

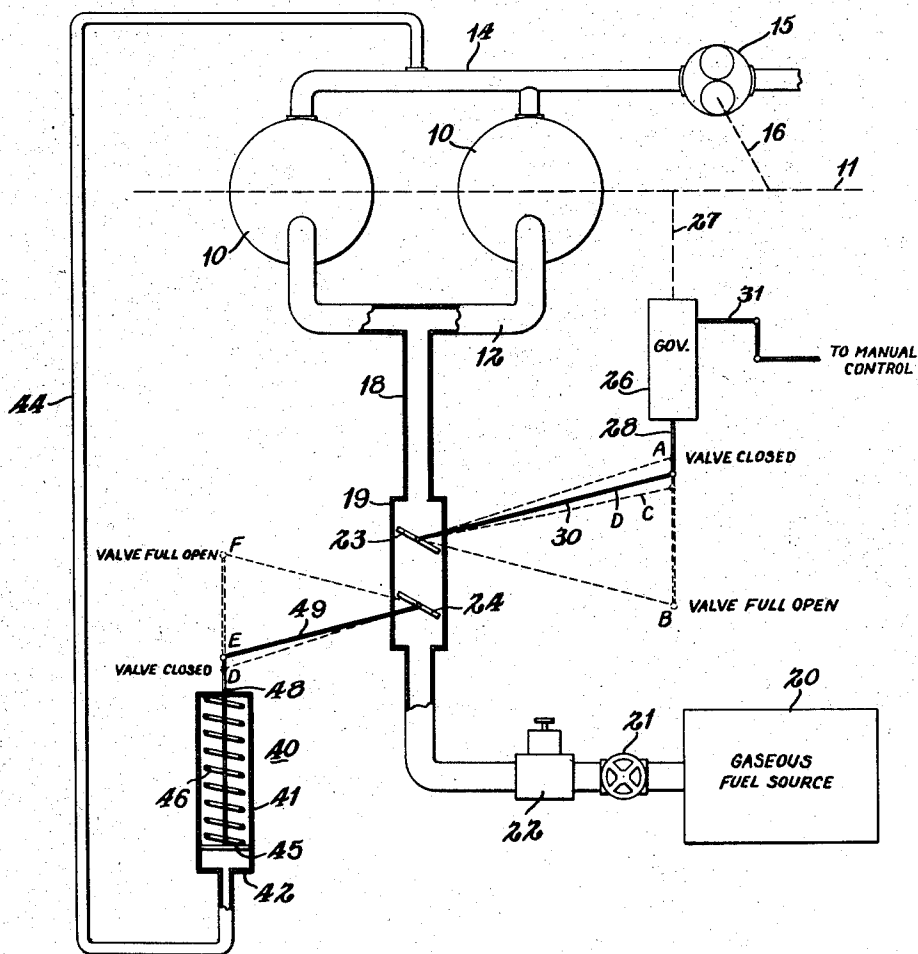
Feb. 5, 1957

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2,780,210

ENGINE FUEL DELIVERY CONTROL

Filed July 20, 1955



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1

2,780,210

ENGINE FUEL DELIVERY CONTROL

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Application July 20, 1955, Serial No. 523,299

7 Claims. (Cl. 123—103)

This invention relates to improvements in the control of fuel delivery to internal combustion engines, and has particular reference to a novel method and manner of regulating fuel supply to engines operable on gaseous fuels.

Engines adapted for operation on gaseous fuels such as propane and the like, are now in relatively wide use with oil drilling rigs and the like, as for operating slush pumps, drill line hoists and other rig equipment. In connection with engines in such use, gaseous fuel is supplied from a fuel source maintained under a substantially constant predetermined supply pressure, with engine delivery of fuel controlled by a throttle valve positioned by an engine driven governor operating responsively to and in accordance with engine torque output or loading. The governor of the type usually employed for controlling the fueling of these engines, is adjustable to and between adjustment settings corresponding to high and low engine speeds, whereby to effect conditioning of the governor for proper load response under various engine speeds.

In the operation of gas engines having a fueling system of the character above indicated, it is found in practice and particularly in connection with drill rig operation, that the operator usually effects governor adjustment to its high speed setting upon any load application to the engine irrespective of whether the applied load is light, intermediate or at the maximum of engine capacity. Moreover, such adjustment generally is effected quite rapidly, as by a quick throw of the governor adjustment to the maximum or high speed setting. As a result, the immediate response of the governor to the applied load, is such as to open the throttle valve to its full open position or at least to an open position greatly in excess of that required for effective fueling of the engine in its acceleration to the speed necessary to carry the then applied load. Consequently, gaseous fuel delivery to the engine is in such quantity as to result in over-rich fuel mixtures which are difficult if not impossible to ignite. Moreover, even though localized ignition may occur as in the immediate region of the ignition device in the cylinder, as a spark plug for example, the remainder of the over-rich mixture usually will quench the initial flame, thus precluding fuel combustion. The result, of course, is that the engine ceases operating or stalls, requiring the operator to restart the engine and make another attempt to place it in operation under the desired load. Very often in drill rig operation, such stalling condition is produced at critical times. Hence, it is highly important to provide a fuel control system which will avoid the difficulty hereinabove described, and which will assure proper engine fueling under all conditions.

