

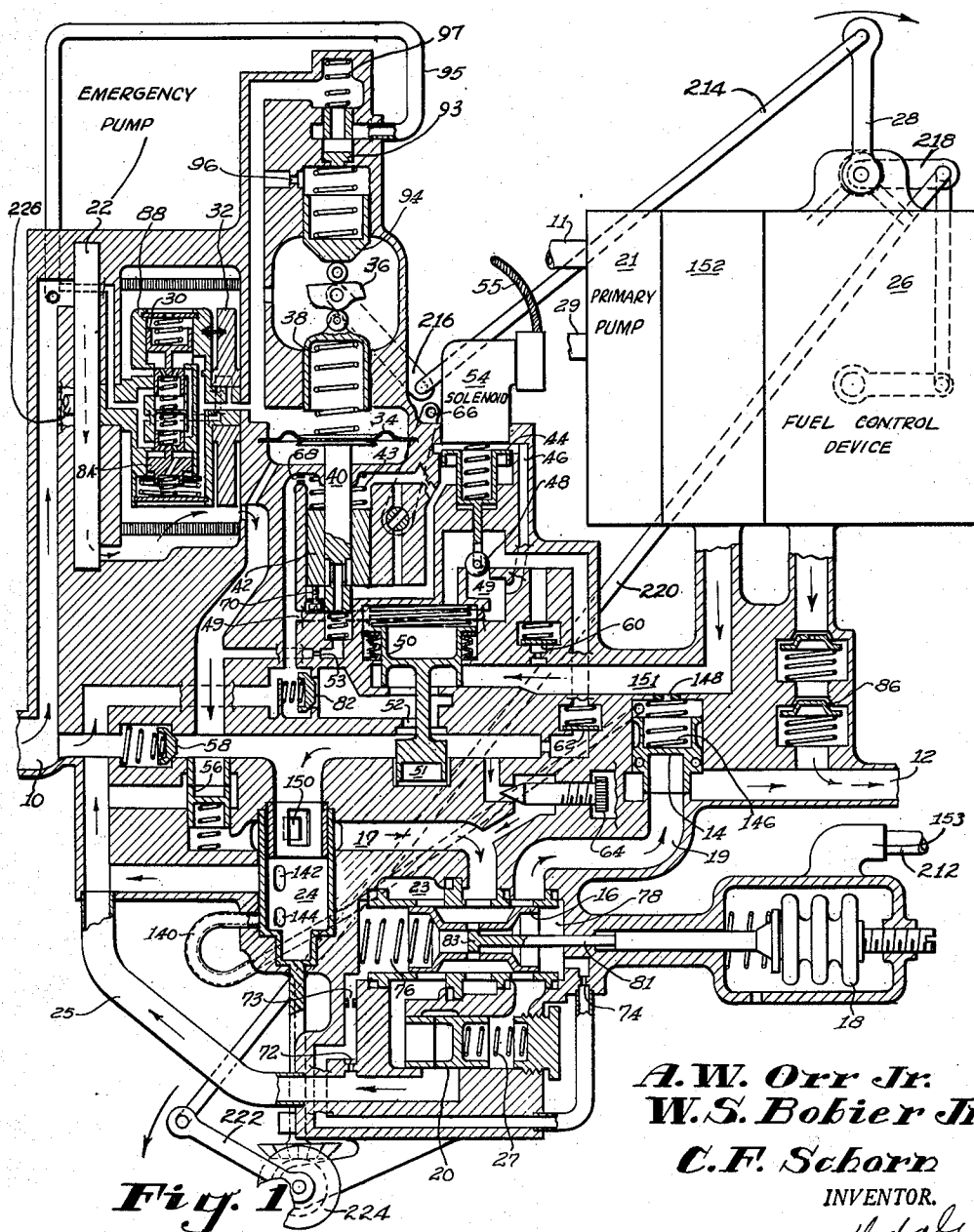
March 31, 1953

C. F. SCHORN ET AL
EMERGENCY FUEL SUPPLY

2,633,188

Filed April 20, 1948

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

