

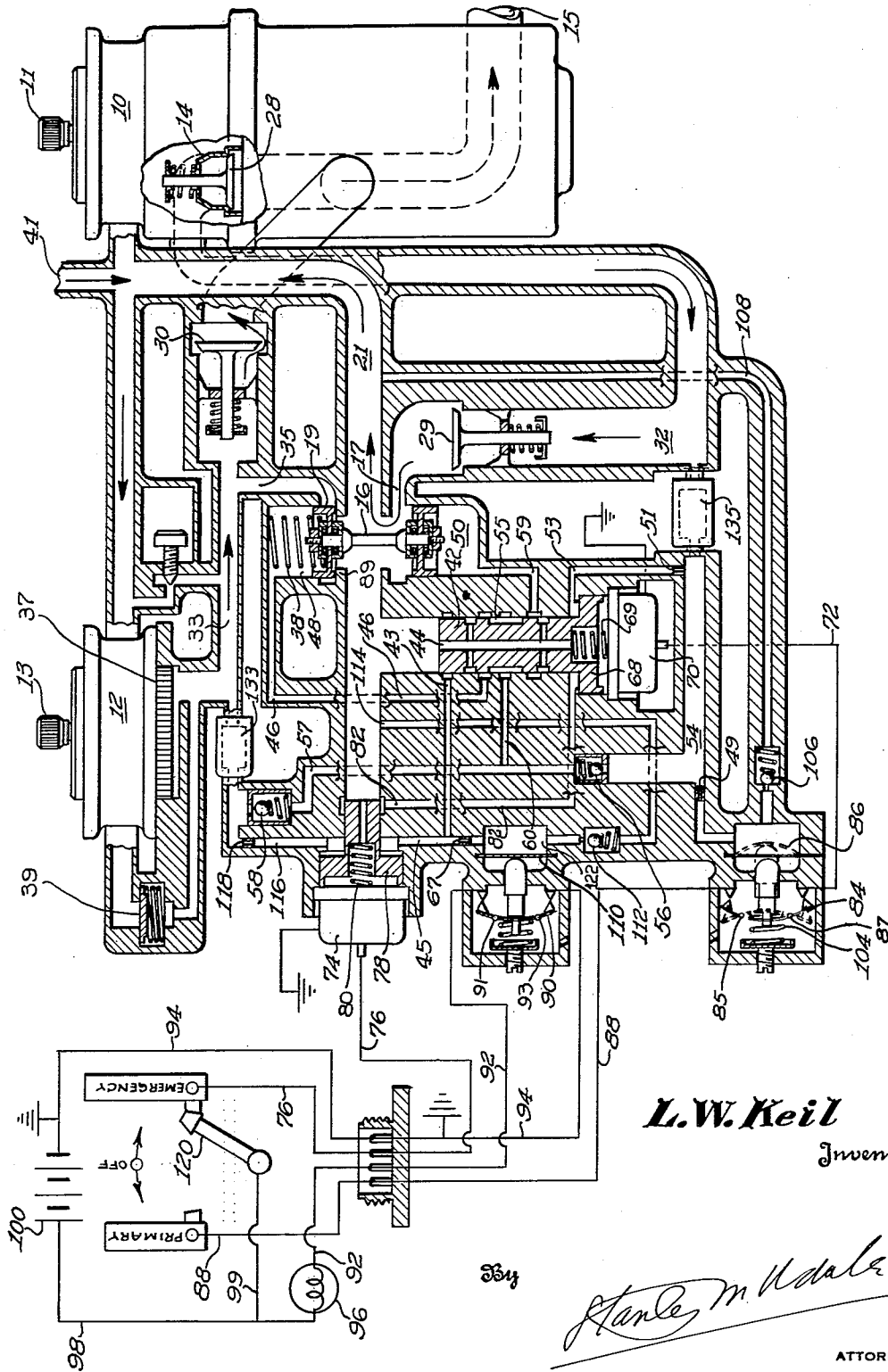
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DUAL FUEL SUPPLY FOR A GAS TURBINE

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1

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DUAL FUEL SUPPLY FOR A GAS TURBINE

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This invention relates to a dual fuel supply for a gas turbine. The object of my invention is to provide an automatically or electrically selected emergency fuel pump of the gear type for turbo-jet engine fuel systems when using the unloaded type of emergency pump and a cockpit warning light to indicate the operation of the emergency fuel pump which is automatically brought under load when the primary pump fails. At the same time a manually operated electric switch controlling two solenoids is available in order that the pilot can override the automatic control.

