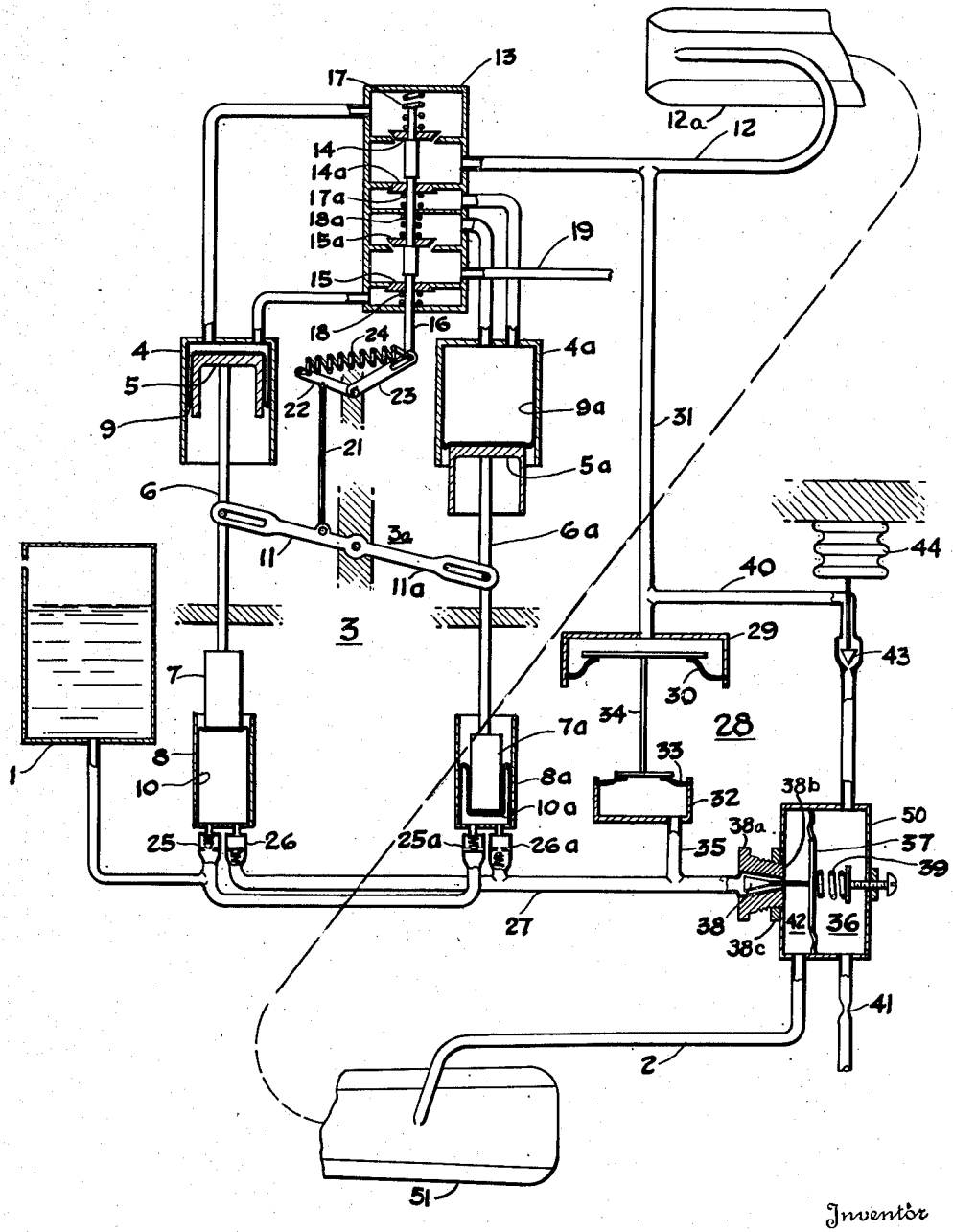
May 1, 1951 W. K. DEACON 2,550,678

RAM AIR OPERATED FUEL PUMP

Filed March 14, 1946



Inventor

WALTER K. DEACON

By F. J. Schmitt

Attorney

Patented May 1, 1951

2,550,678

UNITED STATES PATENT OFFICE

2,550,678

RAM AIR OPERATED FUEL PUMP

Walter K. Deacon, United States Navy

Application March 14, 1946, Serial No. 654,484

3 Claims. (Cl. 60—35.6)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

This invention relates to ram jet engines and in particular to the fuel system therefor.

It has been recognized that the fuel requirements for combustion in a ram jet engine vary directly with the square root of the dynamic head or ram pressure created by the forward velocity at any given altitude and also that the fuel flow through a nozzle also varies with the square root of the pressure drop thereacross. It is apparent, therefore, that the ram pressure becomes a convenient fuel pressure source to deliver fuel in accordance with engine requirements. When used directly however, it has the disadvantages that with an increase in altitude at a given velocity the fuel requirements decrease at a greater rate than the ram pressure available for a given Mach number thus tending toward enrichment, and at low speeds the ram pressure available is not sufficient to insure optimum fuel atomization or to compensate for sudden pressure changes in the combustion chamber.