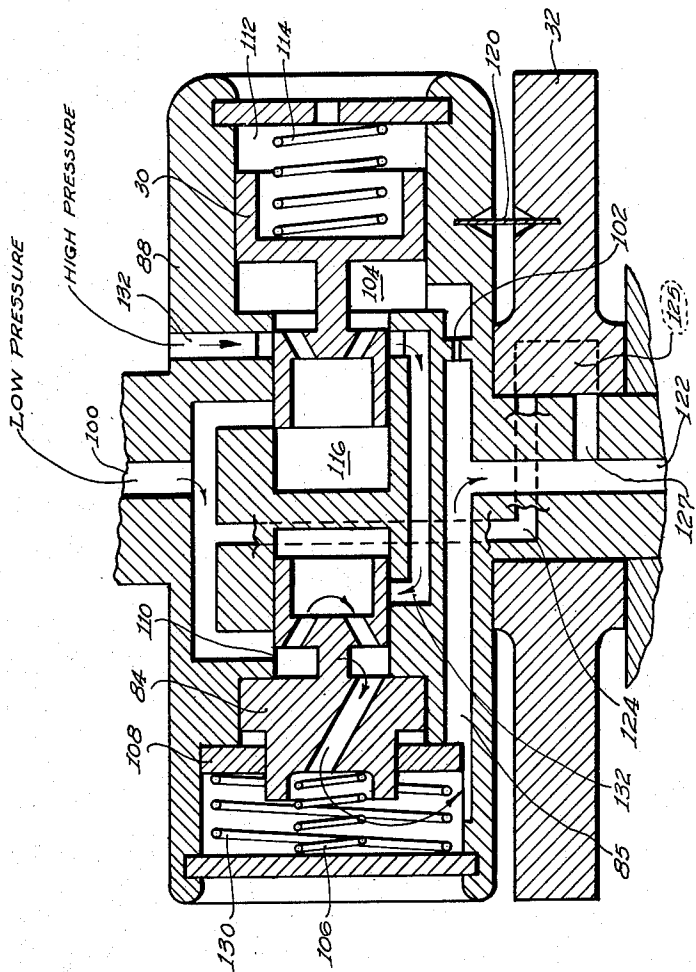


Fig. 2

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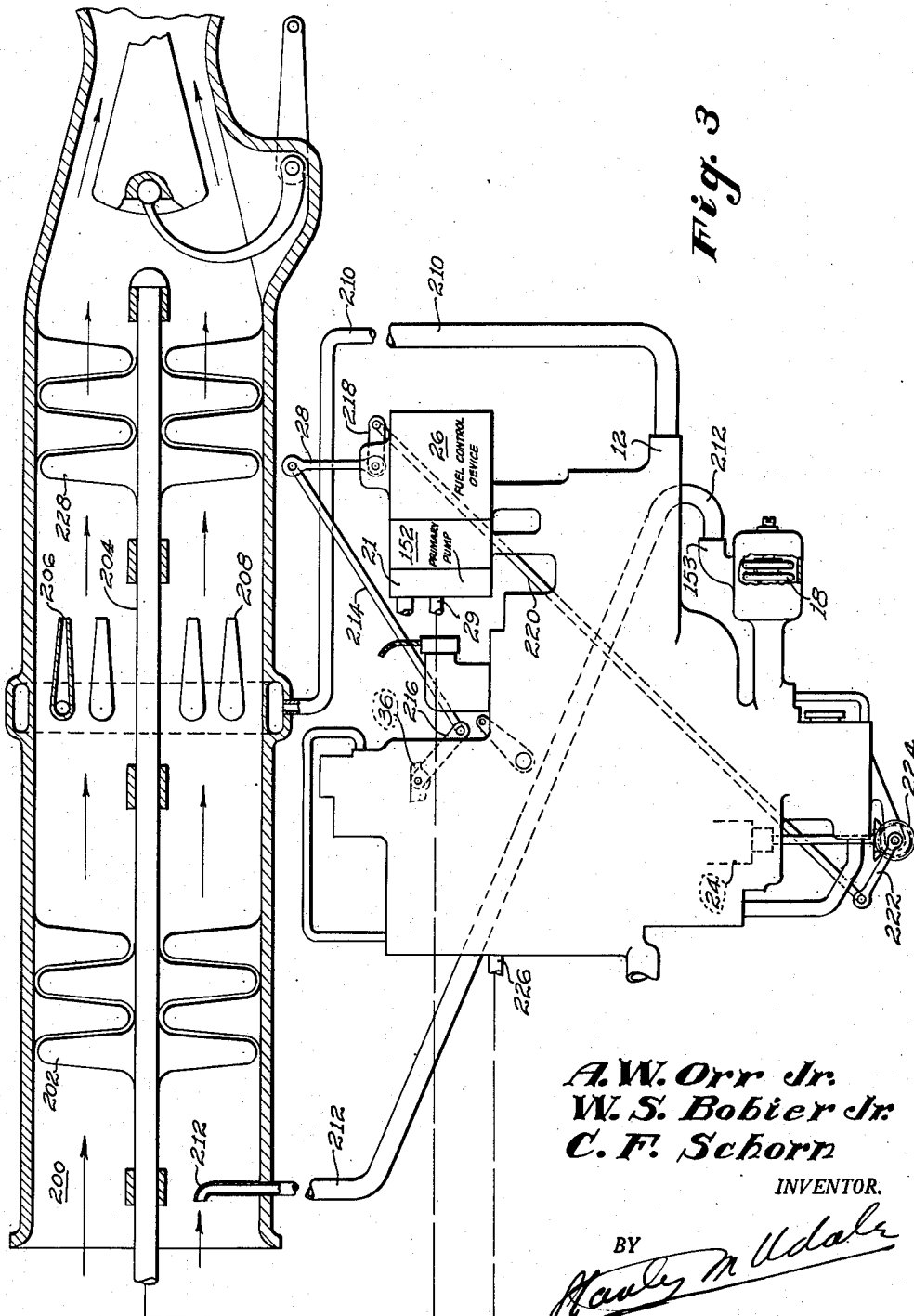
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2,633,188