On a turbo jet engine provided with two gear type fuel pumps, one pump is generally run at an idling or low load condition while the other pump carries on normal or high-load operations. In the event of a failure of the primary pump shaft the fuel flow to the fuel control must not stop for longer than a few tenths of a second while a switch over to the filtered emergency pump is being made automatically.

This device provides not only a system which accomplishes this on a failure of the primary pump shaft, but also permits checking by hand to find out whether or not the emergency pump is available even though a failure has not occurred.

The electrical transfers are so rapid that they are scarcely noticeable even to the skilled observer. This is due to the utilization of highest and lowest pressures in the system to provide the maximum operating "slamming" differential pressures possible in order to operate quickly the selector valve which switches operation from one pump to the other. The unit is intended to be almost fool-proof from the pilot's standpoint. He automatically starts on the primary system unless he selects emergency. The system transfers as well to emergency whether there is an electrical failure or not and will "hold" on either primary or emergency in the event of an electrical failure. Operation on either pump is the same.

A cockpit light is provided which notifies the pilot when the engine is running on "emergency." If the pilot selects "primary" electrically either during or after a failure of the primary he cannot obtain it. Again if he is operating on emergency and the emergency pump fails, the system automatically transfers back to the primary pump. Also a hydraulic interlocking device prevents getting "half way" between primary and emergency pump operation, which is a common fault of existing transfer systems.

In the figure, 10 is the primary (normally operating) fuel pump driven by a splined driving shaft 11. 12 is the secondary (emergency) pump driven by the splined drive shaft 13. 37 is an emergency flow fuel filter and 39 is a safety check valve to open in the event filter 37 becomes clogged. Both pumps 10 and 12 are normally constantly in operation but only one operates under load. 14 is the outlet from the primary pump 10. 16 is the doubleheaded slave valve which determines whether pump 10 or pump 12 should be under load. A non-return valve 28 in the outlet 14 opens when the pump 10 is under load and

2

allows fuel to discharge out of the common outlet 15 which leads to the gas turbine.

32 is the escape passage from which fuel escapes from the primary pump 10 when the doublehead slave valve 16 is in the position shown. Fuel then flows past the second non-return valve 29 around the slave valve 16 entering through the annular port 17. Under these circumstances, a second annular port 19 is closed by the doubleheaded slave valve 16 and blocks the exit 35 from the emergency pump 12. This port 19, when it is opened, serves as an outlet for a passage 35 leading from the secondary pump 12. In passage 33 there is another non-return valve 30 which, when opened (as shown in the drawing), discharges fuel to the outlet 15 leading to the gas turbine, the outlet from the non-return valve 30 being downstream of the non-return valve 28 which is shown in its closed position. 35 is the escape passage leading to the annular port 19 and is connected to the outlet passage 33 of the secondary (emergency) pump 12. A spring 38 biases the doubleheaded valve 16 into the position in which it is shown, that is, the port 19 closed and the port 17 open. The lower edge of the upper part of valve 16 rests on shoulder 89. A filter 133 is inserted between the outlet passage 33 from the pump 12 and the restriction 118. A similar filter 135 is inserted between the outlet passage 32 from the pump 10 and the passage 54.

