March 9, 1954 J. E. BEVINS 2,671,860

LOAD SENSITIVE FUEL GOVERNOR FOR GAS TURBINES

Filed June 26, 1947 2 Sheets-Sheet 1

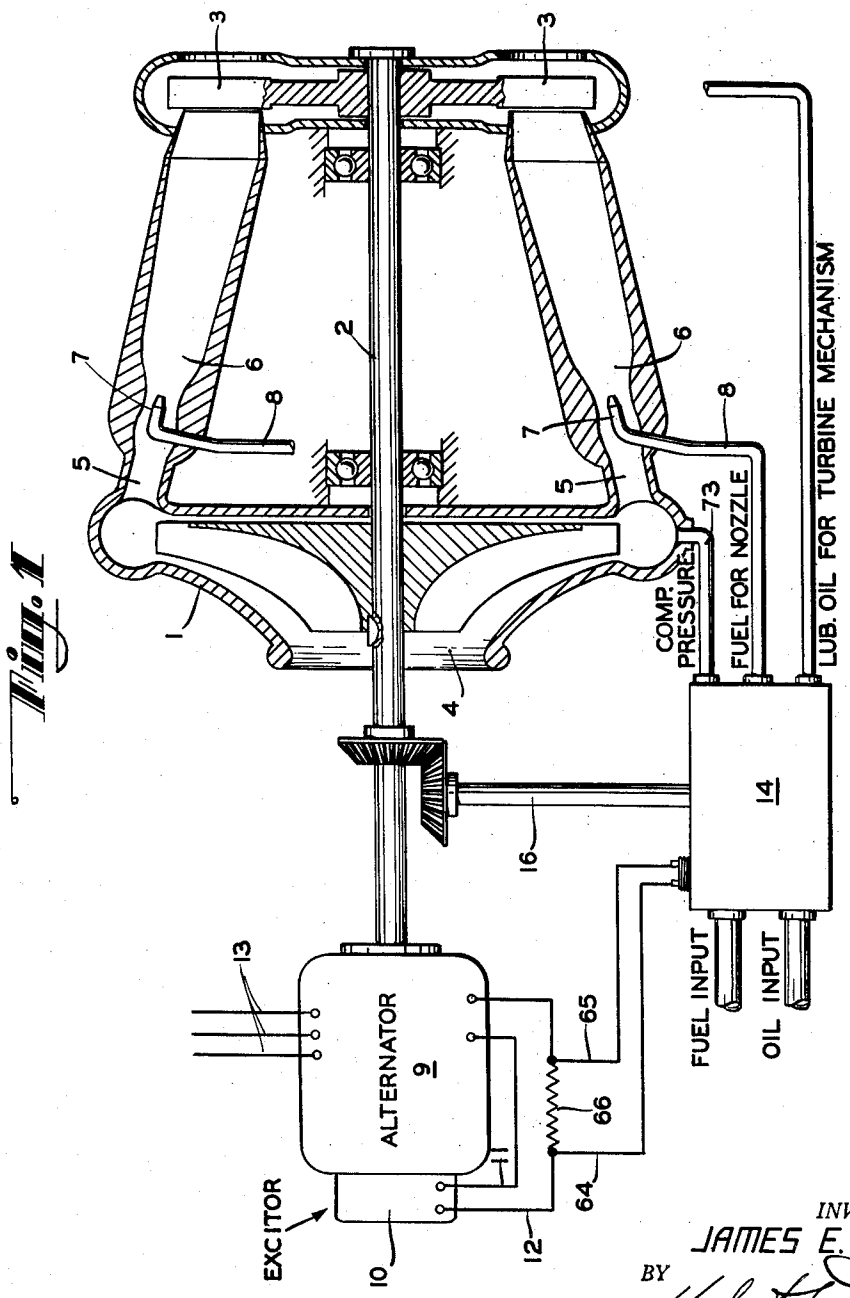


Fig. 1

INVENTOR.
JAMES E. BEVINS
BY Herbert Landau Jr.
- ATTORNEY -

March 9, 1954 J. E. BEVINS 2,671,860

LOAD SENSITIVE FUEL GOVERNOR FOR GAS TURBINES

Filed June 26, 1947 2 Sheets-Sheet 2

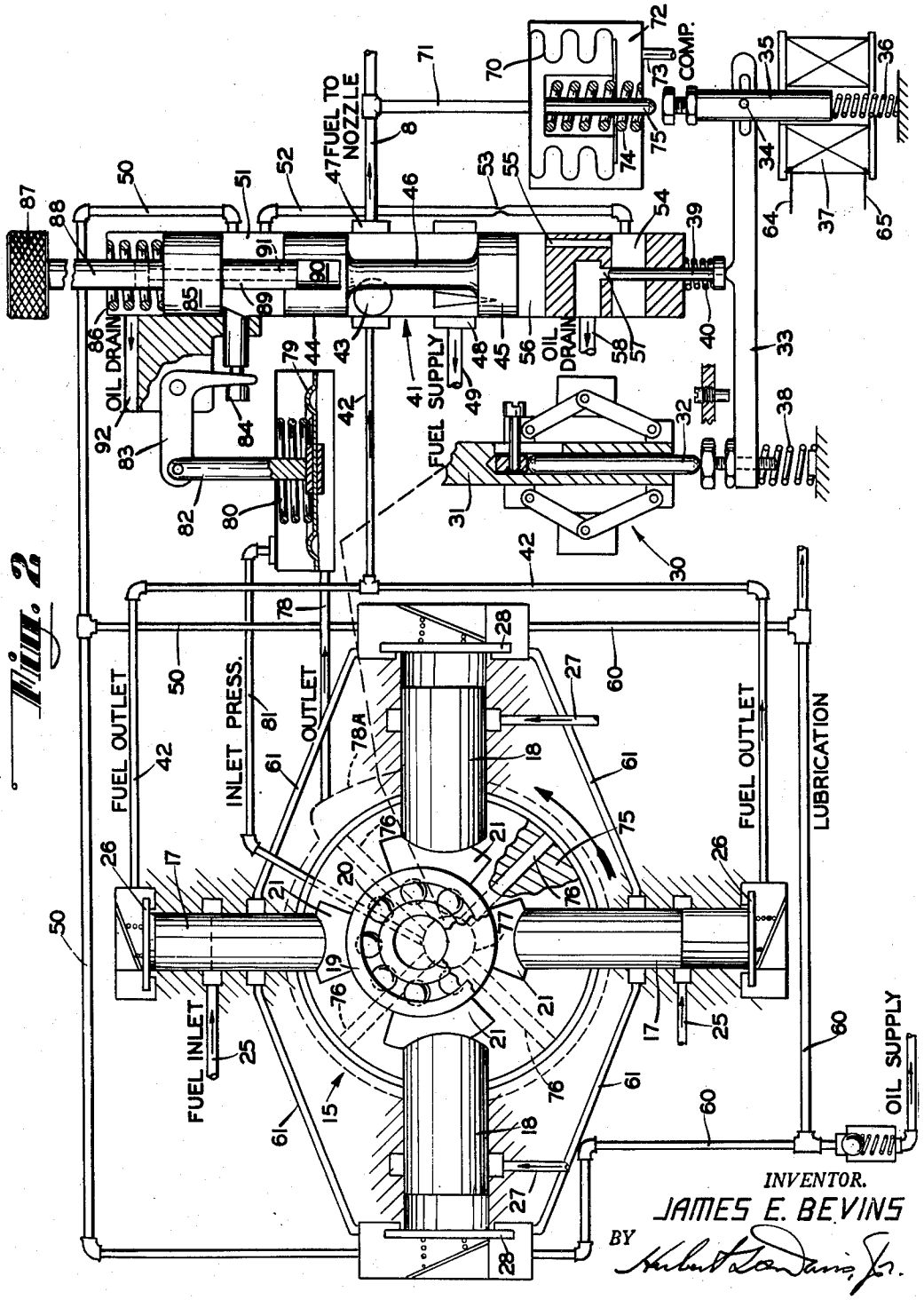


Fig. 2

INVENTOR.
JAMES E. BEVINS
BY
-ATTORNEY-

Patented Mar. 9, 1954 2,671,860

UNITED STATES PATENT OFFICE

2,671,860

LOAD SENSITIVE FUEL GOVERNOR FOR GAS TURBINES

James Emil Bevins, Ramsey, N. J., assignor to Bendix Aviation Corporation, Teterboro, N. J., a corporation of Delaware

Application June 26, 1947, Serial No. 757,109

23 Claims. (Cl. 290—40)

1

The present application relates to a load sensitive fuel regulator system and governor for a gas turbine drive.

An object of the invention is to provide a regulator or governor to keep the air-fuel ratio of a gas turbine at a safe minimum and to make the control sensitive to the electrical load applied to a generator driven by the turbine.