EMERGENCY FUEL SUPPLY

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22 Claims. (Cl. 158—36.4)

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The object of this invention is to provide a speed responsive device to call on an emergency control to take control should the normal control fail.

Fig. 1 shows the preferred form of our invention.

Fig. 2 shows an enlargement of the centrifugal governor detail shown in Fig. 1.

Fig. 3 shows the application of the control to a gas turbine of the type in general use.

In Fig. 1 10 is the fuel entrance for the emergency fuel. 11 is the fuel entrance for the primary pump 21 and the normal fuel control device contained in chamber 26, both driven by the shaft 29. 12 is the common exit from both the normal and emergency fuel supply systems and leads to the gas turbine 228, (Fig. 3).

14 is the shut off valve which when closed, as shown, seals off the emergency control system from the normal control contained in casing 26.

16 is the flow divider valve for the emergency system controlled by the servomotor valve 83 which in turn is controlled by the barometric element 18. 18 is a barometric element subjected through pipe 212 and elbow 153 with the pressure existing in the inlet 200 to the air compressor 202 of the gas turbine unit that is usually almost the same as the atmospheric pressure. This element responds to altitude, and, if partially gas filled, to temperature and thus controls the position of the valve 16 as the density of the air falls. 20 is a balanced valve controlling the return of fuel from the flow divider valve 16, to the fuel entrance 10 through the pipe 25. 27 is a light spring engaging with the valve 20.

22 is the emergency pump, the control of which is the subject of this invention.

88 is the governor housing containing two hydraulic valves 30 and 84 responding to centrifugal forces. (This detail is shown in more detail in Fig. 2). The function of this governor is to recognize the existence of an emergency and to thereupon bring the emergency pump 22 into action and to take over the control of the fuel from the turbine from the primary pump 21 and the normal fuel control 26.

32 is the acceleration element consisting of an elastically driven fly wheel adapted to prevent a false indication of an emergency misleading the control. (See Fig. 2),

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34 is a diaphragm which is acted upon by four forces:

- (a) Emergency pump 22 pressure acting below the diaphragm 34.
- (b) A lower pressure, that is, lower than the emergency pump pressure by an amount which responds to speed, acting above the diaphragm 34.
- (c) The pressure due to spring 38 acting on diaphragm 34.
- (d) The pressure due to position of cam 36 acting on spring 38.

Hence, the manual adjustment of the cam 36 selects the speed at which the diaphragm will locate itself in a neutral position. Cam 36 is thus a speed selecting means under manual control from the lever 28 which lever controls the speed when the normal fuel control device 26 is in operation and also when the emergency fuel is in action.

36 is the cam manually controlled and linked with the emergency manual valve 24 and throttle control 28 of the normal fuel control system 26.

For every position of lever 28 the normal system 26 should give a definite number of revolutions per minute of the turbine. For every position of cam 36 a predetermined load is placed on diaphragm 34 to bring spring 38 to balance the pressure differential thus created by hydraulic valves 84 and 30. Therefore, valve 40 at all speeds remains normally in a fixed position. Should normal control 26 fail partially, say 10% below scheduled speed, then the hydraulic valves 30 and 80 will automatically provide a hydraulic pressure above diaphragm 34 which is more than that required to balance pump 22 pressure minus spring 38. Valve 40 then moves down and valve 48 moves up and opens passage 49 for the following reasons:

Pressure from emergency pump 22 is admitted through restriction 53 and valve 40 to space below the annular piston 42. Piston 42 then moves up into a "lock-out" position and stays up. Fuel under pressure from emergency pump 22 is then admitted to the underside of piston 44. Passage 46 communicates with the top of piston 44 to the low pressure of the inlet 10 through the low pressure passage 49. Piston 44 then moves up and unseats valve 48 and allows pressure to escape

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from above valve 50 to inlet through passage 49. The restrictions associated with the check valves 60 and 62 are ineffective when valve 48 is open because of the unrestricted area of the valve seat under valve 48. This reduces the pressure above selector valve 50 which selects emergency system in preference to the normal control system contained in box 26. When selector valve 50 moves up it shuts off passage 52 and emergency fuel is now directed through the manual valve 24, through flow divider 16—80—20 (which is described below) to the fuel outlet 12 and so to turbine. The valve 24 is manually operated by gear wheel 224, lever 222, link 220, lever 218, link 24 and lever 216 which lever controls the cam 36.