This invention obviates the disadvantages above mentioned and has, therefore, as one of its objects, the provision of a ram jet fuel system which delivers the optimum amount of fuel under the variable conditions of velocity and altitude.

Another object is the provision of a ram jet fuel system which utilizes available air pressures for delivering fuel to a combustion chamber thereby eliminating cumbersome pumping devices which require for their operation a source of energy carried by the unit, thus decreasing the complexity and overall weight thereof.

Another object is the provision of a ram jet fuel system which utilizes air at ram pressure to pump fuel at a pressure in excess of combustion chamber fuel pressure requirements.

Another object is the provision of a ram jet fuel system which incorporates a fuel pump operable by ram pressure capable of delivering fuel at a pressure higher than ram pressure.

Further objects, advantages, and salient features of the invention will become apparent from a consideration of the description to follow, the accompanying drawing and the appended claims.

The accompanying drawing is a side elevational view, partly in section, of an embodiment of the invention.

Referring to the drawing, 1 respresents a fuel tank from which it is desired to deliver fuel to a conduit 2, the latter being connectable to any suitable fuel nozzle system in a ram jet combustion chamber illustrated diagrammatically at 5 or other engine. Reference character 3 represents a fuel pump and 3a its driving motor and

2

50 a regulator for controlling fuel delivery to conduit 2.

Fuel pump 3 and motor 3a comprise a pair of motor cylinders 4, 4a having reciprocating pistons 5, 5a therein connected respectively by piston rods 6, 6a to pump pistons 7, 7a which reciprocate in cylinders 8, 8a. Diaphragms 9, 9a and 10, 10a, provide fluid seals for the pistons in the motor and pump cylinders, respectively. A bell crank having arms 11, 11a interconnects these units by pin and slot connections so that they are constrained to operate in opposite directions.

The motor is operated by air flowing in conduit 12 the end of which is located in any convenient position where it may receive air at ram pressure as shown at 12a. Operation of the respective motor pistons 5, 5a is controlled by a valve 13 having inlet valves 14, 14a and exhaust valves 15, 15a. These valves have sliding movement on valve stem 16, the valves of each pair being urged toward each other by suitable compression springs 17, 17a, 18 and 18a. The lower end of valve stem 16 is connected to bell crank arm 11 by link 21 and a toggle actuator comprising a pair of relatively movable arms 22, 23 and an overcenter spring 24.

In the position of parts, as shown, air from conduit 12 enters valve 13 and then passes through intake valve 14, which is held open by the upper shoulder on valve stem 16, and thence to cylinder 4, urging piston 5 downwardly, exhaust valve 15 being held closed by spring 18. Since piston 5a is moving upwardly at this time the air in cylinder 4a must be exhausted which is effected through exhaust valve 15a held off its seat by the valve stem shoulder thereunder. The air then flows to surrounding air at static pressure through conduit 19. When piston 5 approaches the end of its stroke, arm 22, operated by 11, reaches a position in line with arm 23. This stretches spring 24 to its maximum extent and as arm 22 moves beyond the inline position spring 24 snaps arm 23 downwardly. At this point spring 17 urges inlet valve 14 to its seat and the valve stem shoulder above valve 14a opens the latter to admit air to cylinder 4a which is now at the top of its stroke. Exhaust valve 15a is also closed under urge of spring 18a and exhaust valve 15 is opened by the valve stem collar thereabove. As piston 5a moves downwardly, arm 22 moves upwardly to its overcenter position at which point 23 snaps back to the position shown at which point the cycle is completed.

As the motor pistons reciprocate, pump pistons

7, 7a receive fuel from tank 1 through inlet check valves 25, 25a, respectively, and deliver it to conduit 27 through check valves 26, 26a. In order that the delivery pressure may be higher than ram pressure, the motor piston areas are larger than the pump piston areas hence any desired increase in delivery pressure over ram pressure may be achieved by suitable selection of this area ratio.

To obviate surges in fuel delivery pressure which might occur at or near the ends of the piston strokes a surge motor and pump 28 is provided. This comprises a closed motor chamber 29 having a diaphragm 30 subjected to ram pressure through conduit 31, and a pump chamber 32 having a diaphragm 33 connected to diaphragm 30 by rod 34. A conduit 35 provides liquid communication between chamber 32 and conduit 27. The area ratio of diaphragm 30 to diaphragm 33 is slightly less than the ratio of piston 5, or 5a to 7, or 7a hence the surge pump is inoperative during constant fuel pressure delivery but when the fuel pressure tends to drop, diaphragm 30 temporarily operates pump diaphragm 33 to maintain delivery pressure substantially constant.

