Aug. 25, 1959 A. CHADWICK 2,901,030

LIQUID FUEL CONTROL MECHANISM

Filed Feb. 8, 1955 2 Sheets-Sheet 1

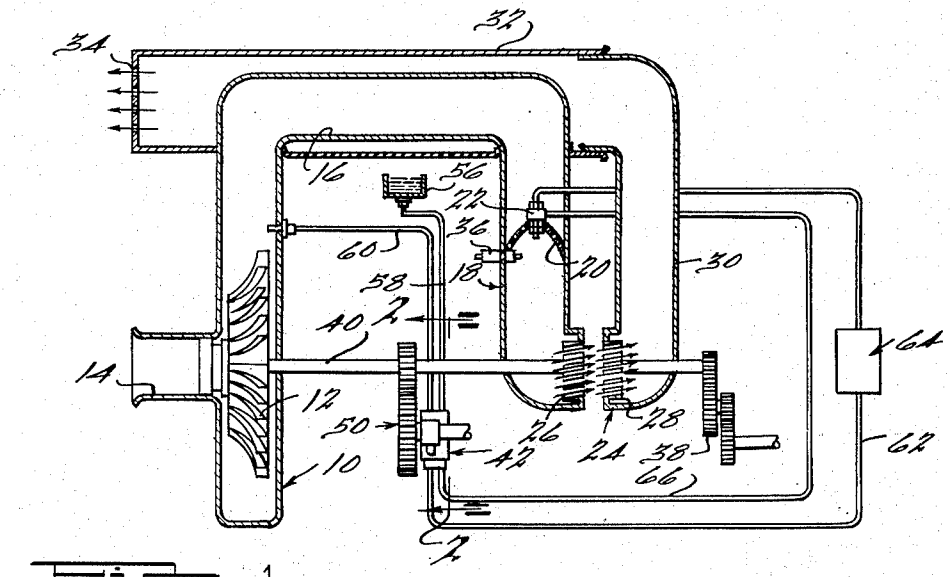


Fig. 1.

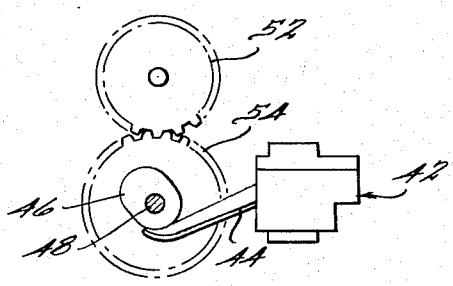


Fig. 2.

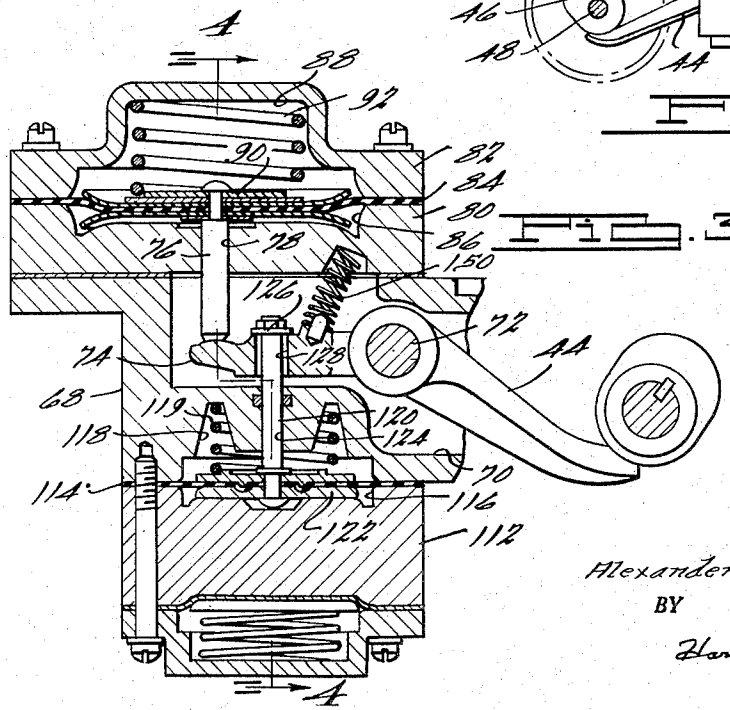


Fig. 3.