There are means for automatically reversing the motion of the doubleheaded slave piston 16 which includes a servomotor valve 42. This servomotor valve is moved by a piston 68 into its alternative positions and a compression spring 69 will move and hold the servomotor valve 42 in the position in which it is shown. An electromagnetic solenoid 70 controlled by a conductor 72, when energized, draws the servomotor valve 42 downwardly compressing the spring 69 and reversing the position of the servomotor valve 16. When the valve 42 descends, the low pressure in the passage 21 is transferred from chamber 50 to chamber 48. This passage 21 serves as the fuel entrance to both pumps 10 and 12 and is connected at entrance 41 with a source of fuel at low pressure (not shown). This low pressure, when valve 42 descends, is applied to the upper surface of the valve 16 through the passage 44, which communicates with the passage 46, which communicates with the chamber 48 immediately above the valve 16.

At the same time that the servomotor 42 descends, the chamber 50, which is located below the valve 16, is connected through passage 59 to the port 55 in the middle of the valve 42. This port 55 is always maintained at a comparatively high pressure because it is in communication with either the passage 54 through the check valve 56 or it is in communication with the passage 33 through the check valve 58. In either event, high pressure fuel from pumps 10 and 12 is admitted to the port 55 through the cross-passage 60.

A second electrically operated electro-magnet 74 controlled by an electric conductor 76 moves the slave valve 78. When 76 is in operation (and it is so shown), the low pressure in passage 21 is transmitted to the upper surface of the piston 68 through the passage 82 which is a means for insuring that the servomotor valve 42 assumes the position in which it is shown. When the solenoid 74 is energized the spring 80 is compressed as valve 78 moves to the left.

The electric switch 84 which should be shown closed when the pump 10 is under load and when the pump 12 is not under load is operated by the pressure transmitted through the restriction 49 from the passages 32 and 54 which will cause the diaphragm 86 to move to the left to compress the spring 104 and thereby closing the switch 84 and the electrical current can now flow through the conductor 72 from the conductor 88, the terminal of

which is marked "primary" when the switch 120 is moved over to the left stationary pivots 85 and 87 support the movable elements of the electric switch 84.

90 is a similar electric switch which is shown closed as the pump 12 is under load and here an electric conductor 92 is shown communicating with another electric conductor 94 through switch 90. Switch 90 is closed by the pressure built up to the right of diaphragm 110 by reason of the pressure necessary to unseat the spring loaded valve 112. Conductor 92 connects through a cockpit lamp 96 with a conductor 98 which is connected to one terminal of the battery 100, the other terminal 94 being grounded. Hence, in the position shown, the lamp 96 is burning indicating that the emergency pump is under load.

120 is a manually operated switch. In the position in which it is shown, it is over to the right in its emergency position, therefore, electric current is flowing from battery 100 through the conductor 98 through the cross conductor 99 through the switch 120 and down the conductor 76 to the electro-magnet 74 with the result that the piston 78 is drawn over to the left compressing the spring 80 as shown. This admits low pressure fuel from passage 21 to the passage 82 and so permits the spring 69 to elevate the piston 68 and place the servomotor valve 42 in the position in which it is shown. The switch 84 is controlled by a compression spring 104 which opens it when the pump 10 fails. It is closed by the pressure built up to the right of diaphragm 86 by reason of the spring loaded check valve 106 which will not unseat until switch 84 has been closed by the high hydraulic pressure existing in passages 32 and 54 when operating with the primary pump 10 brought under load when the valve 16 has been moved up.

When primary pump 10 is in operation it generates say 300 p. s. i. in passage 32 which holds the valve 16 up against the action of the spring 38.

When the primary pump is first brought into operation it generates say 50 p. s. i. due to the spring loaded check valve 29 and this is the pressure which starts the valve 16 moving up.

When the primary pump 10 fails the pressure in passages 32, 135 and 54 and the chamber to the right of diaphragm 86 falls instantly to 15 p. s. i. The reduced pressure force against diaphragm 86 allows spring 104 to push diaphragm 86 to the right and open switch 84.

In a similar manner, the chamber 122 containing the diaphragm 110 which operates the switch 90 communicates with the non-return valve 112 to the passage 114 which terminates in the low pressure passage 21. Valve 112 is a relief valve which tends to limit the maximum pressure which can exist in the chamber to the right of diaphragm 110.