The fuel delivered by 27, in the system so far described, may be conducted directly to a combustion chamber 51 if so desired, however, in many installations it will be more desirable to further control the metering characteristics of the pumping system. To this end, a flow controller 50 may be provided, this device comprising a chamber 36 having a diaphragm 37 forming one side thereof and operably connected to control valve 38. One side of diaphragm 37 is subjected to ram pressure through conduit 40 and a spring 39 aids ram pressure in urging diaphragm 37 to the left against delivery pressure. An adjustment to regulate the metering characteristics of valve 38 such as externally threaded valve stem and seat 38a adjustably secured in tapped hole 38b in wall of chamber 36 and secured with locknut 38c may also be provided. The metered fuel, after entering chamber 42 is delivered to conduit 2 which may be connected to any fuel delivery system for a combustion chamber.

To also provide control under variable altitude a variable orifice 43 may be incorporated in conduit 40 under control of a suitable barostat device 44 and an orifice 41 for controlling the pressure drop between chamber 36 and ambient static pressure. The evacuated barostat being responsive to air pressure changes moves valve 43 toward its closed position with increase of altitude thus reducing the pressure in chamber 36 which in turn permits delivery pressure to move valve 38 toward its closed position. This reduces the quantity of fuel delivered to the combustion chamber which is necessary since the mass flow of air through the combustion chamber decreases with increase in altitude, assuming velocity to be constant.

From the foregoing description it becomes apparent that at low ram pressures which are normally insufficient to directly deliver fuel at optimum pressure, this invention delivers fuels at any desired pressure above ram pressure depending on the design of the areo ratio of the motor pistons to pump pistons. As velocity increases and hence the quantity of air flowing to a combustion chamber increases, requiring greater increase in fuel flow, the ram pressure also increases which in turn will render the pump

operable to deliver fuel at the higher pressures and hence higher quantities requisite for proper combustion. The final metering being under control of the pressure drop between ram and static pressures provides a means to regulate the optimum fuel flow for variation of velocity at any fixed altitude. To further control flow at variable altitude a barostat augments the previous controls.

The fuel system described, being automotic in operation under variable flight conditions is well adapted to aircraft or other installations where no human pilot or operator accompanies the craft, such for example as guided missiles. It is, of course, not so limited and may be used also in operator controlled vehicles of any type which have speed characteristics sufficient to establish the requisite ram pressures for its operation.

While a single embodiment has been described it is apparent that other modifications will occur to those skilled in the art and it will be understood that the illustrated construction is not presented by way of limitation but that the invention comprehends all constructions coming within the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a device of the class described the combination comprising; a conduit open forwardly to receive ram air, fluid motor means connected to said conduit for operation by said ram air, a fuel delivery line, a fuel pumping means driven by said fluid motor means, said fluid motor and pumping means having operative pistons of relative diameters such that the fuel is delivered to said delivery line at a pressure in excess of said ram pressure, a chamber having a movable wall, said chamber being connected to said conduit for directing ram pressure to said wall, and a fuel accumulator in communication with said delivery line having a second movable wall, said movable walls being connected for simultaneous movement in response to ram air and fuel delivery pressure to maintain substantially constant fuel delivery to said delivery line between pump strokes.

2. In a fuel feed system for ram jet engines the combination of a conduit opened forwardly to receive air at ram pressure, a two-cylinder air motor with opposed pistons connected to said conduit to be operated by said ram pressure, a reciprocating piston in a cylinder for pumping fuel connected to each of said motor pistons, the cross sectional area of the pumping pistons being less than the cross sectional area of the motor pistons whereby the pump delivery pressure is in excess of ram pressure, fuel supply means and fuel delivery means connected to said pumping pistons, a fuel accumulator with a flexible wall responsive to ram air pressure in said conduit and connected to said fuel delivery means, and metering means in said delivery means for controlling the rate of fuel delivery to a combustion chamber, said metering means being responsive to variations in ram air pressure and ambient atmospheric pressure.

3. The device as set forth in claim 2 in which said fuel accumulator has a first flexible wall responsive to ram air pressure on a second flexible wall connected thereto and said second flexible wall and said first flexible wall having a ratio

of slightly less than the ratio of areas of said motor pistons to said pumping pistons.

WALTER K. DEACON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,369,672	Koenig	Feb. 22, 1921
1,888,749	Urquhart	Nov. 22, 1932
2,233,307	Dodson	Feb. 25, 1941
2,274,224	Vickers	Feb. 24, 1942
2,402,363	Bradbury	June 18, 1946

FOREIGN PATENTS

Number	Country	Date
625,104	France	Apr. 19, 1927
799,258	France	Mar. 27, 1936