Valve 48 may also be manually operated through manually controlled solenoid 54 so that the emergency pump 22 can be made operative at will (in place of the primary pump 21 and fuel control device 26) at any time through a switch, not shown, connected to electrical cord 55.

When selector valve 50 moves up any fuel being pumped by primary pump 21 and by normal control 26 is bypassed back to inlet (the upper part of valve 50 accomplishes this), through passage 151, past the valve 82 which is a check valve set at 20 p. s. i.

Valve 56 is a constant pressure valve which controls the maximum flow through manual valve 24 regulating the maximum drop.

Valve 58 is a pressure relief valve which limits the maximum internal pressure to 600 p. s. i.

A clearance around the piston 51, at the bottom of valve 50, ensures pump delivery pressure from emergency 22 and is available to hold valve 50 up when the pressure above valve 50 is low, that is, when valve 48 is open.

When normal control 26 functions valve 50 is held down by high pressure admitted past check valve 60. Another check valve 62 admits pressure from emergency pump 22 around the valve 50 and so to the upper side of valve 50 to ensure that during the starting cycle or after manual operation of solenoid 54 sufficient pressure is available above valve 50 to overcome pressure on the bottom side of valve 50 and to hold valve 50 in the normal position in which it is shown when the port 52 is open. During normal operation the fuel pumped by emergency pump 22 flows through port 52, back through the valve 82 to fuel entrance 10. Needle valve 64 is in parallel with valve 24 and provides a minimum flow for minimum low speed operation.

After a failure, reset valve lever 66 may be manually moved anticlockwise to the override position, that is, into the open position. This balances the pressure on each side of free annular piston 42 allowing piston 42 to move down under influence of spring 43. Restriction 68 makes this operation function.

If a false failure was indicated this reset permits operation to return to normal control 26 operation. Annular piston 42 prevents hunting between emergency control and normal control (cycling).

Set screw 70 is an adjustable stop for piston 42 and is needed to determine the percent of failure of primary system 26 before the emergency system automatically takes over. Hence, stop 70 serves as the sensitivity control.

In the flow divider passages are restrictions 72, 73 and 74 which control the pressures in chambers 76 and 78, to the left and right of flow divider valve 16. Servomotor valve 83 responds to

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the expansion of the barometric element 18 but a slight unbalance is provided.

The amount of unbalanced load is determined by the diameter of shaft 81 and this gives a false barometric pressure amounting to a few inches of Hg in addition to the true barometric pressure acting on bellows 18.

The check valve 82 is seated by a spring stiff enough to assure enough pressure discharge from emergency pump 22 to make the hydraulic governor system 30—84—88 operative.

Speed governor (Fig. 2)

This consists of two weighted valves, hydraulic valve 30 to the right of Fig. 2 and hydraulic valve 84 to the left of Fig. 2. Hydraulic valve 30 provides a series of pressures responsive to the R. P. M. of the turbine. Hydraulic valve 84 also contributes the safety feature to the emergency system so as to prevent excessive speeds and prevents false indication of failure during the starting period.

Low pressure is admitted to passage 100 at the start, (zero speed). Chamber 104 is wide open to admit pressure the moment pressure is generated by the operation of the pump 22. The rotating mechanism is surrounded by high pressure fuel from pump 22.

Valve 84, in the position shown, admits low pressure fuel to the upper side of the diaphragm 34 through the valve 84, passage 85, and passage 122, when starting the turbine.

A restriction 102 prevents any higher pressure existing in the chamber 104 from interfering with the low pressure existing in the entrance 100. A light spring 106 engages with valve 84 and immediately yields so that at about 1500 revolutions per minute (normal engine starting speed) the valve 84 travels a short distance to the left and engages with the washer 108 and is stopped by this washer. This is the position shown in Fig. 1. The governing mechanism is driven at a reduced speed ratio, about $3\frac{1}{2}$ to 1. Hence, 1500 R. P. M. corresponds to about 400 R. P. M. of the governing mechanism.

At the moment of this engagement, communication is cut off from entrance 100 with port 110. At all higher speeds the diaphragm 34 responds to the pressure in chamber 104 acting above the diaphragm 34 and to the higher pressure of pump 22 acting below the diaphragm 34.

Spring 114 is a stabilizing spring and has practically no influence. When the centrifugal valve 30 goes to the right, low pressure fuel from entrance 100 enters the two connected chambers 116 and 104 and lowers the pressure above diaphragm 34. Equilibrium at each speed is established when the high pressure acting on the right side of the weight of the hydraulic valve 30 equals centrifugal force acting on the weight of the hydraulic valve 30 plus pressure in chambers 116 and 104 acting on the left side of weight 30. (See copending application of W. S. Bobier, Jr., Serial No. 783,071, filed October 30, 1947.) Restriction 102 is now inoperative. The space surrounding the governor 88—84 is at the pressure in the outlet from the pump 22.