Valve 106 is also a relief valve which tends to limit the maximum pressure which can exist in the chamber to the right of diaphragm 86 to protect the diaphragm 110 and 86 when the pressures in passages 33 and 54 rise to high values. In the position in which it is shown, however, pressure is admitted to the right of the diaphragm 110 through the passage 116 through the restriction 118 which connects with the passage 33 which, as shown, is at a comparatively high pressure due to the fact that the port 19 is closed.

The chamber above the piston 68 is connected through a passage 53 and through a restriction 51 with the passage 54 and so with the passage 32.

The high pressure port 55 of servomotor valve 42 can be put (a) in communication through check valve 56 with the pressure existing in passage 54; (b) in communication through check valve 58 with the pressure existing in passage 33 generated by secondary pump 12. (This position is the one shown in the illustration.)

Operation

Assume that the parts are in the positions shown and

the emergency pump 12 is in operation with the main switch 120 over to the right, that is, in its emergency position. The switch 90 is closed. The upper solenoid 74 is energized and therefore the valve 78 is electro-magnetically drawn to the left. The lamp 96 is then lit. The pressure in passage 32 is thus reduced to the low pressure prevailing in the fuel entrance 41 as it is then in free communication with passage 21.

The spring 69 pushes the servomotor valve 42 up into the position in which it is shown as the lower solenoid 70 is not now energized the primary switch leading to conductor 88 being open. The electric switch 84 is shown closed because the pump 10 is operated and is exerting sufficient pressure to open the check valve 29. That means there is sufficient pressure transmitted from the passage 32 to the passage 54 through the restriction 49 to the chamber to the right of the diaphragm 86 to close the switch 84. It is only when the pump 10 fails, as for example when the spline shaft 11 fails, that the switch 84 is opened by the spring 104 and is then moved into the open position.

Valve 42 has a central passage 44 which is always at the pressure of the low pressure in the fuel entrance 41. This upward motion of the valve 42 cuts off the communication of low pressure from passage 44 to the upper horizontal passage 43, which passage communicates with the vertical passage 45 which is a continuation of passage 116. This passage 45 communicates through a restriction 67 with the chamber 122 located on the right-hand side of the diaphragm 110, which diaphragm is flexible and is pushed to the left by the pressure generated by the pump 12 (which now that passage 43 is closed has a chance to exert itself) to close the spring-loaded switch 90 so that electrical current now flows through switch 120 and switch 90 and the solenoid 74 is now energized stationary pivots 91 and 93 support the movable elements of the electric switch 90. For similar reasons, pressure is now applied to the chamber 48 in which is located above the upper piston of the valve 16. This pressure is derived from the high pressure port 55 in the valve 42.

High pressure is always available at the port 55 in valve 42, either as in the position shown; from the emergency pump 12, past the check valve 58 and down the vertical passage 57 and across the horizontal passage 60 or alternatively past the check valve 56, up the passage 57 and across passage 60. In the position shown, the passage 46 thus derives its high pressure from this port 55. When the switch 120 moves $\frac{1}{2}$ way to the left it is held there by opposing springs not shown and the switch is in its "Neutral" position. The control however remains in "Emergency" by reason of high pressure from pump 12 transmitted through restriction 118 and passage 116 to the chamber to the right of the piston 78.

Assume that the emergency pump spline shaft 13 fails: High pressure is no longer available through passage 116 to the right of piston 78. Spring 80 pushes valve over to the right and pressure rises in passage 82 and pushes piston 68 down. Servomotor valve 42 then reverses the slave valve 16 very rapidly. The pressure in passage 54, which is derived from the pump 10 at, say, 35 p. s. i. above the pressure in passage 21, this pressure (35) depending on the spring loaded check valve 29, acts through the non-return valve 58. Instantly pressure is built up in and transmitted through the horizontal passage 66 to the port 55 and thence through passage 59 to chamber 50 where this pressure pushes valve 16 up to its upper position. It is to be noted that with the piston valve 68 down the passages 60 and 59 are in free communication with each other through the port 50.