Another object of the invention is to provide an overspeed trip acting independently of the governing means and arranged to shut off inlet fuel to the turbine under excessive speed conditions and which trip may be manually reset.

Another object of the invention is to provide a combination fuel and oil pump driven by the turbine for supplying oil for operating the regulator and fluid fuel for the turbine.

Another object of the invention is to provide a governor system for a gas turbine in which the basic control is speed which is put into the system by a centrifugal governor driven by the turbine through the fuel and oil pump and in which the governor operates a lever which in turn operates a pilot valve so as to control a throttling valve in the fuel supply line for the turbine.

Another object of the invention is to provide in the latter system means to prevent hunting in the form of a load sensitive solenoid which acts as a movable fulcrum for the lever aforenoted and resets the governor to a lower speed for increased load. The action of the solenoid is to provide a predetermined droop in the speed curve with increasing load and it is considered that a five percent droop from zero to one hundred percent load will effectively stabilize the system.

Another object of the invention is to provide a novel control piston positioned by the servo oil pressure so as to vary fuel flow to the nozzle of the turbine in response to a governor driven from the drive shaft of the turbine and controlling a pilot valve.

Unless suitable means is provided to protect the gas turbine during accelerating cycles and periods of overload the governor may adjust the fuel throttle so as to cause the gas turbine to overheat due to the air-fuel ratio falling below a safe minimum. Therefore another object of the invention is to provide an overspeed diaphragm sensitive to the difference between nozzle fuel pressure and compressor air pressure to override the system and control the fuel throttle so that the air-fuel ratio is held to a safe minimum.

A further object of the invention is to provide an auxiliary overspeed governor arranged to cut off the supply of servo oil and mechanically close the main fuel inlet valve upon failure of the governing system or upon the speed of the turbine exceeding a predetermined safe rate.

The above and other objects and features of

2

the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawings wherein one embodiment of the invention is illustrated by way of example.

In the drawings:

Figure 1 is a schematic illustration of a gas turbine system to which the novel regulator may be applied.

Figure 2 is a schematic illustration of the regulator.

Referring to Figure 1, there is shown a typical gas turbine system to which the novel regulator may be applied and including a compressor 1 driven through shaft 2 by the turbine 3. The turbine 3 has an air inlet 4 and air outlet passages 5 leading through suitable expansion chambers 6 to the turbine 3. The expansion chambers 6 are heated by suitable nozzles 7 supplies with fuel by conduits 8.

The shaft 2 is arranged to drive an alternator 9 having an exciter 10 also driven by shaft 2. The output of the exciter 10 is connected by lines 11 and 12 across the field, not shown, of the alternator 9 in a conventional manner. The output of the alternator 9 is indicated by lines 13.

The foregoing gas turbine and generator system may be of conventional design and therefore a further detail description thereof is not deemed necessary.

Fuel-regulator system and governor

The novel feature of the invention resides in the fuel regulator and governor indicated generally in Figure 1 by the numeral 14 and shown schematically in Figure 2.

In the latter arrangement there is provided a combination oil and fuel pump indicated generally by the numeral 15.

The combination oil and fuel pump 15 may be of a rotating eccentric type driven by shaft 16, shown in Figure 1, from the turbine drive shaft 2. As shown in Figure 2, the pump may include fuel pistons 17 and oil pistons 18 which are reciprocated by an eccentric 19 mounted on ball bearings 20 and driven by shaft 16.

Suitable connections are made so that shoes 21 transmit the load from the pumping eccentric 19 to the pistons 17 and 18. Fuel is supplied by a conduit 25 to the cylinder of the fuel pump at the bottom of the suction stroke of the pistons 17 and is discharged through flap valves 26 at the ends of the fuel cylinders. Similarly, oil is supplied by conduits 27 to the cylinder of the oil pump at the bottom of the suction stroke of the pistons 18 and is discharged through flap valves 28 at the ends of the oil cylinders. The oil pumped by the pistons 18, supplies lubrication for the main gas turbine engine shown in Figure 1 and also for operating the servo system of the regulator 14.

The basic control of the regulator is speed, which is put into the system by a centrifugal governor indicated generally by the numeral 30 and driven by shaft 31 connected to the drive shaft of the pump 15 and through shaft 16 to the main drive shaft of the gas turbine engine shown in Figure 1. The governor 30 may be of a conventional fly ball type and is arranged to operate actuating pin 32, adjusting the position of a lever 33. The lever 33 is pivotally connected at 34 to an adjustable fulcrum pin 35 biased by spring 36 and controlled by electromagnet 37 as will be explained hereinafter. The opposite end of the lever 33 is biased by a spring 38 into contacting relation with the actuating pin 32. Positioned intermediate the opposite ends of the lever 33 is a valve pin 39 biased into contacting relation with the lever 33 by a spring 40. The valve pin 39 controls the operation of a throttling valve indicated generally by the numeral 41.

