the form of an annular pipe to which the fuel nozzles of the several combustion chambers are connected. In the present instance, by way of example, I have shown three fuel nozzles 6 connected to header 5 in parallel, this being intended to represent any suitable number of fuel nozzles connected to a header of any suitable type. The branch pipes connecting header 5 to the fuel nozzles are indicated at 7. Each fuel nozzle is provided with an overflow pipe 8, the several pipes 8 being connected in parallel to a return pipe line 9 which leads back to fuel pump 3 and tank 1. The discharge side of pump 3 at a point in advance of header 5 is connected to

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pipe line 9 by a by-pass pipe 10 in which is located a suitable hand control valve 11. When hand control valve 11 is open, fuel discharged from pump 4 can by-pass through pipe 10, 9, and 2 back to pump 3 and the supply tank 1 so that when valve 11 is open, no fuel oil is supplied to header 5. As valve 11 is closed, fuel oil will be supplied to header 5, its pressure being gradually increased as the valve moves toward closed position. Thus, valve 11 forms a control valve for regulating the amount of fuel supplied to header 5 and the pressure in the header.

Each fuel nozzle 6 may supply fuel to a separate combustion chamber. The fuel nozzle may be of a type in which fuel is atomized to the combustion chamber by pressure alone or it may be of a type in which it is atomized by means of air. In the present instance, the latter arrangement has been illustrated, 12 indicating a pipe line leading from a suitable source of air pressure.

Referring to Fig. 2, 15 indicates a cylinder in which is mounted one end of an elongated hollow piston 16. In the head of cylinder 15 is a discharge opening 17 with which a pipe 8 connects. In the discharge opening is a plug 18 having a central opening 19 for flow of fuel oil to opening 17. Plug 18 is provided with a threaded stem 20 on which is a nut 21 with which engages one end of a spring 22. The other end of spring 22 is located inside piston 16 and engages head 23 of the piston. Plug 18 is provided with a suitably shaped socket in its left hand end to receive a tool for turning the plug. By turning plug 18, nut 21 may be moved longitudinally of cylinder 15 to adjust the compression of spring 22, the nut being held from turning by reason of its engagement with the end of the spring. The right hand end of cylinder 15 (Fig. 2) is counterbored to provide a fuel oil supply chamber 24 with which a fuel oil supply pipe 7 connects. In fuel oil supply chamber 24 is a suitable filter screen 25 carried on a metal framework 26. From the above described arrangement, it will be seen that the right hand face of the head 23 of piston 16 is subjected to the pressure of the fuel oil supplied through pipe 7. In the wall or sleeve portion of the hollow piston 16, just in advance of the shoulder formed in cylinder 15 by the counter-bored end, is an opening 27 which connects fuel oil chamber 24 with the interior of cylinder 15 and hence with discharge pipe 8.

Connected to the right hand open end of cylinder 15 by means of a suitable coupling 30 is a cylinder 31, the end 32 of which is provided with

a spray opening 33. Fixed adjacent the end 32 is an atomizing head 34, the parts being shaped to provide a swirl chamber 35 in advance of spray opening 33. Atomizing head 34 is carried on one end of a tubular post 36. The other end of tubular post 36 is provided with a head 37 which has a beveled edge to engage a cooperating beveled edge at the right hand open end of cylinder 15 to make a tight fit with cylinder 31 and seal against the open end of cylinder 15. This sealing arrangement is more fully described in my copending application, Serial Number 526,583, filed March 15, 1944. The outer surface of post 36 in connection with cylinder 31 forms an air chamber 38 with which connects the air pipe line 12. Inside post 36 is a spool 39 having a discharge opening surrounded by a valve seat with which engages the pointed end of a fuel oil metering pin 40, such pointed end forming a valve head 40a. Metering pin 40 projects out through a fluid control opening in bushing 41 threaded into the end of post 36 and is provided with a head 42 by which it is suitably attached to the right hand end of piston 16. In metering pin 40 is a longitudinally extending metering groove 43 which increases gradually in size from the left hand end of the metering pin toward the right hand end. Between spool 39 and atomizing head 32 there is a fuel oil chamber 44 which is connected by passages 45 to air flow passages which connect air chamber 38 with the swirl chamber 35. These air passages each comprise an axially extending portion 46 formed in the peripheral portion of the swirl head and a tangentially extending portion 47, the fuel passages 45 communicating with the tangentially extending portions 47. With this arrangement, the fuel and air enter the swirl chamber tangentially, thus setting up a swirling movement of the air and fuel in the chamber to provide a thorough mixture before the fuel and air are atomized through the opening 33 to the combustion chamber. At 48 is a suitable coupling means by which the fuel nozzle may be fastened in the wall of a combustion chamber.