Acceleration

During acceleration restriction 102 again becomes operative. Flywheel 32 is permitted to move relative to main body 88 due to the bending of an elastic element 120 made of flexible music wire or of thin steel drill rod.

Passage 122 is thus placed in communication

with the low pressure in the entrance 100 through the passage 124. A slot 125 in the hub of the loose flywheel 32 makes this possible by lining up with radial passage 127. During acceleration this prevents false failures being indicated and prevents bringing in the emergency pump 22 until there is a real need for it.

Washer 108 is loaded by stiff spring 130 so that valve 84 is held fixed at all normal speeds. At an abnormal speed, for example 14,000 R. P. M., valve 84 overcomes spring 130 due to centrifugal force and port 132 opens. Port 132 admits high pressure fuel direct to the upper side of diaphragm 34 along passage 85 and the emergency system is called into action immediately. This is purely a safety feature. (Fig. 1.)

When lever 28 is manually rotated clockwise to call for more speed the cam 36 rotates counter-clockwise. Momentarily the valve 93 moves up under the influence of the restriction 96. The pressure generated by the piston 94 lifts piston valve 93 and compresses compression spring 97. High pressure above the diaphragm 34 is thus momentarily reduced by the pipe 95. When the cam 36 ceases to move valve 93 is restored to the position shown and the pressure above the diaphragm 34 once more is able to respond to speed. This prevents valve 40 from interfering with the operation of the normal control device 26 during acceleration. This device operates in conjunction with the rotating weight 32 already described.

Action of emergency system. (Fig. 1)

At the closed throttle position of manually controlled valve 24 high pressure fuel is admitted to flow through passage 140 from port 144 to restriction 148 above the shut off valve 14 in order to balance pressure below valve 14. Spring 146 thereupon closes the valve 14.

When this throttle 24 is in its closed position port 142, in throttle 24, by-passes fuel to the low pressure side of the emergency system to prevent any dangerous internal pressures.

In the closed position of valve 24 upper port 150 (normally open) closes as ports 144 and 142 open.

Check valve 86 (shown below the normal control 26) is lightly loaded by a spring to prevent the loss of emergency fuel back through the primary system 26 when this normal system is not acting to control the fuel supply system. When this happens fuel from 26 flows along passage 151.

Flow divider 16—18—83 (Fig. 1)

At any given pressure in the entrance to the air compressor (connected through 152) and at any altitude the bellows 18 assumes a certain position. The pressure of fuel acting on the small shaft 81 has an influence on the position of the servomotor valve 83 equal to a few inches Hg. The servomotor valve 83 determines the position of the flow divider valve 16. Fuel arrives at this fuel divider valve 16 through manually controlled valve 24 and passage 17 and leaves through passage 19 and also through passage 23. At higher altitudes more and more escapes back through passage 23, past the balanced valve 20, through the passage 25 and so to the low pressure side 10 of the system. The right hand side of valve 20 is loaded lightly by a spring 27.

The servomotor valve 83 places the right hand or left hand side of valve 16 in communication with the fuel entrance 17.

The chambers 76 and 78, through restrictions

72 and 74 and 73 communicate with the low pressure system through the return pipe 25. Whenever valve 83 moves to the left valve 16 is sure to follow as pressure on the right hand side of valve 16, in chamber 78, increases and pressure in chamber 76, to the left of valve 16, decreases.

Primary bypass

During the abnormal operation with control 26 in action excess fuel from primary system 26 is returned to the low pressure fuel entrance 10 along the passage 151 from the filter casing 152, past the valve 50 (which is now raised up and is open), past the check valve 82 and so to the emergency fuel entrance 10.

In Fig. 3, 200 is the air entrance. 202 is the air compressor driven by a shaft 204. 206 and 208 are fuel burners fed by pipe 210 connected to the fuel outlet 12 (Fig. 1). 228 is the gas turbine mounted on shaft 204 driven by the burners 206 and 208. 212 is the air entrance pipe leading to the air entrance 153 of the chamber surrounding the barometric element 18.

The control lever 28 is connected through link 214 with a lever 216 which moves the cam 36. Arm 218 is connected to lever 28 and to link 220. Link 220 is connected to lever 222 which operates bevel gear 224 which gear rotates the valve 24 (Fig. 1).

The rotating wheel 88 is driven by shaft 226 which in its turn is driven by the shaft 204 of the gas turbine 228. The shaft 29 of the primary pump 21 and primary control 26 is also driven by the shaft 204 of the gas turbine 228.