The principal object of the present invention, then, is to provide a novel method and manner of controlling gaseous fuel supply to a gas engine which will avoid the disadvantages hereinabove mentioned, attending the single governor operated control, and which will facilitate proper engine operation at all speeds and loads within the range of the engine.

2

Another object is to provide for engine delivery of gaseous fuel in quantity and pressure determined in direct accordance with both engine speed and engine torque output or loading, whereby to obtain proper cylinder fuel mixtures throughout the operating range of the engine.

Other objects and advantages of the invention will appear from the following description of one exemplary embodiment thereof illustrated in the accompanying drawing, wherein the single figure of the drawing discloses diagrammatically, a presently preferred form of fuel control system according to this invention.

Referring to the drawing, only so much of an internal combustion engine as is necessary to a full understanding of the present invention, is here shown in schematic manner. The portion of the engine shown includes engine cylinders 10, the engine crankshaft indicated by the broken line 11 representing the crankshaft axis, a fuel intake manifold 12 for cylinder delivery of gaseous fuel, and a scavenging and charging air supply manifold 14 for cylinder supply of air under pressure established by a suitable air compressor or blower 15. The compressor is driven from the engine crankshaft, as indicated by the broken line drive connection 16, and is of a type or character to produce and maintain compressed air in the manifold 14 at a pressure directly proportional to engine speed.

A fuel supply conduit 18 containing a regulatable fuel control or fuel throttle device 19 hereinafter to be described, connects the engine fuel manifold 12 with a source of gaseous fuel, as the supply tank 20, wherein gaseous fuel is maintained under a substantially constant, determined supply pressure, as for example, a pressure of 40 pounds per square inch. Included in conduit 18 between the source and the device 19, are a main valve 21 and a suitable pressure regulator 22 which may be adjusted to determine and maintain the pressure of the fuel delivered to the control device 19 at any desired value, say for example, about 30 pounds per square inch. The throttle device 19 embodies a chamber and a pair of pivotal throttle valves 23 and 24 arranged in series therein, in the path of gaseous fuel flow through the device. It functions through the valve elements, as a variable orifice for throttling the constant pressure gas supply in line 18 anterior to the device, to a pressure and rate of feed on the discharge or engine delivery side thereof determined by the positions of the valves. The throttle valve 23 which is the leading valve in respect to the direction of fuel flow, is under control of an engine operated speed-settable governor 26 of suitable type, driven from the engine crankshaft as indicated by the broken line 27. The governor which includes speed-setting mechanism (not shown) under adjustment control of the engine speed setting means (not shown) through linkage 31, provides an operating element 28 connected at its end to a valve turning or operating lever 30 extending to and connected with valve 23.

Assuming at this point that the device 19 contains only the governor operated throttle valve 23, the function of the fueling system then is as follows: In the nonoperating or shut-down condition of the engine, the governor 26 then inactive, locates lever 30 at position A shown in dotted lines, closing the throttle valve. The dotted line position B of the lever, wherein valve 23 is full open, is effected by the governor responding either to full load torque output of the engine at rated full speed or to overload torque output within the capacity of the engine. Now when the engine is started (in suitable manner) for operation initially at its normal no-load, idling speed, the governor 26 (as it may be adjusted through linkage 31 to a low or idling speed setting) operates during starting and engine acceleration to idling speed, to open the throttle

3

valve 23 for gaseous fuel admission to the engine. Under normal conditions, governor operation of the valve at such time, effects valve opening to an open condition represented by governor location of the lever 30 at say position C which in the present example may represent the extent of valve opening required for throttling fuel delivery to a pressure and rate of feed sufficient for causing engine acceleration to its idling speed. The solid line position D of the lever is that in which the throttle valve 23 is in its optimum open position establishing fuel delivery to the engine at a rate of feed and pressure just sufficient for maintaining no-load, idling speed operation of the engine. The latter position normally is effected as the engine reaches and assumes its no-load, idling speed. While the foregoing is the normal function, under certain conditions including adjustment of the governor to its high speed setting at starting, the governor may tend to and actually open the throttle valve 23 to an excessive open condition. The resultant over-rich fuel mixtures in this event, would be productive of no better than sporadic engine firing and more usually, engine stalling as before indicated.