The operation is as follows:

Assume that fuel oil pump 3 is operating and that valve 11 is open. Under these conditions, the oil discharged from pump 3 will flow through by-pass 10 back to pump intake line 2, no oil pressure being built up in header 5. The pointed heads 40a of metering pins 40 in each of the fuel nozzles will be against its seat, closing the discharge opening in spool 39. Now, as valve 11 is moved toward closed position, oil will be directed to header 5 and will be supplied from header 5 to each of the fuel nozzles through pipes 7. The fuel oil entering a nozzle through pipe 7 builds up a pressure in fuel oil chamber 24 which pressure acts on cylinder head 23 in a direction tending to move it toward the left to move the head of the metering pin away from its valve seat. At the same time oil flows through by-pass opening 27 in the wall of cylinder 16 to the return pipe 8. As valve 11 is moved further toward closed position, a pressure will be built up in the fuel oil chamber 24 sufficient to move piston 16 against the action of spring 22; and, after a predetermined short movement, by-pass opening 27 is covered by the cylinder wall. When this happens, the pressure is built up more quickly in oil chamber 24 since a part of the oil can no longer escape through by-pass opening 27. As a result, the metering pin 40 is moved quickly to a definite metering position to admit fuel to fuel chamber 44, from whence it is discharged through openings 45 in the atomizing head to swirl chamber 35. In the swirl chamber 35 the fuel is mixed with air under pressure conducted thereto from the air chamber 38 through the passages 45, 47. The mixture finally is discharged through the spray opening 33 into a combustion chamber or other consumer. The metering pins of all the fuel nozzles will be moved by the same amount which means that each will be feeding an equal amount of fuel to its combustion chamber. Now, as the pressure is increased and decreased by moving valve 11 toward closed and open positions, the pressure in header 5 is varied and the amount of fuel supplied by each fuel nozzle to its combustion chamber varied. The fuel flow in each nozzle is controlled by the axially extending metering groove 43, cooperating with the fluid control opening in bushing 41, and by the pressure of the fuel oil. Because of the comparatively long travel of metering pin 40, accurate metering of fuel over a wide range of flow rates is possible by careful design of the contour of slot 43.

There is a substantial drop in oil pressure in the fuel oil as it flows past the metering pin and through spool 39 to fuel oil chamber 44. As a result, the difference in head due to the fuel nozzles being connected into header 5 at different points has a negligible effect on the distribution of the oil to the respective fuel nozzles. It will be understood that initially the springs 22 of the several fuel nozzles are adjusted relative to each other so that all the fuel nozzles operate in a like manner.

When valve 11 is opened to shunt the flow of fuel oil from header 5, as soon as the by-pass opening 27 reaches a point where it communicates with fuel oil supply chamber 24, the oil pressure in the supply chamber is quickly released through opening 27, thus permitting the metering pin to move quickly to its final closed position. Due to this arrangement, the fuel nozzles, when being put out of operation, will all be quickly and simultaneously moved to their closed positions thus insuring positive shut-off of fuel oil to all the combustion chambers. This is one important feature of my invention since it does away with the possibility of fuel oil being supplied to certain of the fuel nozzles while others are entirely closed.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a variable pressure wide-range fluid metering device, the combination of a casing having walls forming a bore including an inlet chamber and a fluid control opening and a discharge opening in series flow relation, an axially slidable metering pin disposed in the bore and adapted to project at least partially into and cooperate with the discharge opening, said metering pin having a first portion cooperating with the discharge opening to form a positive shut-off valve and a second axially spaced portion shaped to define with the fluid control opening a variable area metering orifice in series flow relation with the shut-off valve, means responsive to pressure in the inlet chamber for positioning the metering pin to consecutively open the shut-off valve and then vary the size of the metering orifice as a predetermined function of increasing inlet chamber pressure, said pressure responsive means including a piston connected to the metering pin and slidably disposed in said bore with an outer end surface subjected to fluid inlet pressure tending to move the piston toward metering position,