As valve 16 moves up this motion is accelerated rapidly. The initial movement restricts annular passage 17 thus increasing the effect of the pressure generated by pump 10 in the chamber 32 through filter 135 to passages 54, 60, 55, 59 and 50. The upward motion of valve 16 ac-

5

celerates the rate at which the pressure in line 32 rises. Hence, as the passage 17 becomes more and more restricted the valve 16 as a result rises faster and faster. The switch-over to the live pump 10 from 12 (which pump is assumed to have gone dead) takes place in a split second.

When the turbine was first started, that is as soon as the primary pump 10 started to rotate the pressure from the primary pump 10 in passage 54 is admitted past the restriction 49 to the chamber located on the right-hand side of the diaphragm 86, which is thus moved to the left compressing the spring 104 and closing the switch 84 which permits energizing the solenoid 70 when switch 120 is thrown to the left. When 70 is energized the servomotor valve 42 is drawn down and held securely in its lower position. When the primary pump 10 is under load either from the fact that the valve 16 is in its upper position or because of the pressure from the valve 29 when the valve 16 is in its lower position, pressure for port 55 comes through check valve 56 to passage 60.

When the switch 120 is thrown counterclockwise (over to the left) the pump 10 becomes under load even when spline shaft 13 is O. K. because the upper solenoid 74 is de-energized and the spring 80 now can move the piston 78 to the right so that the passage 82 is no longer open to the low pressure in the fuel entrance 41, instead high pressure is admitted from the primary pump 10 past the restriction 51 and passage 53 from the passages 32 and 54, which passages communicate with the upstream side of the non-return valve 28 in the outlet from the primary pump 10.

When this servo valve 42 is in its lower position, the pressure in the chamber 48 is immediately lowered. The passage 44 communicates with the passage 46 through the upper port in the valve 42. Meanwhile the lower port in valve 42 no longer permits low pressure to exist in chamber 50, instead, the maximum available pressure is always present in the middle port 55 is now admitted to the chamber 50 through the passage 59. Valve 16 immediately rises under the influence of this pressure and the outer port 17 of the primary pump 10 is closed and the outlet port 19 of the emergency pump 12 is opened. Non-return valve 30 now closes and the pump 10 becomes under load and pump 12 becomes under no load. Assume the main switch 120 is moved to its neutral (mid) position from the primary. (NOTE.—There are two neutral positions. If the pilot goes from emergency to neutral the system remains in emergency, if as now the pilot goes from primary to neutral the system remains in primary.) If then the drive shaft 11 breaks or assume that pump 10 fails to generate sufficient pressure, immediately thereafter the pump 12 becomes loaded because of the following sequence of events:

The non-return valve 28 closes, the pressure above the piston 68 thereupon fails and the servomotor valve 42 is then raised by the spring 69 to the position in which it is shown. The pressure in chamber 50 below the valve 16 is lowered because the passage 59 now communicates through lower port of valve 42 with the central low pressure passage 44 of valve 42. The pressure generated by the emergency pump 12 is admitted past the port 55 to the passage 46 to chamber 48 and thus enters the chamber 48 where it assists the compression spring 38 in moving the valve 16 down into the position in which it is shown, against the shoulder 89. This position is the position in which the emergency escape port 19 is closed and the primary escape port 17 is open. Hence, should the primary pump 10 fail entirely or partially, the servomotor valve 42 acts and the slave valve 16 is moved down to cut out the primary pump and to establish the emergency pump as the source of fuel under pressure at the fuel outlet 15. This automatic feature can always be dominated as long as there

6

is no failure in the primary system by the electrical means, the two solenoids 70 and 74. These two solenoids in their turn can be selectively controlled by manual means.