Fuel pressure lines 42 lead from the fuel pump previously described to openings 43 in the fuel throttling valve 41. The throttling valve 41 includes valve portions 44 and 45 which are connected by a stem portion 46. Fuel outlet opening 47 leads from the throttling valve 41 to a conduit 8 leading to the nozzles 7 of the turbine engine shown in Figure 1. Also leading from the throttling valve 41 are by-pass openings 48 connected to conduit 49 which returns excess fuel to a fuel supply tank. The valve portion 45 controls the by-pass openings 48 of the throttling valve 41 so that as the throttling valve moves upward, the by-pass openings 48 are closed, increasing the fuel supply to the nozzle 7 and as the throttling valve 41 moves downward, the by-pass valves are further opened, decreasing the supply fuel to the nozzle line 8.

The operation of the fuel throttling valve 41 is controlled by oil pressure supplied by the pumping pistons 18 through pressure line 50. The pressure line 50 opens into a chamber 51 immediately above the valve portion 44 of the throttling valve 41. A second line 52 leads from the chamber 51 through a restriction 53 to a valve chamber 54, controlled by the valve pin 39.

The valve chamber 54 is connected through a passage 55 to a pressure chamber 56 immediately below the valve portion 45 of the throttling valve 41. The valve 39 controls by-pass passage 57 leading from the valve chamber 54 to oil drain 58. The surface area of the valve portion 45 is subject to the pressure in the chamber 56 and has a considerably greater surface area than that of the valve portion 44 which is subject to the pressure in the chamber 51. It will be seen then that upon the valve pin 39 closing the outlet port 57, as upon the speed of the fly ball mechchanism 30 decreasing below a predetermined value, a pressure will be built up in the chamber 56 exceeding that in the chamber 51 and tending to bias throttling valve 41 in an upward direction so as to further close the by-pass valve ports 48 and increasing the supply of fuel to the nozzle line 8.

However, upon the speed of the fly ball mechanism 30 increasing above a predetermined value, the lever 30 will be actuated in a counterclockwise direction so as to cause valve pin 39 to open the by-pass passage 57 causing a relative increase in the pressure built up in the chamber 51 to be effected due to a resulting increase in the pressure drop across the restriction 53 in the conduit 52. In the latter event, the

throttling valve 41 will be biased downward, tending to open the by-pass ports 48 so as to decrease the supply of fuel to the nozzle line 8.

It will be seen then that as the speed of the turbine exceeds a predetermined value, the supply of fuel to the nozzle line 8 will be decreased and upon the speed of the turbine mechanism decreasing below a predetermined value, the fuel supplied to the nozzle line 8 will be increased so as to bring the speed of the turbine to the predetermined value.

As shown schematically in Figure 2, outlet lines 60 lead from the oil pistons 18 for supplying lubricating oil to the main turbine engine. Also, lines 61 lead from the pumping piston 18 for lubricating the fuel pistons 17.

The current in the line 12 from the exciter 10 to the field winding of the alternator 9 is regulated in a conventional manner through operation of a voltage regulator which may be of a suitable type well known in the art. The voltage regulator may be mounted in the alternator 9 and arranged so as to respond to the output voltage across the lines 13 of the alternator 9 to regulate the excitation of the field winding of the alternator 9 so as to maintain the voltage across the lines 13 substantially constant under varying load conditions. Thus the voltage regulator will effect an increase in the field current supplied through line 12 to the alternator 9 with decrease in the output voltage resulting upon an increase in the applied load and will further effect a decrease in the field current supplied through line 12 with increase in the output voltage resulting upon a decrease in the applied load.

In order to prevent hunting, the solenoid 37 is connected by lines 64 and 65 across a shunt resistor 66 connected in line 12 leading from the exciter 10 to the field of the alternator 9 as shown in Figure 1. Thus, the solenoid 37 is responsive to changes in the load on the alternator 9 and tends to bias the movable fulcrum pin 35 downward upon increase in load so as to reset the fly ball governor mechanism 30 to a lower speed for increased load. The action of the solenoid 37 is to build a predetermined droop into the speed curve with increasing load. It is considered that a five percent (5%) droop from 0 to 100% should stabilize the system during acceleration cycles and periods of overload.