Although the system illustrated shows a combined failure recognizing system and simple emergency fuel metering system it is quite obvious that the failure recognizing system could be divorced from the fuel metering system and used with any two fuel metering systems.

Operation—General

Most of the operation has been fully discussed in the description and need not be repeated. Attention, however, is called to the fact that whenever the manually operated valve 66 is opened to make the servomotor valve 40 function after switching from the normal to the emergency control the valve 66 should be immediately reclosed to avoid undesirable "hunting." Attention is also called to the fact that when the solenoid 54 is operated manually the normal control 26 is positively put out of action and the emergency system is then relied upon 100%.

When cam 36 is rotated too rapidly anticlockwise the piston 94 and inertia flywheel 32 jointly give the turbine's normal control 26 a chance to "find itself" before calling on the emergency system to take over.

If the plane in which the turbine is installed is dived and the turbine thus accelerates with a fixed fuel throttle position the flywheel 32 acts alone to prevent an unnecessary and undesired transfer from the normal to the emergency system.

If the emergency pump 22 should ever fail (partially or wholly) and the speed sensitive mechanism (governor) 30—34—32, etc. should continue to function then the stiffness of the spring 43 should be great enough so that the sleeve 42 is held down and the device is prevented from transferring from the normal control system 26.

The normal control device 26 obtains fuel from pipe 11 and is driven by a shaft 29. 26 contains

a speed responsive fuel device controlled by lever 28 which automatically restricts fuel flow at the speed corresponding to positions of lever 28 which device is similar to that shown in the copending application of Wilfred S. Bobier, Jr., Serial #783,071, filed October 30, 1947.

What we claim is:

1. An emergency fluid fuel control system for a gas-turbine-air-compressor power plant having an air entrance to said compressor, a fuel supply having two branches comprising, a first branch including a normal fuel supply, a normal control for the fuel supply, means forming a passage adapted to lead to the turbine, means forming a first escape passage, and a second branch comprising, an emergency source of fluid fuel, an emergency fuel pump connected thereto having means forming an outlet and a second escape passage and adapted to be driven by said turbine, a variable pressure valving device connected to said emergency fuel source and also adapted to be driven by said turbine, said emergency fuel pump together with said variable pressure valving device adapted to generate a specific pressure at each turbine speed below that of the pressure of the emergency pump by an amount that is constant for each speed, a chamber, a moving wall in said chamber dividing the chamber into two parts, means forming a first passage connecting one part to the said pressure which is below that of the pressure of the emergency pump, means forming a second passage connecting the other part to the high pressure generated by the emergency fuel pump, a servomotor valve connected to said moving wall, a spring engaging with said wall, a manually operated linkage connected to said normal fuel control device, a speed selecting cam also operated by said linkage and engaging with said spring, a fuel selector valve controlled by said servomotor valve, said valve being adapted when in its normal position to block the first mentioned escape fuel passes from said normal fuel control device and in its abnormal position to block the second mentioned escape passage from the emergency fuel pump so as to force the emergency fuel pump to supply the turbine during the emergency when the normal fuel control means fails to maintain the speed selected by the manually operated cam.

2. A device as set forth in claim 1 in which there are pump means interconnected with the manual control responsive to the rapid movement thereof adapted for momentarily generating a pressure, a valve responsive to said pressure which renders the servomotor valve temporarily inoperative to control the fuel control valve by reducing the effective pressure acting on the low pressure side of said moving wall by admitting thereto fluid at the pressure in the fuel entrance to the emergency fuel pump.

3. A device as set forth in claim 1 in which there is a turbine driven acceleration device comprising a rotating mass, a valve controlled by said mass and located in said first passage, yieldable means connecting said rotating mass to the driving means, said valve being adapted to open momentarily during acceleration so as to equalize the pressure on the low pressure side of said moving wall and the fuel entrance to said emergency pump.

4. A device as set forth in claim 1 in which there is a shut off valve in the outlet passage from the emergency fuel pump leading to the

turbine, said valve having automatic opening and closing means consisting of a moving wall subjected to the pressure of the normal fuel supply on one side adapted to close the valve and on the other side to the pressure of the emergency fuel supply which pressure is adapted to open the valve to permit the emergency fuel to reach the turbine.

5. A device as set forth in claim 1 in which there is a manually operated fuel throttle in the fuel passage from the emergency fuel pump located downstream therefrom and controlled by the mechanism controlling the speed selector cam and the normal fuel control mechanism.