Whenever the primary pump 10 fails switch 84 opens preventing the energizing of primary solenoid 70 even if pilot puts switch 120 over to the left into the primary position. As pointed out above actually the switch 84 would be shown closed as the pump 10 is shown operating as is the non return 29 which is shown open hence sufficient pressure would be generated by pump 10 to act on the diaphragm 86 to close the switch 84.

It will be observed that there is no check valve in the emergency escape passage 35 whereas in the primary escape passage 32 there is a check valve 29. The reason for the absence of such a check valve in passage 35 is the fact that the emergency pump 12 normally operates under no load all the time the primary pump 10 operates on full load, hence such a check valve would impose a continuous additional load on pump 12 and the intent is to keep this idle load on the emergency pump 12 as low as possible. Another reason for the check valve 29 in the primary pump outlet 32 is that when starting the gas turbine with switch 120 "off"—that is in its middle (neutral) position the pressure in the escape passage 32 transmitted through the restriction 51 to passage 53 will build up rapidly enough so as to push the piston 68 and thus the servomotor valve 42 down immediately so as to be sure to start promptly and automatically on the primary pump 10. The shorter the period of time taken to start the less drain on the turbine starting means.

One advantage of this dual fuel control is that the two solenoid operated servomotors valves 42 and 78 are positively held in their desired position by:

- (a) Hydraulic means
- (b) Electric magnetic means

and this interlocking alternative construction enables the pumps to continue to operate in the desired manner in the event of an electrical failure and also when the switch 120 is open in which cases the hydraulic pressure acts as a substitute for the electromagnetic force exerted by the solenoids.

What I claim is:

1. A dual fuel pump system for a prime mover having a primary pump, a secondary emergency pump, means by which both are constantly rotated by said prime mover, an outlet from the primary pump to said prime mover, a first non-return valve therein, a first escape passage leading from said outlet upstream of said first non-return valve, an outlet from the emergency pump leading to the prime mover a second non-return valve in said outlet a second escape passage from said emergency pump, a cylindrical chamber having two larger end diameters and a smaller intermediate portion leaving a shoulder in between the two ends, a first annular port at one end, a second annular port at the other end of said cylindrical chamber, a double-headed piston acting as a selector valve sliding in the cylinder and designed to close one port and to open the other two annular valve seats at the two changes in diameter of said cylinder located one on each side of said shoulder, two corresponding shoulders on said piston valve adapted to engage alternatively with the seats on said intermediate shoulder, the first escape passage terminating in said first annular port, the 2nd escape passage terminating in said 2nd annular port, a first spring means for biasing the double-headed valve so as to close the second annular port and means for reversing the motion of said piston selector valve including a servomotor valve controlling said piston valve, one high and a first and second low pressure ports in said servomotor valve, second spring means adapted to bias said servomotor valve into a position in which its first low pressure ports admits low pressure to that end of said cylinder towards which the

first spring means tends to move said slave valve, a moving wall connected to said servomotor valve, a pressure chamber associated therewith, a passage leading therefrom to the pressure in first escape passage generated by said primary pump so as to move said servomotor valve and said moving wall against said second spring so as to disconnect said first low pressure port from one end of said cylinder and to admit high pressure fluid to the first mentioned end of said cylinder to overcome the first spring means so as to move said piston valve to open the escape port from said secondary pump and to close the escape port from said primary pump.

2. A device as set forth in claim 1 in which there is an electromagnetic solenoid, a source of electrical energy, a pressure responsive electric switch closed by the pressure in said primary pump upstream of said first non-return valve and adapted when closed to permit the solenoid to be energized and to move and hold said servovalve in opposition to said spring means.

3. A device as set forth in claim 1 in which there is a low pressure passage communicating with the chamber adjacent said moving wall, an escape valve in said passage, third spring means for seating said escape valve, a second moving wall communicating on one side with the pressure generated by said secondary pump and with the low pressure on the other, said second moving wall thus moving under the influence of said secondary in opposition to said third spring means to open said low pressure passage to permit said servomotor valve to move under the influence of said 2nd spring.

