

Sept. 16, 1958

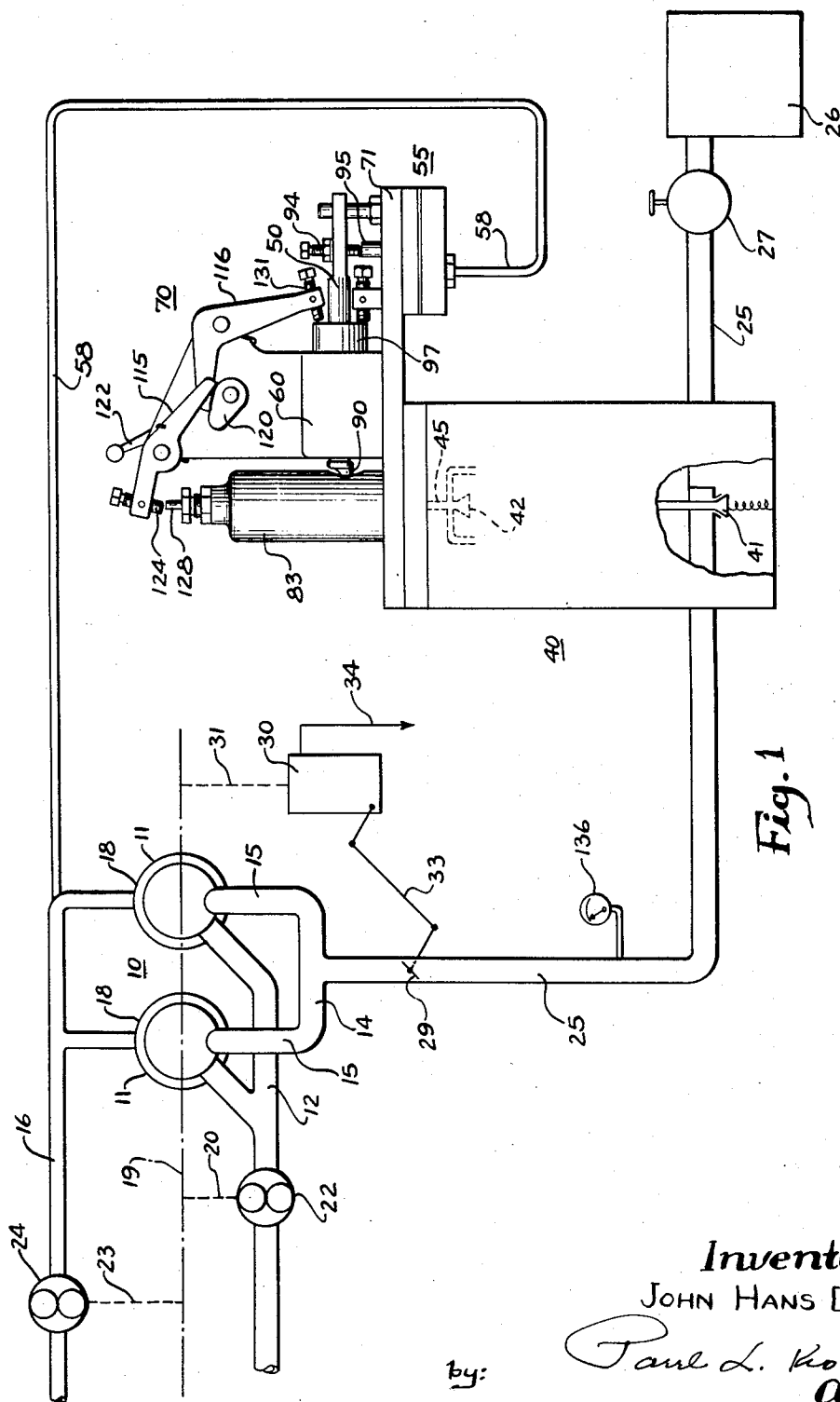
J. H. DAVIDS

2,852,013

FUEL SUPPLY REGULATOR FOR GAS ENGINES

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3 Sheets-Sheet 1