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LIQUID FUEL CONTROL MECHANISM

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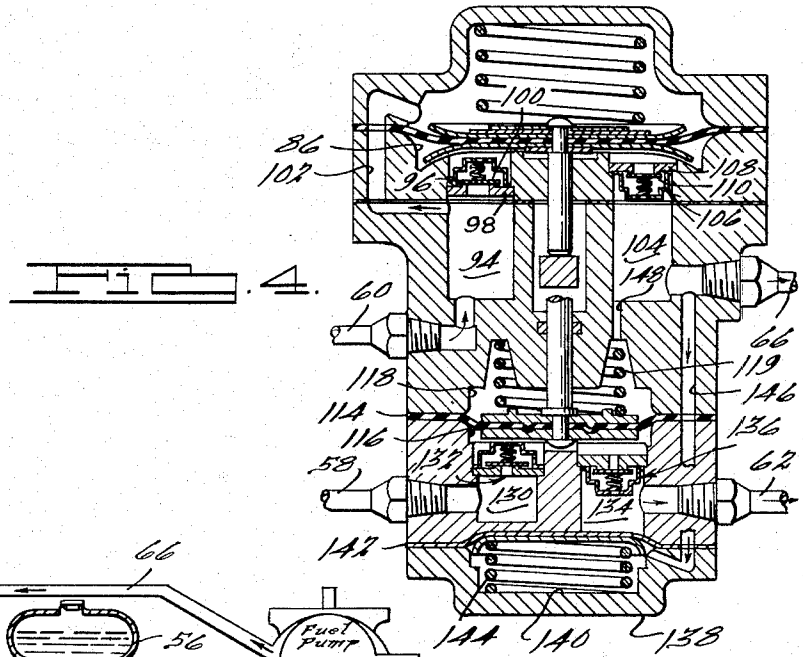


FIG. 4.

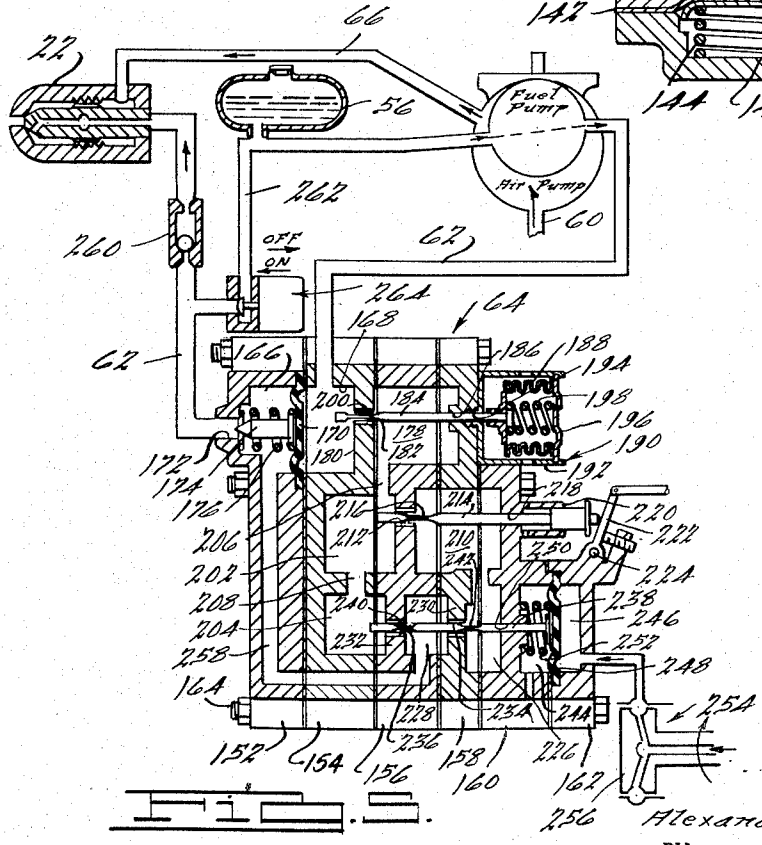


FIG. 5.

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2,901,030

LIQUID FUEL CONTROL MECHANISM

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Application February 8, 1955, Serial No. 486,816

2 Claims. (Cl. 158—36.4)

My instant invention relates generally to liquid fuel combustion apparatus and to fuel control mechanisms for use therewith. More particularly, my instant invention comprises a new and improved control valve assembly which is particularly adapted to be used with and form a part of a fuel system for a gas turbine power plant, although it is contemplated that it is also capable of being used with other types of fuel combustion apparatus.

My instant invention represents an improvement in the fuel control mechanism described in my copending U.S. patent application Serial Nos. 452,568 and 452,569, filed August 27, 1954, which is assigned to the assignee of my instant invention, the latter application being now abandoned.