The above-described character of governor-valve operation usually obtains in even more pronounced degree, consequent to loading of the engine. For example and as mentioned at the outset, upon applying a load to the engine the operator usually adjusts the governor from its low speed setting (under no-load, idling operation of the engine) all the way to its high speed setting, whether or not the load applied is low, intermediate or a maximum. The governor then in response to the load on the engine, actuates the throttle valve 23 in the opening direction and tends to move the valve to its full open position, admitting fuel to the engine in excessive amount. The result is an over-fueling of the engine with consequences as before mentioned. This condition at times, may be such as to choke the engine to the point of engine stalling, before the engine can accelerate to a speed providing the requisite engine torque output equal to or commensurate with the applied load, at which point the governor normally would have returned the valve to its optimum open position for maintaining such engine speed under the applied load.

Therefore, the present invention contemplates additional control means to assure proper fuel regulation under the hereinabove indicated critical engine operating conditions. Such control now to be described and which includes the throttle valve 24 anterior to governor valve 23 in device 19, is operable responsively to and in accordance with engine speed. Its function is such as to introduce fuel throttling during engine acceleration to idling speed or to a speed commensurate with a then applied load, which will assure proper engine fueling to bring the engine to its idling or running speed under load, even though the governor operated valve 23 is open to an excessive extent or full open at least in the initial phase of acceleration. When the required speed is reached (idling or under the then applied load), the governor then positions the valve 23 according to the load condition of the engine, while the valve 24 occupies a position corresponding to the attained engine speed. The conjoint throttling effect of the valves as then so related (determined by proper orifice design of the device 19), is such as to determine engine fuel delivery in quantity and pressure just sufficient to maintain engine operation at the attained speed. Engine speed operation of valve 24 is here effected as shown, by a pressure responsive device or servo-motor 40 operatively subject to the air pressure in the engine air supply manifold 14 wherein as before indicated, the air pressure varies directly with engine speed. The device 40 may be of any suitable character, but as here shown diagrammatically, it comprises a cylinder 41 having its head end 42 in communication with engine air manifold 14 through an air line 44, a piston 45 slidable in the cylinder and spring-loaded in the direction of the cylinder

4

head 42 by a compression spring 46, and an operating element 48 connected to the piston and projecting from the cylinder to connection with the valve actuating lever 49 of valve 24. The device 40 and throttle valve 24 are so operatively related that in the inactive condition of the engine (zero engine speed), the piston 45 will be located by spring 46 at its limit position adjacent the cylinder head 42, thereby affecting closure of throttle valve 24 through lever 49 and piston rod or element 48 with the lever at dotted line position D. When the engine is operating at no-load, idling speed, the device 40 then functions in response to the pressure of air obtaining in the engine air manifold at engine idling speed, to displace its operating element 48 for locating lever 49 at said solid line position E, thereby to effect a slight open condition of throttle valve 24. At full or maximum engine speed, the device 40 responds to the maximum manifold air pressure corresponding to such engine speed, to locate the lever 49 at dotted line position F, wherein the throttle valve 24 is at full open position. Correspondingly, under engine speeds between idling and maximum speeds, the device operates to effect intermediate open positions of the throttle valve 24 in direct correspondence with engine speed.

The two throttle valves in series or tandem relation, with one positioned in direct accordance with engine speed, while the other is positioned in direct accordance with engine torque output or loading, thus cooperate in normal running operation of the engine either at idling speed or at a speed commensurate with the applied load, to determine proper engine fueling, while the speed operated valve 24 is effected during engine acceleration for assuring regulation of gaseous fuel admission to the engine in a manner to establish such pressure and quantity of fuel delivery in the acceleration phase, as will avoid over rich, difficult and impossible to ignite fuel mixtures and consequent engine stalling.

While in the diagrammatic, exemplary embodiment of the engine fuel control system as shown, the pressure operated, engine speed responsive device 40 is actuated by air pressure from the engine air supply manifold 14, it is to be understood that the device 40 may be provided or adapted for response to any other fluid system embodied in the engine and in which the pressure or temperature of the fluid therein varies in direct accordance with engine speed. For example, such other fluid system may be the jacket cooling water system of the engine (not shown) in which the temperature of the cooling water or other coolant fluid is proportional to engine speed, or it may be the pressure lubricating oil system of the engine (also not shown).

In accordance with the improved method and manner of engine fuel delivery control as herein provided, it will appear now that the fuel supplied to the engine is controlled in respect to pressure and quantity delivery thereof, by regulation of the fuel supply in direct accordance with both engine speed and engine torque output or loading, and that such regulation is effected in the preferred manner shown, by series-related throttle valves one positioned according to engine speed and the other positioned according to engine loading.