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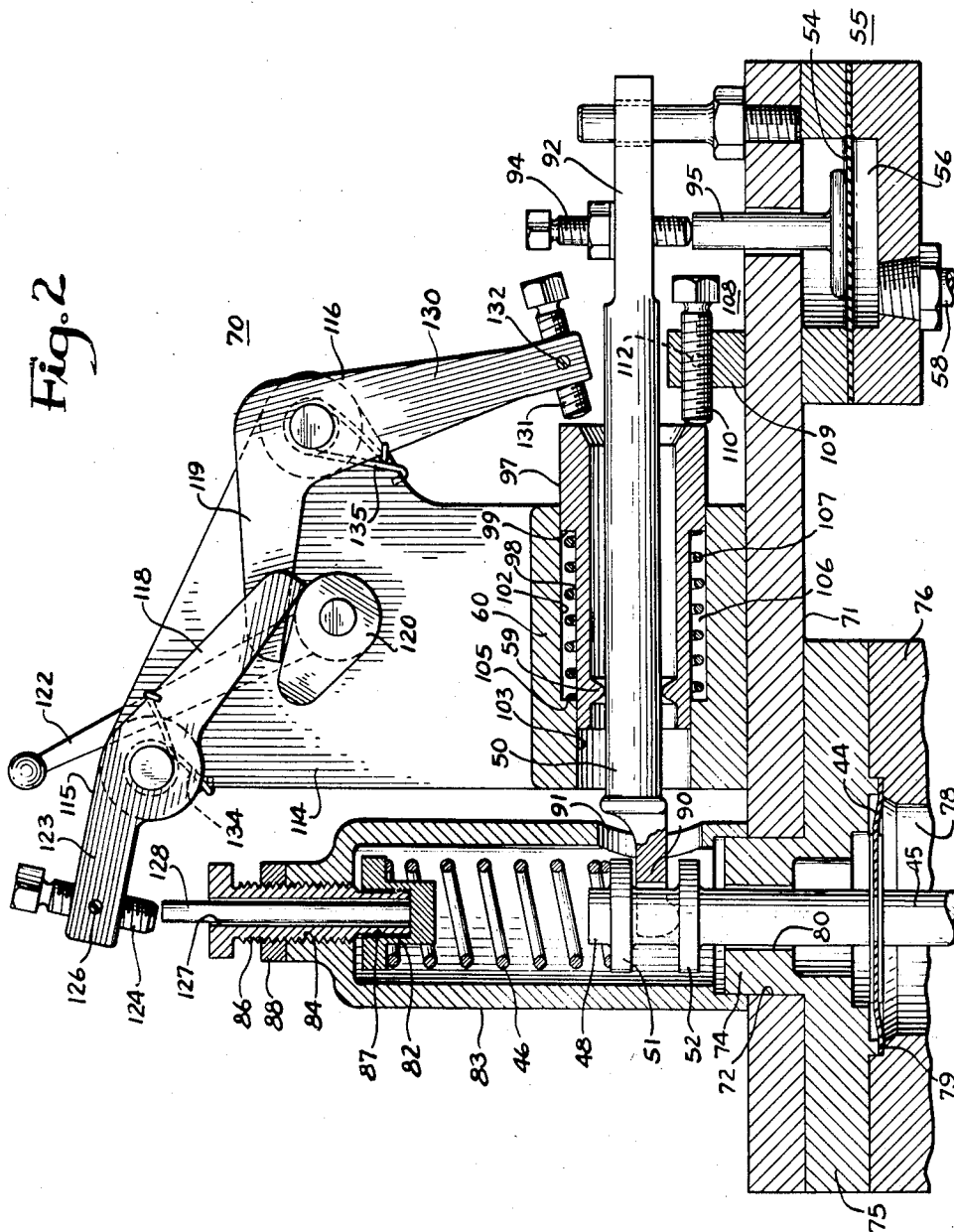
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FUEL SUPPLY REGULATOR FOR GAS ENGINES