For the purpose of illustrating the novel features of my invention, I have presently disclosed the same in combination with a gas turbine power plant of the automotive type but it will become apparent that my invention is not restricted in use to power plants of this type.

In general, a gas turbine power plant of the type herein disclosed may comprise a liquid fuel burner mechanism, air intake passage means for supplying the burner with combustion supporting air, an air compressor for compressing the intake air before it enters the burner mechanism, and at least two rotary turbine stages which are adapted to be powered by the combustion gases produced within the burner mechanism, one stage being drivably coupled to the compressor for powering the same and the other being drivably connected to a speed reduction transmission which in turn is adapted to deliver power to a power absorbing means such as the driving wheels of a wheeled vehicle. A rotatable exhaust gas passage means is provided for transferring the exhaust gases from the downstream side of the rotary turbine stages to the exterior of the power plant. A regenerator mechanism is preferably provided for utilizing a large portion of the thermal energy of the hot exhaust gases to raise the temperature of the compressed intake air before it is caused to enter the burner mechanism as above described.

The fuel system of which my instant invention forms a part includes a fuel and air pumping unit which may be powered by the above described first turbine stage. This pumping unit has been previously disclosed in the copending application of David W. Barton, Serial No. 440,932, filed July 2, 1954, which is assigned to the assignee of my instant invention, and it includes a fuel pumping chamber and an air pumping chamber, each of said chambers being partly defined by a spring loaded pumping diaphragm.

An air atomizing nozzle is provided within the above mentioned burner mechanism for producing a combustible spray of liquid fuel and separate delivery conduit means are disposed between the air atomizing nozzle and each of the pumping chambers. Another conduit is provided for delivering high pressure air from the discharge side of the turbine compressor to the intake side of the air pumping chamber of the pumping unit. The discharge side of the air pumping chamber is interconnected

with the fuel pumping portion of the pumping unit so that the air pressure at the discharge side of the air pumping chamber is adapted to act upon the fuel diaphragm for the fuel pumping chamber to supplement the pumping action of a fuel pumping spring which is provided for this purpose.

The improved fuel control mechanism of my instant invention may be disposed in the fuel delivery conduit interconnecting the fuel pumping portion of the above described pumping unit and the air atomizing nozzle and it is sensitive to operating variables of the gas turbine engine for controlling and scheduling the flow of liquid fuel to the air atomizing nozzle so that the fuel-air ratio within the burner mechanism will be maintained at a predetermined optimum value during operation of the engine at varying speeds and loads and during variations in the engine operating conditions.

The control valve mechanism of my instant invention is somewhat similar in function to the control valve mechanism described in my above mentioned copending applications, Serial Nos. 452,568 and 452,569, but it is unique in that it is characterized by its greater simplicity. The provision of a fuel control mechanism with this characteristic being a principal object of my instant invention, it is another object of my invention to provide a fuel control mechanism which is possessed of a high degree of reliability.

Another object of my invention is to provide a fuel control mechanism of the type referred to above in which the component elements thereof are relatively few in number and are arranged in a composite assembly with minimum space requirements.

It is another object of my instant invention to provide a fuel control mechanism for use with a power plant of the type mentioned above which includes a first valve means for regulating the flow of liquid fuel to the power plant burner mechanism during starting and during acceleration of the turbine elements up to a normal idling speed.

It is a further object of my invention to adapt the first valve means, mentioned in the preceding object, to function as an idle speed governor valve to limit the speed of the engine turbine elements to a predetermined maximum idling speed.

It is a further object of my instant invention to provide a fuel control mechanism of the type set forth in the preceding object wherein a second valve means is operatively associated with the first valve means and is effective to control and to schedule the flow of fuel to the power plant burner mechanism during acceleration of the turbine elements from an idling speed to a predetermined maximum speed.

It is a further object of my instant invention to adapt the above mentioned second valve means to function as a turbine speed governor valve for limiting the turbine speeds to values below a predetermined limiting value.

It is a further object of my instant invention to provide a fuel control mechanism of the type set forth in the preceding object wherein a personally operable throttle valve is provided for use in combination with the above mentioned first and second valve means and which is effective to permit regulation of the flow of fuel to the power plant burner mechanism, said second valve means being disposed in series with the throttle valve in a common fuel flow path.