4. A device as set forth in claim 1 in which there are means for positively locking out the primary pump comprising a low pressure passage communicating the chamber adjacent said moving wall, an escape valve in said passage, third spring means for seating said escape valve, a source of electricity, an electromagnetic solenoid connected so as to open said valve against said third spring means, a manually operated switch to make the solenoid active, a second moving wall communicating on one side with the pressure generated by said secondary pump and on the other side with the low pressure, said second moving wall thus being moved under the influence of pressure from said emergency pump and under the influence of said electromagnetic solenoid.

5. A dual fuel pump system for a prime mover having a primary pump, a secondary emergency pump, means by which both are constantly rotated by said prime mover, two escape passages one from each pump a check valve in the escape passage from the primary pump, a selector valve for alternatively closing the escape passage from one of the two pumps so as to make that one develop its full pressure and assume the load of supplying fuel under pressure to said prime mover, a servomotor valve for reversing said selector valve, spring means operatively associated with said servomotor valve to move the servomotor valve to cause the selector valve to move so as to put the load on the other pump by closing the escape port therefrom, means responsive to the pressure generated by the first mentioned pump to oppose said spring pressure so as to prevent the shift to the other pump until the first mentioned pump fails.

6. A device as set forth in claim 5 in which there is an electro solenoid a manually operated switch therefore said solenoid being located so as to attract said servomotor valve so as to reverse said selector valve.

7. A device as set forth in claim 5 in which there are two electric solenoids and a manually operated switch for both solenoids one of said solenoids being located so as to attract said servomotor valve so as to hold said selector valve in the position in which the escape port from the primary pump is closed, a second solenoid, a second servomotor valve, said second valve being located so as to be attracted by said second solenoid, said second servomotor valve being located and connected

so as to dominate said first servomotor valve so that the first servomotor valve is moved by second servomotor valve into a position where it moves the selector valve into the position in which the escape port from the second pump is closed and the secondary pump is thus made to assume the load.

8. A dual fuel pump system for a prime mover having a primary pump, a secondary emergency pump, means by which both are normally constantly rotated by said prime mover, two outlet passages leading to the prime mover one from each pump, a check valve in each passage, two escape passages one from each pump connected upstream of said check valves, a selector valve for alternatively closing the escape passage from one pump so that that pump automatically assumes the load and for simultaneously opening the escape passage from the other, a servomotor valve for reversing said selector valve, spring means to move said servovalve into the position in which the escape from the emergency pump is closed, an electric solenoid arranged to attract said servomotor valve to move said valve in the opposite direction against the action of said spring, electric switch in the circuit of said solenoid, spring means for opening said switch, means responsive to the pressure generated by said primary pump to close said switch against the spring load on said switch.

9. A device as set forth in claim 8 in which there is a spring loaded check valve in the escape passage from the primary pump and the pressure generated by the primary pump in opening this valve is the pressure which closes the spring loaded switch.

10. A dual fuel pump system for a prime mover having a primary pump, a secondary emergency pump, means by which both are normally constantly rotated by said prime mover, two outlet passages leading to the prime mover one from each pump, a check valve in each passage, two escape passages one from each pump connected upstream of said check valves, a selector valve for alternatively closing the escape passage from one pump so that that pump automatically assumes the load and for simultaneously opening the escape passage from the other, a servomotor valve for reversing said selector valve, hydraulic means responsive to the pressure generated by the primary pump to move the servomotor valve into and to hold it in that position in which the selector valve closes the escape passage from the primary pump so that the primary pump assumes the load.

11. A dual fuel pump system for a prime mover having a primary pump, a secondary emergency pump, means by which both are normally constantly rotated by said prime mover, two outlet passages leading to the prime mover one from each pump, a check valve in each passage, two escape passages one from each pump connected upstream of said check valve, a selector valve for alternatively closing the escape passage from one pump so that that pump automatically assumes the load and for simultaneously opening the escape passage from the other, a servomotor valve for reversing said selector valve, hydraulic means responsive to the pressure generated by the emergency pump to move the selector valve into and to hold it in that position in which the selector valve closes the escape passage from the emergency pump so that the emergency pump assumes the load.