6. A device as set forth in claim 1 in which there is a manually operated fuel throttle in the fuel passage from the emergency pump located downstream therefrom and mechanically controlled by the mechanism controlling the speed selector cam and the normal fuel control mechanism, in which there is a balanced valve located upstream of said manually operated fuel throttle subjected on its opening side to the pressure upstream of the fuel throttle and on the other side to the pressure downstream of the fuel throttle plus the pressure of a spring and a flow divider valve located downstream of said manually operated fuel throttle consisting of a first fuel outlet passage connected with the fuel entrance, a first valve therein, a second outlet passage connected with the turbine, a second valve therein rigidly connected to the first so that one opens as the other closes, barometric means responsive to the pressure in the air entrance to said compressor and adapted to open the first valve and to close the second valve as the atmospheric pressure falls with increasing altitude.

7. A device as set forth in claim 6 in which there is a third valve in said flow divider consisting of a balanced valve located downstream of said first valve and subjected on one side to the pressure downstream of said second valve and on the other to the pressure downstream of the first valve so that the pressures downstream of the first and second valves are maintained substantially equal to each other.

8. An emergency fluid fuel control system for a gas-turbine-air-compressor power plant having an air entrance to said compressor, a normal fuel supply, a normal control for the fuel supply, means forming a passage adapted to lead to the turbine, means forming an escape passage, an emergency source of fluid fuel, an emergency fuel pump connected thereto having means forming outlet and escape passages and adapted to be driven by said turbine, a variable pressure valving device adapted to be driven by said turbine which together with said emergency fuel pump is adapted to generate an operating pressure that is a function of the square of the revolutions per minute of the turbine, a chamber, a moving wall in said chamber dividing the chamber into two parts, means forming a first passage connecting one part to the said variable pressure which varies as a function of the square of the revolution per minute of the turbine, means forming a second passage connecting the other part to a substantially constant pressure, a servomotor valve connected to said moving wall, a spring engaging with said wall, a manually operated linkage connected to said normal fuel control device, a speed selecting cam also operated by said linkage and engaging with said spring, a fuel selector valve controlled by

said servomotor valve, said valve being adapted when in its normal position to block the means forming the first mentioned escape fuel passage from said normal fuel control device and in its abnormal position to block the means forming the second mentioned escape passage from the emergency fuel pump so as to force the emergency fuel pump to supply the turbine during the emergency when the normal fuel control means fails to maintain the speed selected by the manually operated cam.

9. A device as set forth in claim 8 in which there are pump means interconnected with the manual control responsive to the rapid movement thereof for momentarily generating a pressure, a valve responsive to said pressure which renders the servomotor valve temporarily inoperative to control the fuel control valve by neutralizing the said operating fluid pressure by admitting thereto through the said pressure responsive valve fluid at a substantially constant pressure.

10. A device as set forth in claim 8 in which there is a turbine driven acceleration device comprising a rotating mass, a valve controlled by said mass and located in said first passage, yieldable means connecting said rotating mass to the driving means, said valve being adapted to open momentarily during acceleration so as to neutralize the said operating fluid pressure by admitting thereto through said acceleration responsive valve fluid at a substantially constant pressure.

11. A device as set forth in claim 8 in which there is a shut off valve in the outlet passage from the emergency fuel pump leading to the turbine, said valve having automatic opening and closing means consisting of a moving wall subjected to the pressure of the normal fuel supply on one side adapted to close the valve and on the other side to the pressure of the emergency fuel supply which pressure is adapted to open the valve to permit the emergency fuel to reach the turbine.

12. A device as set forth in claim 8 in which there is a manually operated fuel throttle in the fuel passage from the emergency fuel pump located downstream therefrom and controlled by the mechanism controlling the speed selector cam and the normal fuel control mechanism.

13. A device as set forth in claim 8 in which there is a manually operated fuel throttle in the fuel passage from the emergency pump located downstream therefrom and mechanically controlled by the mechanism controlling the speed selector cam and the normal fuel control mechanism, in which there is a balanced valve located upstream of said manually operated fuel throttle subjected on its opening side to the pressure upstream of the fuel throttle and on the other side to the pressure downstream of the fuel throttle plus the pressure of a spring and a flow divider valve located downstream of said manually operated fuel throttle consisting of a first fuel outlet passage connected with the fuel entrance, a first valve therein, a second outlet passage connected with the turbine, a second valve therein rigidly connected to the first so that one opens as the other closes, barometric means responsive to the pressure in the air entrance to said compressor and adapted to open the first valve and to close the second valve as the atmospheric pressure falls with increasing altitude.

14. A device as set forth in claim 13 in which there is a third valve in said flow divider consisting of a balanced valve located downstream of

said first valve and subjected on one side to the pressure downstream of said second valve and on the other to the pressure downstream of the first valve so that the pressures downstream of the first and second valves are maintained substantially equal to each other.