It is a further object of my instant invention to provide a fuel control mechanism of the type above set forth wherein the valve components thereof are disposed in the fuel flow path extending from a fuel delivery pumping mechanism and the power plant burner mechanism and wherein regulator valve means are provided for maintaining the pressure differential across the valve compo-

nents at a substantially constant value, said regulator valve means being of an improved and simple construction.

It is a further object of my instant invention to provide a fuel control mechanism of the type above set forth wherein additional valve means are included for correcting the rate of fuel flow to the power plant burner for variations in ambient air pressure, said additional valve means being effective to maintain the fuel-air ratio within the power plant burner at a constant value during variations in ambient air pressure.

It is a further object of my instant invention to provide a new and improved liquid fuel control mechanism which includes a personally operable throttle valve, a plurality of fuel flow regulating valves and an ambient air pressure compensating valve, each of said valves including a flow restricting orifice and a movable valve element registering with the orifices to vary the rate of fuel flow therethrough, said orifices forming a portion of the fuel flow path extending to the power plant burner.

It is a further object of my invention to form the above mentioned first and second valve means with a common, movable valve element for controlling the flow of fuel through the respective orifices, said common valve element including separate valving portions for cooperating with each of said orifices.

It is a further object of my instant invention to provide a fuel control mechanism as above set forth wherein the valve elements thereof are characterized by their simplicity and by their relatively low manufacturing cost.

It is a further object of my instant invention to provide a fuel control mechanism capable of controlling the distribution of liquid fuel to the burner of a fuel combustion apparatus so that the fuel requirements of the latter are automatically accommodated throughout the entire operating speed and load range.

For the purpose of particularly pointing out the new and unique features of my invention, reference will be made herein to the accompanying drawings:

Figure 1 is a schematic representation of an automotive type power plant capable of employing a fuel control mechanism of my instant invention;

Figure 2 is a sub-combination view taken along section line 2—2 of Figure 1 showing the schematic arrangement of the fuel and air pumping unit and the means for powering the same;

Figure 3 is a cross sectional view of the power plant fuel and air pumping mechanism which is shown schematically in Figures 1 and 2;

Figure 4 is a cross sectional view of the pumping unit of Figure 3 taken along section line 4—4 of Figure 3; and

Figure 5 is a schematic representation of the fuel control mechanism of my instant invention and it shows the principal valve components.

Referring first to the schematic power plant assembly view of Figure 1, a rotary turbine compressor is designated by numeral **10** and it includes a bladed rotor **12** and an intake air opening **14**. Air is conducted through the intake opening **14** and is discharged radially from the periphery of the bladed rotor **12** at an increased pressure. The pressurized intake air is caused to pass through a first regenerator passage means **16** into the vicinity of a power plant burner which is generally designated in Figure 1 by numeral **18**. The compressed intake air is caused to enter the interior of a burner cone **20** where it is mixed with a spray of atomized liquid fuel which is discharged by a fuel atomizing nozzle **22**. The liquid fuel is burned within the burner **20** and the combustion gases are caused to pass through a two-stage turbine assembly generally designated by means of numeral **24**. This turbine assembly comprises a first turbine stage **26** and a second turbine stage **28** which are rotatably mounted in coaxial adjacent relationship.

After passing through the two-stage turbine assembly **24**, the motive gases are conducted through a suitable passage means **30** into a second regenerator passage means **32**. The exhaust gases are then exhausted through a suitable exhaust portion as shown at **34**. The relatively hot exhaust gases passing through the regenerator passage means **32** are effective to increase the temperature of the relatively cooler compressed intake air passing in the opposite direction through the regenerator passage means **16**. This transfer in thermal energy substantially increases the thermal efficiency of the power plant.

An igniter plug **36** is provided, as shown, within the burner tube **20** for the purpose of initiating combustion during the starting cycle of the power plant. After the turbine elements have attained a normal idling speed, the igniter plug **36** may be deenergized and thereafter combustion within the burner tube **20** will be self-sustaining.

The second turbine stage **28** functions as a power turbine and it may be drivably coupled to a suitable speed reduction transmission **38** which in turn may be connected to a power absorbing means such as the vehicle driving wheels. The first turbine stage **26** functions as a compressor turbine and it is drivably coupled to the turbine rotor **12** by means of shafting **40**.

A liquid fuel and air pumping unit is generally designated in Figures 1 and 2 by means of numeral **42** and it includes a rocker arm **44** for actuating the pumping elements thereof. The arm **44** is adapted to contact a cam **46** which is integrally connected to a shaft **48**. This shaft **48** may be powered by the compressor rotor shafting **40** and it is drivably connected thereto by suitable gearing **50**, said gearing **50** including a first gear **52** drivably connected to the shafting **40** and an intermeshing gear **54** drivably connected to the shaft **48**.