During periods of overload, the fly ball governor 30 may tend to cause the turbine engine to overheat due to the air fuel ratio falling below a safe minimum. In order to protect the turbine mechanism from such action, there is provided a bellows 70 connected interiorly to nozzle line 8 through a conduit 71. A chamber 72 surrounds the bellows 70 and is subjected to the air pressure from the compressor 1 through a conduit 73, as shown in Figures 1 and 2. A spring 74 tends to compress the bellows 70 against the fuel nozzle pressure applied through the line 71. A pin 75 projects from the bellows 70 actuating the movable fulcrum pin 35. Thus, upon the air fuel ratio decreasing below a safe minimum, the bellows 70 expands, causing the movable fulcrum pin 35 to be biased downward and thereby causing valve pin 39 to open the by-pass passage 57 and the fuel throttling valve 41 to decrease the supply of fuel to the line 8. Thus, the bellows 70, sensitive to the difference between nozzle pressure and compressor pressure, overrides the system and controls the valve pin 39 so that the air fuel ratio is held to a safe minimum.

A centrifugal pump, indicated generally by the numeral 75 is built integrally with the crank shaft of the pump 15 and supplies pressure which is proportional to the speed of the turbine mechanism. The centrifugal pump 75 includes radial passages 76 which lead from a central inlet passage 77, indicated by dotted lines in Figure 2. Oil under centrifugal force is supplied by the radial passages 76 to an outlet chamber 78A which is connected by outlet pressure conduit 78 to one side of a diaphragm mechanism 79. A spring 80 acts on the diaphragm in opposition to the latter pressure. The opposite side of the diaphragm 79 is connected through line 81 to the inlet oil pressure at the central inlet passage 77.

The diaphragm 79 operates through a pin 82 and pivoted arm 83 a trip pin 84 for controlling a plunger or valve 85. Thus, when the centrifugal pressure from the pump 75 exceeds a safe operating speed limit, it overcomes the spring 80 in the overspeed trip diaphragm 79 and allows plunger 85 biased by a spring 86 to be released. The released plunger or valve 85 is biased by spring 86 into chamber 51 so as to close oil servo conduit 50 and cut off the supply of servo oil. The released plunger 85 further biases throttling valve 41 downward so as to mechanically close the main fuel inlet ports 43. The plunger 85 may be manually reset by appropriate adjustment of knob 87 connected through a stem 88 to the plunger 85. At the opposite side of the plunger 85 is a second stem 89 slidably mounted in a suitable channel 90 formed in the valve portion 44. A drain passage 91 serves to permit oil which may seep into channel 90 to be drained to the oil supply through a passage 92.

Operation

There is thus provided a regulator and governor in which the basic control is the speed of the turbine machine. The speed of the turbine machine is connected into the system by a governor mechanism 39 which operates a lever 33 and thereby a pilot valve 39 to control the throttling valve 41 for the nozzle supply line 8. This latter action is effected by operation of the pilot valve 39 so that when the pilot valve 39 closes a by-pass passage 57, the pressure builds up in chamber 56 so as to cause the throttling valve 41 to increase the fuel supply. Opening of the pilot valve 39 causes an opposite effect and a decreased supply of fuel to the nozzle line 8.

In order to prevent hunting, a load sensitive solenoid 37 acts as a movable fulcrum for the lever and resets the governor 39 for a lower speed setting upon an increase in the load on the alternator 9 driven by the turbine machine of Figure 1. The action of the solenoid 37 is to provide a predetermined droop in the speed curve with increasing load on the alternator 9 driven by the turbine machine.

In order to protect the turbine machine during periods of overload a bellows mechanism 70, sensitive to the difference between nozzle pressure and compressor pressure overrides the system and controls the throttling valve 41 so that the air fuel ratio is held to a safe minimum.

A further feature of the control is a centrifugal pump 75 which is driven from the main shaft 2 of the turbine machine and supplies pressure which is proportional to the speed of the turbine machine to a diaphragm 79. When the centrifugal pressure exceeds safe operating speed limits, it biases the diaphragm 79 so as to permit a spring loaded plunger 85 to be released. This plunger cuts off the supply of servo oil and mechanically closes the main fuel supply line 8. Operation of the mechanism may be reset through a manually adjustable knob 87.

Although only one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangement of the parts may be made to suit requirements.