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3 Sheets-Sheet 2



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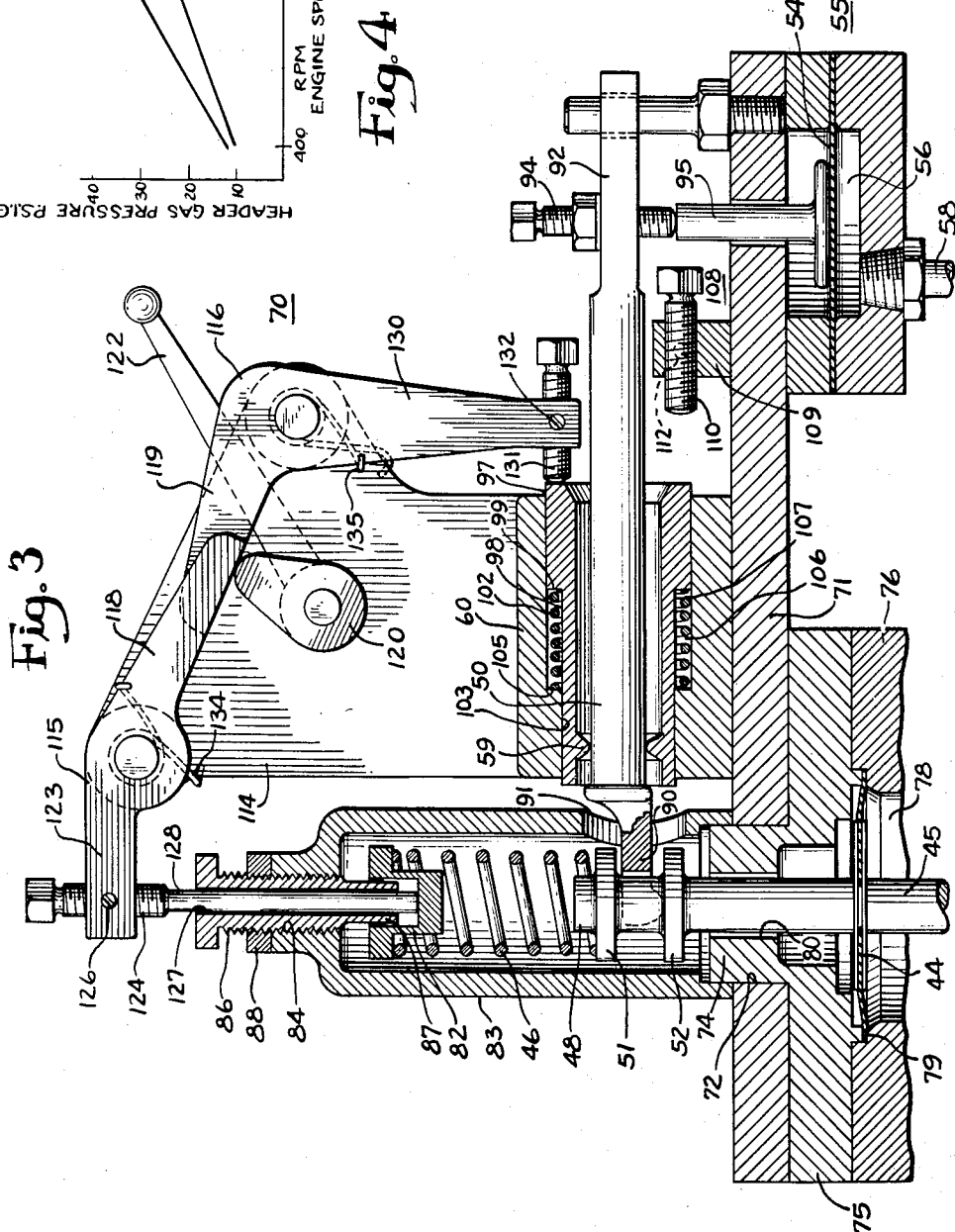
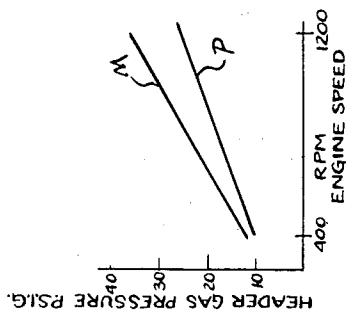
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FUEL SUPPLY REGULATOR FOR GAS ENGINES

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3 Sheets-Sheet 3



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2,852,013

FUEL SUPPLY REGULATOR FOR GAS ENGINES

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Application November 21, 1956, Serial No. 623,606

11 Claims. (Cl. 123—120)

This invention relates to improvements in fuel supply systems for internal combustion engines adapted for operation on suitable gaseous fuels, such as natural gas, propane, or the like. It has particular reference to two-cycle gas engines of variable speed type, such as are employed with oil field rigs and the like, and concerns apparatus for changing over engine operation from one type of gaseous fuel to another, as may be required in oil field service.

In engines of the character indicated there are, among other things, two particularly troublesome problems. One involves the inability of the usual type of fuel system to supply the engine with gas fuel at pressure and in quantities appropriate for effective engine function over the entire speed and load range. A satisfactory solution to this difficulty is afforded by an improved fuel control arrangement forming the subject of a copending application, Serial No. 579,551, filed April 20, 1956, and assigned to the assignee of the instant application, which provides a control provision for adjusting or modulating the gas pressure in direct proportion to engine speed variations.