The fuel and air pumping unit **42** is supplied with liquid fuel by a reservoir **56** as schematically shown in Figure 1, said reservoir being connected to the inlet side of the fuel and air pumping unit **42** by means of a fuel supply conduit **58**. The pumping unit **42** is supplied with pressurized intake air from the compressor **10** by means of an air supply conduit **60**. A high pressure fuel delivery conduit **62** interconnects the discharge side of the fuel pumping portion of the pumping unit **42** with the liquid fuel atomizing nozzle **22** and the fuel control mechanism of my instant invention is interposed in the delivery conduit **62**, as shown at **64** in Figure 1. High pressure or delivery conduit **66** is interconnected between the air pumping portion of the pumping unit **42** and the fuel atomizing nozzle **22**. The air delivered through the conduit **66** to the nozzle **22** is utilized to atomize the liquid fuel into a combustible spray within the burner cone **20**.

Referring next to Figures 3 and 4, the above-described fuel and air pumping unit **42** is shown in more particular detail and it includes a first body portion **68** which is formed with a central opening **70** within which the above-mentioned rocker arm **44** is pivoted, the fulcrum pin for the arm **44** being shown at **72**. The arm **44** includes an extension **74** which extends inwardly within the opening **70** and it is adapted to loosely engage an air diaphragm actuating shaft **76** which is disposed in a vertical direction as shown in Figures 3 and 4. The shaft **76** is slidably situated within an aperture **78** formed in another housing portion **80** which may be positioned upon the upper surface of the intermediate pump housing portion **68**. An upper pump housing portion **82** is situated above the housing portion **80** and a flexible air diaphragm **84** is situated between the juxtaposed surfaces of the housing portions **80** and **82**. The air diaphragm **84** is effective to define with the housing portion **80** an air pumping chamber **86** and is also effective to define with the housing portion **82** a spring chamber **88**. The diaphragm actuator shaft **76** is connected at its upper end to the center of the air diaphragm

80 by suitable fastening means 90. An air pumping spring 92 is disposed within the spring chamber 88 for the purpose of biasing the diaphragm 84 and the diaphragm actuating shaft 76 in a downward direction.

As best seen in Figure 4, the air supply conduit 60 communicates with an inner chamber 94 which communicates with the above-described air pumping chamber 86 through a one-way check valve mechanism 96, said check valve mechanism including an orifice plate 98 and a spring loaded valve element 100 for selectively blocking the orifice formed in the orifice plate 98. The spring chamber 88 communicates with the inner chamber 94 through a suitable air passage 102 to accommodate the displacement of air during movement of the air diaphragm 84.

The air pumping chamber 86 also communicates with another inner chamber 104 through a second one-way check valve mechanism 106, said mechanism 106 including an orifice plate 108 and a movable spring loaded valve element 110. The chamber 104 communicates with the air delivery conduit 66 for the nozzle 22 as shown.

Another pump housing portion 112 is mounted against the lower surface of the intermediate housing portion 68 and a flexible fuel diaphragm 114 is secured between the juxtaposed surfaces of the housing portions 68 and 112. The fuel diaphragm 114 is adapted to define with the housing portion 112 a fuel pumping chamber 116 and is adapted to define with the intermediate housing portion 68 a fuel spring chamber 118, said spring chamber 118 containing a fuel spring 119 which is adapted to urge the fuel diaphragm 114 in a downward direction. The center of the fuel diaphragm 113 is secured to a diaphragm actuating shaft 120 by suitable fastening means 122. The shaft 120 is slidably received within a vertical opening 124 and it is joined to the rocker arm extension 74 by means of a lost motion connection. This lost motion connection consists of a washer element 126 secured to the end of shaft 120 and an opening 128 through which the shaft 120 is loosely received.

The fuel pumping chamber 116 is in communication with an interior cavity 130 through a one-way check valve 132 which is similar in construction to the above-mentioned check valves 96 and 106. Cavity 130 is in fluid communication with the fuel supply conduit 58 as shown.

The fuel pumping chamber 116 is also in communication with another cavity 134 through another check valve 136 and this cavity is in fluid communication with the fuel delivery conduit 62. The check valve 132 is adapted to admit fuel into the chamber 116 during an upward movement of the fuel diaphragm 114 and the check valve 136 is effective to allow the fuel to pass from the chamber 116 into the cavity 134 and the delivery conduit 62.