12. A dual fuel pump system for a prime mover having a primary pump, a secondary emergency pump, means by which both are normally constantly rotated by said prime mover, two outlet passages leading to the prime mover one from each pump, a check valve in each passage, two escape passages one from each pump connected upstream of said check valve, a selector valve for alternatively closing the escape passage from one pump so that the pump automatically assumes the load and for simultaneously opening the escape passage from the other, a servomotor valve for reversing said selector valve, an electric solenoid, a manually operated switch which when in its

emergency position energizes said solenoid, a valve controlled by said solenoid acting as a pressure escape valve for said passage, means for applying the pressure generated by said primary pump to said passage, a piston connected to said servomotor valve, a cylinder for said piston connected to said passage so that upon failure of the primary pump or upon moving the manual switch to its emergency position the selector valve moves into and is held in the position in which the escape outlet from the emergency is closed.

13. A dual fuel pump system for a prime mover having a primary pump, a secondary emergency pump, means by which both are normally constantly rotated by said prime mover, two outlet passages leading to the prime mover one from each pump, a check valve in each passage, two escape passages one from each pump connected upstream of said check valves, a selector valve for alternatively closing the escape passage from one pump so that that pump automatically assumes the load and for simultaneously opening the escape passage for the other, a servomotor valve for reversing said selector valve, pressure means responsive to pressure generated by said emergency pump to hold said selector valve in its emergency position in which the escape outlet from the emergency pump is closed, means for moving said selector valve into its other position when the emergency pump fails to generate pressure comprising a piston connected to said servomotor valve, a cylinder for said piston, a passage conducting primary fuel pump pressure to move said piston and said servomotor valve into the position in which it reverses the selector valve, an escape outlet from said passage, a valve in said passage, a piston connected to said valve, a cylinder for said piston connected to said emergency pressure so as to hold said valve open so long as emergency pump is generating pressure.

14. A dual fuel pump system having a primary pump, a secondary emergency pump, means by which both are normally constantly rotated by said prime mover, two outlet passages leading to the prime mover one from each pump, a check valve in each passage, two escape passages one from each pump connected upstream of said check valves, a selector valve for alternatively closing the escape passage from one pump so that that pump automatically assumes the load and for simultaneously opening the escape passage from the other, a servomotor valve for reversing said selector valve, hydraulic means to move said servomotor valve in response to both maximum and mini-

mum pressures generated by either pump in order to reverse the selector valve comprising a first passage having two inwardly opening check valves one in each end, second and third passages connecting the two check valves one with each pump, ports in said servomotor valve, a fourth and fifth passage connected and controlled by said ports so as to alternatively conduct the pressure generated by either pump to move said selector valve so that when one pump fails the escape passage from the other is automatically closed and thus takes the load.

15. A liquid fuel feeding system comprising a primary and a secondary pump of substantially equal capacity and having similar characteristics, conduit means for connecting said two pumps in parallel for alternative use, an escape outlet from each pump, a single double-headed slave piston valve adapted in one position to close the escape outlet from the primary pump and in the other position to close the escape outlet from the secondary pump, a manually operated electrically controlled solenoid, a servovalve controlled thereby, said slave piston valve being controlled by said servovalve, pressure responsive means generated by said secondary pump to move the servovalve independently of the electrical means so as to make the primary pump operative even if the solenoid is not energized.

16. A liquid fuel feeding system comprising a primary and a secondary pump of substantially equal capacity and having similar characteristics, conduit means for connecting said two pumps in parallel for alternative use, an escape outlet from each pump, a single double-headed slave piston valve adapted in one position to close the escape outlet from the primary pump and in the other position to close the escape outlet from the secondary pump, a manually operated electrically controlled solenoid, a servovalve controlled thereby, said slave piston valve being controlled by said servovalve, pressure responsive means generated by said primary pump to move the servovalve independently of the electrical means so as to make the secondary pump operative even if the solenoid is not energized.

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