What is claimed is:

1. The combination comprising a prime-mover, an electric generator and exciter driven by said prime mover, said exciter connected to supply current for exciting said generator, and said generator connected to supply power to a variable load, a speed governor for said prime mover, electrically operated control means for adjusting the calibration of said speed governor, means responsive to variations in the current supplied by said exciter to said generator for affecting said governor adjusting control means to provide a predetermined droop in the speed setting varying with increasing load, and the speed of said prime mover being controlled simultaneously by said governor and by said control means.

2. The combination defined by claim 1 including position-operated means responsive to the adjusted position of said governor and said control means for decreasing the speed of said prime mover with increase in load.

3. A regulating system for a prime-mover driven electric generator connected to supply power to a variable load, comprising a speed governor for said prime mover, electrically operated control means for adjusting the calibration of said speed governor over a predetermined range, means responsive to variations in said load for supplying a corrective signal to said governor adjusting control means to progressively vary the speed calibration of said speed governor over said range, and position-operated means responsive to the adjusted position of said governor and said control means for affecting the speed of said prime mover in inverse relation to the load applied to the generator.

4. A regulating system for a prime-mover driven electric generator connected to supply power to a variable load, comprising a speed governor for said prime mover, electrically operated control means for adjusting the calibration of said speed governor over a predetermined range, means responsive to variations in said load for supplying a corrective signal to said governor adjusting control means to progressively decrease within said range the speed calibration of said speed governor with increase in the load applied to the generator and to progressively increase within said range the speed calibration of said speed governor with decrease in the load applied to the generator.

5. For use in a system including a combustion chamber, a turbine driven by the exhaust gases from said chamber, a compressor driven by the turbine for supplying air to the combustion chamber, a fuel conduit for supplying a combustible fluid to said chamber, and a generator driven by said turbine and connected to supply power to a variable load; the combination comprising means to regulate the fuel supplied by said conduit to said chamber, a speed governor driven by said turbine, electromagnetically operated control means for adjusting the calibration of said speed governor over a predetermined range, means responsive to variations in said load for supplying

a signal to said control means to provide a predetermined droop in the speed setting progressively varying inversely with the load, and a position operated means responsive to the adjusted position of said governor and said control means to control said regulating means.

6. For use in a system including a combustion chamber, a turbine driven by the exhaust gases from said chamber, a compressor driven by the turbine for supplying air to the combustion chamber, a fuel conduit for supplying a combustible fluid to said chamber, and a generator driven by said turbine and connected to supply power to a variable load; the combination comprising, means to regulate the fuel supplied by said conduit to said chamber, a speed governor driven by said turbine, electromagnetically operated control means for adjusting the calibration of said speed governor, means responsive to variations in said load for supplying a signal to said control means to provide a predetermined droop in the speed setting with increasing load, a floating lever responsive to the adjusted position of said governor and control means to control said regulating means, a diaphragm differentially responsive to the fuel pressure and the compressor outlet pressure to affect said floating lever so as to maintain the air-fuel ratio of the combustion chamber within a safe range during periods of acceleration of the turbine and overload of the generator, a fluid pump driven by the turbine, a differential diaphragm responsive to the inlet and outlet fluid pressures of said pump, and a latch mechanism operated by said diaphragm to cause said regulating means to close the fuel conduit upon the fluid pump outlet pressure exceeding the pump inlet pressure by a predetermined value.

7. For use in a system including a combustion chamber, a turbine driven by the exhaust gases from said chamber, a compressor driven by the turbine for supplying air to the combustion chamber, a fuel conduit for supplying a combustible fluid to said chamber, and a generator driven by said turbine and connected to supply power to a variable load; the combination comprising, means to regulate the fuel supplied by said conduit to said chamber, a speed governor driven by said turbine, electromagnetically operated control means for adjusting the calibration of said speed governor, means responsive to variations in said load for supplying a signal to said control means to provide a predetermined droop in the speed setting with increasing load, a floating lever responsive to the adjusted position of said governor and control means to control said regulating means, and a diaphragm differentially responsive to the fuel pressure and the compressor outlet pressure to affect said floating lever so as to maintain the air-fuel ratio of the combustion chamber within a safe range during periods of acceleration of the turbine and overload of the generator.

8. Means for controlling the fuel line of an engine, comprising a regulating valve in said line, servo fluid pressure means for operatively positioning said valve, a second valve to control said fluid pressure means, means responsive to speed of said engine, means controlled by said speed responsive means for actuating said regulating valve independently of said fluid pressure means so as to close said fuel line, and a third valve operated by said actuating means to render said fluid pressure means inoperative upon the speed exceeding a predetermined value.