The pump housing also includes a lower housing portion 138 which defines a surge chamber 140. A flexible diaphragm 142 is extended across the surge chamber 140 and is spring biased in an upper direction by spring 144. The upper surface of the diaphragm 142 is exposed to fuel discharge pressure within the cavity 134. An air passage 146 is provided, as shown, between the air delivery conduit 66 and the surge chamber 140 for the purpose of charging the latter with high pressure air. The spring chamber 118 for the fuel pumping portion of the unit is in fluid communication with chamber 104 through a passage 148.

During the operation of the power plant, the gearing 50 is effective to rotate the cam 46 which in turn causes the rocker arm 44 to oscillate about its pivot point 72. During a clockwise movement of the rocker arm 44, as viewed in Figure 3, the air diaphragm 84 and the fuel diaphragm 114 are moved vertically upward against the opposing forces of the springs 92 and 119 respectively. During this upward stroke, the valve 96 is effective to admit air into the air pumping chamber 86 and the valve 132 is effective to admit fuel into the fuel pumping chamber 116. When the rocker arm 44 moves in a counterclockwise direction, the rocker arm extension 74 becomes disengaged from each of the actuator shafts 76 and 120. A spring 150 is provided, as shown in Figure 3, for the purpose of normally biasing the rocker arm 44 in a counterclockwise direction. The fuel diaphragm 114 moves downwardly under the influence of fuel spring 119 while the air diaphragm 84 moves downwardly under the influence of the air spring 92. During this downward movement air is delivered to the air delivery conduit 66 through the check valve 106. Also high pressure fuel is delivered to the fuel delivery conduit 62 through the check valve 136. The surge chamber 140 is adapted to maintain a substantially uniform pressure in the fuel delivery conduit 62 by virtue of the pressure exerted by the spring 144 and the air contained within the chamber 140.

Referring next to Figure 5, the fuel control mechanism 64 of my instant invention is shown in detail and it comprises a multiple piece housing which may consist of six housing portions shown at 152, 154, 156, 158, 160, and 162. These various housing portions may be assembled in stacked relationship and held together as an integral unit by clamping bolts 164. A suitable gasket may be disposed between the juxtaposed surfaces of each of the above-mentioned housing portions. The housing portions 152 and 154 are adapted to define a pair of chambers 166 and 168 respectively, which are separated by a flexible diaphragm 170, said diaphragm 170 being secured about its periphery between the juxtaposed surfaces of the housing portions 152 and 154. The chamber 166 is in fluid communication with the fuel delivery conduit 62 through a valve port 172. A valve element 174 is carried by the flexible diaphragm 170 and it is effective to automatically maintain a substantially constant pressure differential between the chambers 166 and 168. A spring 176 is provided to normally urge the valve 174 toward an open position. The chamber 168 is in communication with the fuel supply conduit 62 as shown.

The pump housing portions 158 and 156 are adapted to define a chamber 178 which is separated from the chamber 168 by a wall 180 which forms a portion of the pump housing portion 154. A fuel metering orifice 182 is formed in the wall 180 and a metering rod 184 is situated within the orifice 182 for the purpose of varying the rate of fuel flow from the chamber 168 to the chamber 178. The metering rod 184 extends outwardly through an opening 186 formed in the housing portion 158 and it is secured at its outer end to a pressure bellows 188. The bellows 188 forms a portion of an altitude capsule 190 which may include a cylindrical cup 192 having means 194 for securing the same to the housing portion 158. The cup 192 may be closed by a disc 196 to which one end of the bellows 188 is secured. A spring 198 may be interposed between the disc 196 and the metering rod 184.

A tapered section 200 is formed on the metering rod 184 and it is adapted to cooperate with the orifice 182 to provide a controlled restriction for the flow of fuel. When the ambient air density decreases by reason of a decrease in ambient air pressure or an increase in ambient air temperature, the capsule 188 expands thereby moving the metering rod 188 to the left as viewed in Figure 5, and this in turn increases the degree of restriction provided by the orifice 182. This decreased rate of fuel flow compensates for the decrease in mass rate of flow of air to the nozzle 22 which accompanies such a decrease in ambient air pressure and the fuel air ratio is thereby maintained to a substantially constant value.

The housing portions 154 and 156 are effective to define a pair of chambers 202 and 204, the former communicating with chamber 178 through a passage 206. Passage 208 provides communication between the chambers 202 and 204.