means biasing the piston to valve-closing position, means for adjusting said biasing means, the shape of said second portion of the metering pin being so related to the fluid control opening that a metering orifice is formed only during the occurrence of a pressure in the inlet chamber above a preselected minimum value, and passage means associated with the casing and piston for by-passing fluid to equalize the pressure difference across the piston throughout a limited range of positions adjacent the valve-closed position, whereby the piston is caused to move quickly between the valve-closed position and the minimum flow metering position.

2. In a variable pressure wide-range fluid metering device, the combination of a casing having walls forming a bore including an inlet chamber and a fluid control opening and a discharge opening in series flow relation, an axially slidable metering pin disposed in the bore and adapted to project at least partially into and cooperate with the discharge opening, said metering pin having a first portion cooperating with the discharge opening to form a positive shut-off valve and a second axially spaced portion shaped to define with the fluid control opening a variable area metering orifice in series flow relation with the shut-off valve, means responsive to pressure in the inlet chamber for positioning the metering pin to consecutively open the shut-off valve and then vary the size of the metering orifice as a predetermined function of increasing inlet chamber pressure, said pressure responsive means including a piston connected to the metering pin and slidably disposed in said bore with an outer end surface subjected to fluid inlet pressure tending to move the piston toward metering position, means biasing the piston to valve-closing position, means for adjusting said biasing means, the shape of said second portion of the metering pin being so related to the fluid control opening that a metering orifice is formed only during the occurrence of a pressure in the inlet chamber above a preselected minimum value, said piston having a restricted port arranged to communicate fluid from the inlet chamber to the opposite side of the piston only when the piston is within a limited range of positions adjacent the closed-valve position, whereby the piston is caused to move quickly between the valve-closed position and the minimum flow metering position.

3. In a variable pressure wide-range fluid metering device, the combination of a casing forming an inlet chamber and a fluid control opening and a discharge opening in series flow relation, an axially movable fluid metering pin disposed in the casing and having an end portion adapted to cooperate with the discharge opening to form a positive shut-off valve and an intermediate portion shaped to define with the fluid control opening a metering orifice of a size variable as a preselected function of the axial position of the pin, a cylinder formed in the casing and communicating with the inlet chamber, a piston slidably disposed in the cylinder with an outer end surface subjected to fluid inlet pressure and connected to the metering pin, means in the casing biasing the piston to a position wherein the metering pin cooperates with the discharge opening to positively stop the flow of fluid, and a restricted passage arranged to by-pass fluid from the inlet chamber to the opposite side of the piston to equalize the pressure differential across the piston when in the valve-closed position, said by-pass being constructed and arranged to be closed by initial movement of the piston when fluid pressure in the inlet chamber rises to a preselected value whereby the piston is caused to move quickly to a fluid-metering position.

4. In a variable wide-range fluid metering device, the combination of a casing having a longitudinal bore with a fluid discharge port adjacent each end thereof, a hollow piston member slidably disposed in a portion of said bore and having an open end communicating with one of said discharge ports, walls defining fluid inlet passages arranged to communicate fluid inlet pressure to the outer end surfaces of the piston remote from said open end, said bore having a second portion forming first and second axially spaced openings, the first being a fluid control opening arranged to communicate with said inlet passages and the second being a discharge opening arranged in series flow relation between the first opening and the other of said fluid discharge ports, metering pin means projecting through said first opening and connected to the piston to be positioned thereby, said pin having a first portion shaped to cooperate with the first fluid control opening to define a variable orifice of an area which varies in a preselected manner as a function of metering pin position, the pin also having an axially spaced end portion constructed and arranged to cooperate with the second opening to form a positive shut-off valve, and means associated with the piston for biasing the metering pin to valve-closing position, said piston having a side wall portion defining a restricted by-pass port communicating between the inlet passages and the interior of the piston, the location of the by-pass port being so related to the configuration of the metering pin that initial movement of the piston first opens the shut-off valve and then covers the by-pass, whereby the pressure differential across the piston is increased to quickly move the pin to a fluid metering position.

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