It is to be noted here that the speed responsive throttle control as herein provided for the purpose described, is effective as an engine overload control under any speed and load operating condition of the engine. For example, assume that the engine is in normal operation at say three-quarter speed under full or one-hundred percent load for such speed. Now, if the engine is subjected to a sudden or rapidly applied overload beyond the engine capacity at such speed, as for example a one-hundred and forty percent load, the governor will respond to effect full opening of throttle valve 23 for full fuel admission. However, initially upon overload application to the engine, the speed responsive device 40 will retain the throttle valve 24 momentarily in its part-open position corresponding to

5

the engine operating condition prior to overloading. Now and unless the overload is promptly removed, the engine speed will decrease with resultant response of device 40 to move throttle valve 24 in the closing direction. Consequently, with insufficient and in fact decreasing fuel admission, the engine will stall or cease operation. This additional function of the speed responsive device, as to preclude engine operation in any overloaded condition, may be set for any given engine installation by selection or adjustment of the spring 46 in respect to its capacity and operating characteristics, so that device 40 will operate throttle valve 24 in a range which will not admit more fuel than is required for maximum permissible engine torque output at a given engine speed. Thus, overload abuse of the engine is thereby prevented.

Having now described and illustrated the present invention, what it is desired to claim and secure by Letters Patent is:

1. In an internal combustion engine operable on gaseous fuel, a supply system for the delivery of gaseous fuel under pressure to the engine, said system including a control device regulatable for determining the pressure and quantity of gaseous fuel delivery to the engine, engine cylinder air supply means separate from said gaseous fuel supply system and including an engine driven blower for cylinder delivery of air under pressure, wherein the air pressure varies in direct proportion to engine speed, engine driven means having a control element positionable in accordance with the torque output of the engine, and pressure responsive means including a control element, connected to said air supply means for air pressure response to position its said control element directly in accordance with engine speed, both said control elements being operatively associated with said control device for regulating the latter.

2. In an internal combustion engine operable on gaseous fuel, a fuel supply system for the delivery of gaseous fuel under pressure to the engine, said system including gas throttle valves for determining the pressure and quantity of gaseous fuel delivery to the engine, engine operated means responsive to engine loading and operatively connected to one of said throttle valves for actuation thereof in direct accordance with engine loading, and engine speed responsive means operatively connected to another of said throttle valves for actuation thereof in direct accordance with engine speed.

3. In an internal combustion engine operable on gaseous fuel, means providing a source of gaseous fuel under pressure, conduit means between said source and the engine for engine delivery of gaseous fuel, a fuel delivery control in said conduit means providing a valve chamber and gas throttle valves in series relation in the chamber, engine operated means responsive to engine loading and operatively connected to one of said throttle valves for

6

actuation thereof in direct accordance with engine loading, and engine speed responsive means connected to another of said throttle valves for actuation thereof in direct accordance with engine speed.

4. In an internal combustion engine operable on gaseous fuel and having a fluid pressure system in which the pressure of the fluid therein is proportional to engine speed, means providing a source of gaseous fuel under pressure, conduit means between said source and the engine for engine supply of gaseous fuel, gas supply throttle valves in the conduit means, engine operated means responsive to engine loading and operatively connected to one of said valves for actuation thereof in direct accordance with engine loading, and a fluid pressure operated device between said fluid pressure system and another of said throttle valves for actuation of the latter in accordance with engine speed.

5. In an internal combustion engine operable on gaseous fuel and having a fluid pressure system in which the pressure of the fluid therein varies directly with engine speed, means providing a source of gaseous fuel under pressure, conduit means between said source and the engine for engine supply of gaseous fuel, a fuel delivery control in said conduit means providing a valve chamber and gas throttle valves in series relation in the chamber, engine operated means responsive to engine loading and operatively connected to one of said valves for actuation thereof in direct accordance with engine loading, and a fluid pressure operated device connected to said fluid pressure system and to another of said throttle valves, effective for actuating the latter valve in accordance with engine speed.

6. The method of controlling gaseous fuel supply to an internal combustion engine, comprising providing gas volume and pressure delivery controlling throttle valves in series in the path of gas fuel supply to the engine, regulating one of said valves in direct accordance with engine loading, and regulating another of the valves in direct accordance with engine speed.

7. The method of controlling gaseous fuel supply to an internal combustion engine, comprising providing a pair of gas volume and pressure delivery controlling throttle valves in series in the path of gas fuel supply to the engine, regulating the valve anterior in the direction of fuel flow in the supply path, in direct accordance with engine speed, and regulating the posterior valve in direct accordance with engine loading.

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