9. Means for controlling the fuel line of an engine, comprising a regulating valve in said line, servo fluid pressure means for operatively positioning said valve, a second valve to control said fluid pressure means, engine overspeed responsive means, a latch mechanism operated by said overspeed responsive means, a plunger releasably locked by said latch mechanism, a spring effective upon release of said plunger to bias said plunger so as to actuate said regulating valve into a position to close said fuel line so as to terminate operation of the engine upon the speed thereof exceeding a predetermined value, said plunger including an auxiliary valve positioned by said spring so as to render said fluid pressure means inoperative.

10. Means for controlling the fuel line of an engine, comprising a throttling valve in said line, said throttling valve having opposite end portions of different surface areas, conduit means for applying fluid pressure to the opposite end portions of said valve, a restriction in said conduit means between said opposite end portions, one end of said conduit means having an opening to a drain, a pilot valve to control said opening for varying the pressure applied at the one end portion of said throttling valve for effecting movement thereof, a governor responsive to an engine condition for controlling said pilot valve, an overriding valve normally opening said conduit means and operable to close said conduit means, an engine overspeed responsive mechanism operating independently of the governor, and biasing means controlled by said mechanism to actuate the throttling valve independently of the fluid pressure so as to close the fuel line and to position the overriding valve so as to close said conduit means upon the speed of the engine exceeding a predetermined value.

11. Means for controlling the fuel line of an engine, comprising a throttling valve in said line, said throttling valve having opposite end portions of different surface areas, conduit means for applying fluid pressure to the opposite end portions of said valve, a restriction in said conduit means between said opposite end portions, one end of said conduit means having an opening to a drain, a pilot valve to control said opening for varying the pressure applied at the one end portion of said throttling valve for effecting movement thereof, a governor responsive to an engine condition for controlling said pilot valve, an overriding valve to control said conduit means, an overspeed responsive means operating independently of the governor, a latch mechanism controlled by said overspeed responsive means, said overriding valve releasably locked by said latch mechanism in a position to open said conduit means, a spring to bias said overriding valve and effective upon release of said overriding valve by said latch mechanism to bias said throttling valve into a position to close said fuel line and to affect said overriding valve so as to close said conduit means upon the speed of said engine exceeding a predetermined value, and manually operable means for resetting said overriding valve, and latch mechanism.

12. Apparatus for use in controlling the fuel line of an engine, comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion for controlling said fuel line, a first conduit for connecting the end portion of smaller surface area directly with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said

end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, and a condition responsive governor adapted to respond to an operating condition of the engine when connected thereto, said governor controlling the operation of said pilot valve.

13. Apparatus for controlling the fuel line of an engine having a supercharger driven thereby for supplying air under pressure to the engine, said apparatus comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion controlling said fuel line, a first conduit connecting the end portion of smaller surface area directly with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, an engine speed governor for controlling the operation of said pilot valve, and an auxiliary control device responsive to the difference between the supercharger air pressure and the fuel pressure in the fuel line of the engine to affect said pilot valve to cause movement of said throttling valve in a closing direction when the fuel pressure exceeds the supercharger air pressure by a predetermined value.

14. Regulating means for regulating a fuel conduit for a combustion engine; said regulating means comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel conduit, a first conduit for connecting the end portion of smaller surface area with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, and a governor operatively connected to said pilot valve, said governor including speed responsive means adapted to respond to the driven speed of the engine when connected thereto for controlling the pilot valve in response to the driven speed of the engine.

15. Regulating means for regulating a fuel conduit for a combustion engine having an air inlet conduit; said regulating means comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel conduit, a first conduit for connecting the end portion of smaller surface area with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve and a governor operatively connected to said pilot valve, said governor including differential pressure responsive means adapted to respond to the ratio of the air-fuel mixture supplied the engine, said governor controlling the pilot valve in response to the air-fuel ratio.

16. Regulating means for regulating a fuel conduit for a combustion engine having an air inlet conduit; said regulating means comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel conduit, a first conduit for connecting the end portion of smaller surface area with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, and a governor operatively connected to said pilot valve, said governor including speed responsive means adapted to respond to the driven speed of the engine when connected thereto for controlling the pilot valve in response to the driven speed of the engine, and a differential pressure responsive means adapted to respond to the ratio of the air-fuel mixture supplied the engine when connected to the air inlet and fuel conduits respectively to control the pilot valve in response to the air-fuel ratio.