The other problem, and the one with which this application deals, concerns the inability of such a gas pressure control provision to accommodate quick and easy change-over between gaseous fuels of different heat values.

To illustrate the problem: as shown specifically in said copending application and described generally herein, the control provision for regulating the gas pressure is operable in accordance with engine speed. The air manifold pressure, water jacket pressure, or any engine shaft driven apparatus which reflects the engine speed, is utilized to actuate said control provision for operating a pressure regulator valve device. Since the control provision and valve device are arranged to determine gas pressure in direct proportion to engine speed, it is necessary that they be pre-set to produce proper pressure values at the upper and lower speed limits. Such settings will then permit proper engine operation over its full range, for a given gas fuel of known B. t. u. heat value.

However, in some locations, propane is used when natural gas (methane) is not available. Since these gases have different heat characteristics, a control provision set-up for one will not accommodate the other to produce proper pressure values for engine operation. Thus, the problem of improved engine operation through engine speed regulation of gas pressure, becomes a problem of providing suitable structure whereby the same control provision can be utilized to regulate the gas pressure of gaseous fuels having different heat characteristics.

Accordingly, the general object of the present invention is to afford, in an engine fueling system as hereinabove mentioned, a control provision arranged in the line of gas fuel supply, and operable automatically to determine the gas supply pressure at values in direct proportion to engine speed.

More specifically it is an object of the present invention to provide a control provision as indicated, for adjusting or modulating the gas pressure in direct proportion to

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engine speed variations, which control provision is so constructed and arranged as to be capable of regulating the gas pressure of gaseous fuels having different heat characteristics.

Another object is to afford a control provision for the purpose indicated, which comprises a gas pressure regulator valve device embodying control means normally adjustable for pre-setting the device to establish the pressure of a given gas of known B. t. u. heat value in discharge from the device at the upper and lower speed limits, and engine speed influenced adjusting means for said control means, adapted and arranged for effecting adjustments of the control means in direct accordance with variations in engine speed, whereby to produce corresponding changes in the pressure of gas discharge from the device.

A further object is to provide a control provision of the character generally indicated in the preceding object, wherein the control means for presetting the gas pressure regulator device embodies adjustable means whereby a single control provision can be pre-set to accommodate more than one type of gaseous fuel without further or subsequent setting of said device.

A still further object is to provide a control provision of the character and for the purpose indicated, which comprises a gas pressure regulator valve device effective on gas supply, having control means operable automatically to determine the gas supply pressure at values in direct proportion to engine speed, said control means including spring biased engine speed influenced adjusting means, and stop means for pre-setting the spring bias of said means whereby to establish upper and lower gas pressure limits.

A yet further object is to provide a control provision of the nature indicated in the preceding object, wherein the stop means for pre-setting the spring biased means contemplates multiple stop members such that said control provision can be set up to accommodate gaseous fuels having different heat characteristics, and selector means for conditioning the control provision for making particular stop members effective in accordance with the type gas to be regulated.

The foregoing and other objects and advantages will appear more fully, upon consideration of the following description of a presently preferred embodiment thereof as exemplified in the accompanying drawings, wherein:

Fig. 1 is a diagrammatic view showing an engine and gas fuel supply system therefor, with the improved gas pressure regulator provision shown schematically in the system.

Fig. 2 is an enlarged fragmentary view, mostly in section, of the gas pressure regulator provision as shown in Fig. 1.

Fig. 3 is an enlarged sectional view similar to Fig. 2, but in which particular control mechanism has been operated to condition the regulator provision for accommodation of a gaseous fuel having heat characteristics different from the gaseous fuel to be regulated by the mechanism condition of Fig. 2.

Fig. 4 is a graph showing the gas pressure range as to propane and methane, over an engine speed range of 400 to 1200 R. P. M.