15. A device as set forth in claim 1 in which the servomotor valve consists of a ported shaft reciprocating in a cylinder, a sleeve surrounding said shaft and making a slidable fit with said cylinder and with said shaft and arranged to close the port in said shaft when in its normal position and when the turbine is operating normally, a stop engaging with one face of said sleeve to determine its normal position, a spring engaging with said sleeve to hold it against said stop, a source of operating fluid under pressure admitted through said port to that face of said sleeve when engaged with said stop whenever said servomotor valve is displaced by said moving wall in response to the action of the said speed-pressure generator when the speed of the turbine fails to attain the desired speed selected by said cam, said spring being adapted to yield suddenly under the pressure of the fluid admitted through said port so as to maintain said port wide open regardless of the subsequent success of the turbine in reaching the desired speed selected by said cam.

16. A device as set forth in claim 8 in which the servomotor valve consists of a ported shaft reciprocating in a cylinder, a sleeve surrounding said shaft and making a slidable fit with said cylinder and with said shaft and arranged to close the port in said shaft when in its normal position and when the turbine is operating normally, a stop engaging with one face of said sleeve to determine its normal position, a spring engaging with said sleeve to hold it against said stop, a source of operating fluid under pressure admitted through said port to that face of said sleeve when engaged with said stop whenever said servomotor valve is displaced by said moving wall in response to the action of the said speed-pressure generator when the speed of the turbine fails to attain the desired speed selected by said cam, said spring being adapted to yield suddenly under the pressure of the fluid admitted through said port so as to maintain said port wide open regardless of the subsequent success of the turbine in reaching the desired speed selected by said cam.

17. A device as set forth in claim 15 in which there is a bypass associated with said cylinder connecting both ends thereof so that when said bypass is opened the sleeve is moved in response to said spring, a manually operated valve in said bypass to open and close said bypass so that when the valve is opened and closed the sleeve is restored to its original position and the servomotor valve is brought back into action.

18. A device as set forth in claim 16 in which there is a bypass associated with said cylinder connecting both ends thereof so that when said bypass is opened the sleeve is moved in response to said spring, a manually operated valve in said bypass to open and close said bypass so that when the valve is opened and closed the sleeve is restored to its original position and the servomotor valve is brought back into action.

19. A device as set forth in claim 15 in which there is a second valve operatively interposed between the servomotor valve and the selector valve which is controlled by said servomotor

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valve, a second moving wall connected to said second valve and in which the selector valve includes an operating third moving wall, a spring engaging with said selector valve so as to move it into its normal position to block the escape of the normal fuel supply and to open the escape passage for the fuel from the emergency fuel pump, a passage connecting one side of said third moving wall to the low pressure side of said emergency fuel pump, said second valve being located in said passage, said second moving wall being moved in response to the admission of emergency fuel pressure admitted by said servomotor valve when displaced by said first moving wall, manual means for opening said second valve so as to positively call on the emergency fuel pump and to render the normal fuel supply means inoperative regardless of whether the normal fuel supply is functioning correctly.

20. A device as set forth in claim 16 in which there is a second valve operatively interposed between the servomotor valve and the selector valve which is controlled by said servomotor valve, a second moving wall connected to said second valve and in which the selector valve includes an operating third moving wall, a spring engaging with said selector valve so as to move it into its normal position to block the escape of the normal fuel supply and to open the escape passage for the fuel from the emergency fuel pump, a passage connecting one side of said third moving wall to the low pressure side of said emergency fuel pump, said second valve being located in said passage, said second moving wall being moved in response to the admission of emergency fuel pressure admitted by said servomotor valve when displaced by said first moving wall, manual means for opening said second valve so as to positively call on the emergency fuel pump and to render the normal fuel supply means inoperative regardless of whether the normal fuel supply is functioning correctly.

21. A device as set forth in claim 1 in which there is also a minimum and maximum speed responsive device driven by said power plant com-

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prising a passage connecting the low pressure fluid to the speed responsive pressure side of said moving wall, a rotating valve in said passage responsive to centrifugal force and rotated by said power plant, power yieldable means engaging with said valve to oppose said centrifugal force so as to permit the passage to be open at the lowest possible speeds to close the passage in response to centrifugal force at all operating speeds and to again open the passage in response to centrifugal force at a predetermined maximum speed so as to neutralize the action of the speed responsive low pressure fluid on said moving wall.

22. A device as set forth in claim 8 in which there is also a minimum and maximum speed responsive device driven by said power plant comprising a passage connecting the speed responsive pressure side of said moving wall to a source of constant pressure, a rotating valve in said passage responsive to centrifugal force and rotated by said power plant, yieldable means engaging with said valve to oppose said centrifugal force so as to permit the passage to be open at the lowest possible speeds, and to close the passage in response to centrifugal force at all operating speeds and to again open the passage in response to centrifugal force at a predetermined maximum speed so as to neutralize the action of the speed responsive pressure on said moving wall.

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WILFRED S. BOBIER, JR.

ANDREW WILLIAM ORR, JR.

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