17. Regulating means for regulating a fuel conduit for a combustion engine; said regulating means comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel conduit, a first conduit for connecting the end portion of smaller surface area with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, and a governor operatively connected to said pilot valve, said governor including a condition responsive means adapted to respond to an operating condition of said engine when connected thereto for controlling the pilot valve in response to such condition.

18. Regulating means for regulating a fuel conduit for a combustion engine; said regulating means comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel conduit, a first conduit for connecting the end portion of smaller surface area with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, an overspeed responsive mechanism adapted to respond to the driven speed of the engine when connected thereto, valve means to control the supply of fluid pressure to position the throttling valve, and means controlled by the overspeed responsive mechanism independently of the governor to actuate the throttling valve

so as to close the fuel conduit and to actuate the valve means so as to cut off the fluid pressure for positioning the throttling valve when the speed of the engine exceeds a predetermined value.

19. Regulating means for regulating a fuel conduit for a combustion engine; said regulating means comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel conduit, a first conduit for connecting the end portion of smaller surface area with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, and an overspeed responsive means adapted to respond to the driven speed of the engine when connected thereto, said overspeed responsive means to actuate the throttling valve to close the fuel conduit when the speed of the engine exceeds a predetermined value.

20. Regulating means for regulating a fuel conduit for a combustion engine; said regulating means comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel conduit, a first conduit for connecting the end portion of smaller surface area with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, an overspeed responsive means adapted to respond to the driven speed of the engine when connected thereto, a latch mechanism controlled by said overspeed responsive means, a plunger releasably locked by said latch mechanism, and a spring effective upon release of said plunger to actuate said throttling valve to a position to close said fuel conduit and said plunger to a position to close at least one of the fluid pressure conduits.

21. Apparatus for use in controlling the fuel line of an engine for driving a generator, said apparatus comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel line, a first conduit for connecting the end portion of smaller surface area directly with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, and a governor including an electrical load responsive means adapted to respond to the load applied to the generator for controlling the operation of said pilot valve.

22. Apparatus for use in controlling the fuel line of an engine for driving a generator, said apparatus comprising a throttling valve having

opposite end portions of different surface areas and an intermediate portion adapted to control said fuel line, a first conduit for connecting the end portion of smaller surface area directly with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, and a governor including an electrical load responsive means adapted to respond to the load applied to the generator, speed responsive means adapted to respond to the driven speed of the engine, and differential pressure responsive means adapted to respond to the ratio of the air-fuel mixture supplied to the engine, and means operatively connecting the load, speed and differential pressure responsive means to said pilot valve for controlling the pilot valve and thereby the position of the throttling valve.

23. Apparatus for use in controlling the fuel line of an engine for driving a generator, said apparatus comprising a throttling valve having opposite end portions of different surface areas and an intermediate portion adapted to control said fuel line, a first conduit for connecting the end portion of smaller surface area directly with a source of fluid pressure and independently of said end portion of larger surface area, a second conduit for connecting said end portion of larger surface area with said source of fluid pressure and having a restriction therein, an opening in said second conduit to drain, a pilot valve controlling said opening to vary the pressure applied to the end portion of larger area to effect movement of the throttling valve, speed responsive means adapted to respond to the driven speed of the engine when connected thereto for controlling the operation of said pilot valve, and an electromagnetic device adapted to respond to the electrical load on said generator when connected thereto for varying the speed setting of said governor.

JAMES EMIL BEVINS.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
Re. 19,114	Stein et al.	Mar. 13, 1934
1,020,685	Cubelic	Mar. 19, 1912
1,222,985	Pharo	Apr. 17, 1917
1,226,073	Herr	May 15, 1917
1,705,688	Staege	Mar. 19, 1929
1,841,425	Taylor	Jan. 19, 1932
1,969,526	Rosch	Aug. 7, 1934
2,193,114	Seippel	Mar. 12, 1940
2,219,994	Jung	Oct. 29, 1940
2,263,705	Seippel	Nov. 25, 1941
2,306,953	Jung	Dec. 29, 1942
2,336,232	Doran	Dec. 7, 1943
2,422,808	Stokes	June 24, 1947
2,432,177	Sedille	Dec. 9, 1947
2,433,725	Ziebolz	Dec. 30, 1947
2,485,374	Farnham et al.	Oct. 18, 1949
2,514,930	Branham	July 11, 1950

FOREIGN PATENTS

Number	Country	Date
490,978	Great Britain	Aug. 24, 1938