Referring to the drawings and particularly to Fig. 1, illustrated diagrammatically at 10 is a variable speed internal combustion engine which may be of two-cycle type, adapted for operation on suitable gaseous fuel, such as propane and methane, or the like. The engine as shown, includes cylinders 11, a scavenging and combustion air supply manifold 12 in connection to the cylinders, a gas fuel inlet manifold 14 having branches 15 each leading to the cylinder inlet valve (not shown) of the associated cylinder, a cooling water supply conduit 16 in

connection to the cylinder jackets 18, and the engine crankshaft indicated by the broken line 19. Driven from the crankshaft, as by the drive connection indicated by the broken line 20, is a suitable blower or compressor 22 of a type to afford an adequate volumetric supply of air in the manifold 12. Also driven from the crankshaft, as by the drive connection indicated by the broken line 23, is a water pump 24 suitable to supply a sufficient quantity of water to the cylinder jackets 18; under a pressure which is in direct proportion to engine speed.

Connected to the engine gas manifold 14 is a gas supply conduit 25 which extends from a source of gas fuel under a predetermined source pressure, such source being represented by the tank 26. For the purpose of this disclosure, the tank 26 is to be considered as a source of several different gas fuels (as propane and methane) of differing heat values, from which any selected one of such gas fuels is in supply to the conduit 25 at any one time. Included in the conduit 25 are a manual shut-off valve 27 and a gas throttle valve 29 illustrated as a "butterfly" type valve. Throttle valve 29 is controlled or regulated by a governor 30 of suitable, well-known form, which is engine driven through connection 31 to the engine crankshaft 19, and operates in accordance with engine torque output or loading. The throttle valve and governor are operatively connected by linkage generally indicated at 33, while the governor is settable for load responsive operation at selected engine speeds, by speed setting mechanism (not shown) embodied in the governor and controlled manually through linkage indicated at 34.

Arranged in the gas supply conduit 25 at a suitable point therein which is anterior to the throttle valve 29, is a pressure regulator valve device generally indicated at 40. Device 40 may be of suitable, readily available type, providing a main gas throttling valve indicated at 41, and a valve positioning means (not shown) which is controlled in a known manner by pilot valve control indicated in outline at 42.

Referring now to Fig. 2, pilot valve operation is determined through a differential pressure responsive diaphragm 44 fixed to pilot valve stem 45. Said diaphragm is subjected on its under side to the pressure of gas fuel at the outlet side of main valve 41 (as the pressure of gas in the conduit 25 between the valve 41 and throttle valve 29), and on its upper side to an opposing pressure provided, in part, by a spring 46 in compression against the outer end 48 of the pilot valve stem 45. The compression of spring 46 is adjustable or settable in a manner to be described later. As is well known in regulators of this type, an increase in the compression of spring 46 to effect a corresponding increase in the opposing force thereof on diaphragm 44, results in pilot valve control of the main valve 41 to determine such increased gas pressure at the regulator output to conduit 25 as will rebalance the pilot valve diaphragm, and hence, establish the pressure of gas fuel in supply to the throttle valve 29 at a value corresponding to the then adjusted compression setting of the spring 46. A decrease in spring compression on the pilot diaphragm will effect on the other hand, a correspondingly lower gas pressure in supply to the throttle valve 29.

In accordance with the present invention, the effect of spring 46 on the pilot diaphragm is augmented or modulated by means acting on the diaphragm of the pilot valve control to impose a force thereon in direct proportion to engine speed, which results in operation of the regulator valve device 40 to determine the pressure of gas supply to the throttle valve 29 at pressure values varying in direct proportion with engine speed variations. The modulating means is comprised in general of a fulcrumed lever 50 having one end engaged between upper and lower flanges 51 and 52, respectively, on the pilot valve stem 45. The opposite end of the lever is connected to the movable element or piston 54 (here shown

as a diaphragm) of a fluid pressure operated servo-motor indicated at 55, the cylinder or pressure chamber 56 of which is in connection by conduit 58, with the cooling water supply conduit 16 (Fig. 1). The lever 50 is pivotally supported, intermediate its ends, by a fulcrum or pivot member 59 of suitable character, which is positionally adjustable along the lever, as on support 60.

With proper setting of the lever fulcrum 59 and selected adjustment of the spring 46, the pressure regulating function of device 40 may be determined such that at engine idling speed, for example, the pressure of gas supply to the throttle valve 29 will be at the pressure required for engine operation under the idling condition. Further, in the example given, upon increase in engine speed to a low or intermediate operating speed, the modulating lever control responds in direct proportion to the increased engine speed, as measured by the corresponding increased water pressure in the supply conduit 16, to increase the loading force on the pilot valve diaphragm correspondingly, and thereby cause the regulator 40 to determine the gas pressure at the value required for effective engine operation under the higher speed condition. With increase in speed to the normal maximum engine speed, the modulating lever device responds in proportion to engine speed, to further increase the valve diaphragm loading force correspondingly and up to a maximum determined by the maximum engine speed, for causing like increase in the gas pressure at the throttle valve to values necessary for effective engine function at high speeds. Of course, with decrease in engine speed, the modulating lever provision operates in the reverse of the foregoing, as to cause the pressure regulator to readjust gas pressure to the required lower values.