The housing portions 156, 158, and 160 are adapted

to define another chamber 210 which is in fluid communication with the above-mentioned chamber 202 through a metering orifice 212. Another metering rod is shown at 214 and it includes a tapered section 216 which cooperates with the metering orifice 212 to vary the rate of fuel flow from the chamber 202 into the chamber 210. The metering rod 214 extends outwardly through an opening 218 formed in the housing portion 160. A suitable dashpot mechanism is schematically shown at 220 and it is adapted to dampen the movement of the metering rod 214. An accelerator pedal lever is shown at 222 and it is pivoted at 224 to the housing portion 162. Upon movement of the lever 222 in a counterclockwise direction about its pivot point 224, it is effective to move the metering rod 214 to the left and to thereby progressively open the metering orifice 212 to provide an increased flow of fuel from the chamber 202 to the chamber 210. When the accelerator pedal lever 222 moves in the opposite direction, the metering rod 214 moves to the right as viewed in Figure 5 to restrict the orifice 212. The dashpot mechanism 220 is effective to retard the rate of movement of the metering rod 214 thereby preventing a sudden decrease in the rate of fuel delivery which could cause a flame "blowout" in the power plant burner.

The housing portions 158 and 160 are also adapted to define a chamber 226 and the housing portions 156 and 158 are also adapted to define a chamber 228. The chamber 226 and 228 are separated by a wall 230 which forms part of the housing portion 158. The chambers 228 and 204 are separated by a wall 232 forming a portion of housing portion 156. Metering orifices are formed at 234 and 236 in the walls 230 and 232 respectively. A metering rod 238 is positioned within each of the orifices 234 and 236 and it includes two tapered sections 240 and 242 which respectively cooperate with the orifices 234 and 236.

Housing portions 160 and 162 are adapted to define a pair of chambers 244 and 246 which are separated by a flexible diaphragm 248 as shown. The metering rod 238 extends through an opening 250 formed in the housing portion 160 and is secured to the flexible diaphragm 248. A spring 252 may be provided to normally bias the diaphragm 248 and the metering rod 238 toward the right as viewed in Figure 5. The chamber 246 is in fluid communication with the high pressure side of an engined driven speed sensor unit shown schematically at 254, said speed sensor unit including a conventional rotor element 256 which is effective to establish a centrifugal head at its periphery. Upon an increase in engine speed, the pressure within the chamber 246 is increased thereby biasing the metering rod 238 to the left to vary the degree of restriction provided by the orifices 234 and 236.

During the starting cycle and during acceleration of the engine up to a predetermined idling speed, the orifice 236 and the tapered metering rod section 240 are adapted to schedule a predetermined flow of fuel from the chamber 204 to the chamber 228. As the engine speed increases, the amount of fuel which is metered by the orifice 236 is increased. The pressure drop across the orifice 236 is near a minimum value when the idling speed is reached. If the engine tends to increase in speed beyond the normal idling speed, the metering rod 238 will be moved further to the left which will in turn increase the degree of restriction offered by the orifice 236. After the idling speed has been reached, the orifice 236 and the metering rod section 240 function as a governor valve to limit the turbine speed to its predetermined value.

To accelerate the engine from an idling speed to a higher operating speed, the metering rod 214 may be urged to the left by means of the accelerator pedal linkage. As the metering rod 214 is moved to the left, the degree of restriction offered by the metering orifice 212 to the flow of fuel from the chamber 202 to the chamber 210 is progressively decreased. Since the metering orifice 234 is in series with the metering orifice 212, movement of the metering rod 214 will not be accompanied by an immediate increase in fuel flow. However, as the engine speed increases, the metering rod 238 is also moved to the left which causes the orifice 234 to become progressively open. It is thus seen that the orifice 234 and the metering rod section 242 function as an accelerating fuel schedule valve which is effective to limit the flow of fuel to the power plant burner to that optimum valve which is required under any given set of power plant operating conditions.

Chamber 228 is in fluid communication with chamber 166 through an internal passage 258, said chamber 166 communicating with the fuel delivery conduit 62 as previously mentioned.

A check valve 260 may be provided, as shown, in the fuel delivery conduit 62 to prevent a reversal in the flow of fuel in the vicinity of the nozzle 22 into the fuel control mechanism after the engine has been turned off.

A bypass passage between the fuel delivery conduit 62 and the fuel tank 56 is provided at 262 and a bypass valve 264 is interposed in the passage 262. The valve 264 may be actuated by means of a solenoid which may be energized by the ignition current when the engine is turned on to block the passage 262. When the ignition current is turned off, the solenoid actuating mechanism may retract the bypass valve element to open the bypass passage 262.

It may be seen from Figures 3 and 4 that the differential between the fuel delivery pressure and the air inlet pressure will tend to remain substantially constant throughout the operating speed range since the fuel delivery pressure is partly determined by the magnitude of the air pressure. However, it has been found that a slight variation does exist as the fuel delivery rate increases from its minimum value to its maximum value. The pressure regulating valve 174 is effective to compensate for this variation in pressure differential and to maintain a constant pressure drop across the various metering valves within the valve assembly 64. It therefore follows that the rate of fuel delivery will be determined solely by the positions which are assumed by the metering rods 238, 214 and 184.

As previously indicated, an important feature of my instant invention resides in the simplicity and reliability which is induced in its construction. By preference, the metering rods 184, 214 and 238 are formed with a circular cross sectional shape because of the accompanying advantages in machining and assembly. The valving portions of the metering rods may be formed as flats with varying transverse dimensions as shown to accommodate the passage of fuel through its associated orifice.

I do not intend to limit my invention to the specific embodiment herein disclosed since many variations thereof may be made without departing from the scope of my invention as defined by the following claims.

I claim:

1. In a liquid fuel control means for an internal combustion engine, the combination of a fuel delivery conduit for connecting said engine with a source of pressurized fuel, throttle valve means, said conduit including a chamber downstream of said throttle valve means, a branch conduit in communication with the first-named conduit upstream of said throttle valve means and bypassing the latter, an acceleration metering orifice and an idle metering orifice comprising portions of said first-named and branch conduit respectively and extending through the walls of said chamber at spaced locations, a fuel scheduling and overspeed governor valve means, a starting fuel scheduling and idle speed governor valve means, the two scheduling and governor valve means comprising separate metering rod portions on a common movable element, said separate rod portions being movable respectively within said acceleration metering and

idle metering orifices, speed responsive means operatively connected with said element for progressively moving the same in one direction or the opposite with increasing or decreasing engine speed respectively, each metering rod portion having an intermediate section of reduced cross sectional area, the metering rod portion in said acceleration metering orifice being arranged to reduce the restriction to fuel flow through the latter orifice progressively upon movement in said one direction under engine accelerating conditions from a position corresponding to a predetermined idling speed to a position corresponding to a predetermined upper speed proximate the maximum allowable speed of said engine and to increase the restriction to fuel flow through the latter orifice upon continued movement in said one direction beyond said last-named position, the metering rod portion in said idle metering orifice being arranged to reduce the restriction to fuel flow through the latter orifice progressively upon movement in said one direction from a position corresponding to an engine starting condition to a position corresponding to said predetermined idling speed and to restrict the fuel flow through said idle metering orifice progressively upon continued movement of the latter metering rod portion in said one direction beyond the latter position, thereby to close said idle metering orifice at speeds above said predetermined idling speed.

2. In a liquid fuel control means for an internal combustion engine, the combination of a fuel delivery conduit for connecting said engine with a source of pressurized fuel, throttle valve means, said conduit including a chamber downstream of said throttle valve means, a branch conduit in communication with the first-named conduit upstream of said throttle valve means and bypassing the latter, an acceleration metering orifice and an idle metering orifice comprising portions of said first-named and branch conduit respectively and extending through the walls of said chamber at spaced locations, a fuel scheduling and overspeed governor valve means, a starting fuel scheduling and idle speed governor valve means, the two scheduling and governor valve means comprising separate metering rod portions on a common movable element, said separate rod portions being movable respectively within said acceleration metering and idle metering orifices, speed responsive means operatively connected with said element for progressively moving the same in one direction or the opposite with increasing or decreasing engine speed respectively, each metering rod portion having an intermediate section of reduced cross sectional area, the metering rod portion in said acceleration metering orifice being arranged to reduce the restriction to fuel flow through the latter orifice progressively upon movement in said one direction under engine accelerating conditions within a range from a predetermined idling speed to adjacent the maximum allowable engine speed and to increase the restriction to fuel flow through the latter orifice upon movement in either direction beyond said range, the latter orifice being only partially closed at said predetermined idling speed, the metering rod portion in said idle metering orifice being arranged to reduce the restriction to fuel flow through the latter orifice progressively upon movement in said one direction from a position corresponding to an engine starting condition to a position corresponding to said predetermined idling speed and to restrict the fuel flow through said idle metering orifice progressively upon continued movement of the latter metering rod portion in said one direction beyond the latter position, thereby to close said idle metering orifice at speeds above said predetermined idling speed.

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