It will be appreciated from the foregoing, that by adjusting the function of the pressure regulator 40 through the modulating lever provision acting in direct proportion to engine speed, the gas pressure at the throttle valve 29 may be set in direct accordance with engine speed, such that for any given engine speed, the gas pressure is at the necessary or optimum pressure value required for effective engine operation over its load range at the given engine speed. Thus, with speed proportioning of gas pressure in this manner, the load limit for any given engine speed may be determined by the gas pressure setting for the given speed. Consequently, overloading of the engine at any given speed is precluded by the present gas pressure regulating provision.

In the indicated embodiment, the adjustable spring 46 affords a fixed force on the pilot diaphragm of the regulator, variable in value according to the adjusted setting of the spring, while the pivoted lever provision provides a modulating force automatically varying in proportion to engine speed. The force ratio of the lever provision is adjustable, as previously indicated, by varying the position of the lever fulcrum 59, whereby to permit of adjustments in the operation of the provision to accommodate given conditions of a given engine installation, and to adapt the modulating control to the B. t. u. heat value of the gas fuel. The manner of effecting the indicated adjustments will now be described.

Referring to Figs. 2 and 3, there is shown enlarged detailed views of the control provision, indicated generally by reference numeral 70, which acts to control the pressure regulator valve device 40 whereby to regulate the gas pressure supply to the engine in direct proportion to the engine speed. Fig. 2 shows said control provision conditioned or set up for use with a particular gaseous fuel, for example, propane, whereas Fig. 3 shows said control provision set-up for use with a different gas, such as methane. In both views like parts are designated by the same reference numeral. As indicated, a base or support member 71 is provided, near one end thereof, with a bore 72, into which seats a hub portion 74 of a flange member 75, said flange member being secured to said base in any suitable manner. Said flange member

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cooperates with an underslung housing 76 to afford a chamber 78, in which is disposed diaphragm member 44, secured at its outer periphery between the flange and the housing, as at 79, and mounted on pilot valve stem 45, said valve stem extending through a bore 80 in flange hub 74 to termination in spaced apart flange portions 51 and 52 and stub or end portion 48. Said pilot valve stem is integral with a pilot valve 42 (shown dotted in Fig. 1), which operates valve positioning means (not shown) in a well known manner to control gas throttling valve 41.

As previously mentioned, the diaphragm 44 is subjected on its underside to the pressure of gas fuel at the outlet side of main valve 41, and on its upper side to an opposing pressure provided, in part, by spring 46 in compression against the outer end 48 of the pilot valve stem 45. Said spring is contained between the stem outer end 48 (against flange 51) and a cup-like member 82, all of which are disposed within a housing member 83 mounted on the base 71. The upper portion of said housing is provided with a threaded bore 84, aligned with the valve stem axis, and having a bolt or stop member 86 threaded therethrough. The end portion 87 of bolt 86 fits into and abuts the cup-like member 82, whereby movement of said bolt, in or out, will cause like movement of said cup-like member, thereby increasing or decreasing the compression factor of spring 46, respectively. A lock nut 88, in threaded engagement with bolt 86, provides means for maintaining said bolt in any degree of adjustment as may be required.

It should be obvious that movement of bolt 86 inwardly will cause an increase in the compression of spring 46 to effect a corresponding increase in the opposing force thereof on diaphragm 44, resulting in pilot valve control of the main valve 41 to determine such increased gas pressure at the regulator outlet to conduit 25 as will rebalance the pilot valve diaphragm, and hence, establish the pressure of gas fuel in supply to the throttle valve 29 at a value corresponding to the then adjusted compression setting of the spring 46. A decrease in spring compression on the pilot diaphragm will effect, on the other hand, a correspondingly lower gas pressure in supply to the throttle valve 29.

As before described, the effect of spring 46 on the pilot diaphragm is augmented or modulated by means acting on the diaphragm of the pilot valve control to impose a force thereon in direct proportion to engine speed, which results in operation of the regulator valve device 40 to determine the pressure of gas supply to the throttle valve 29 at pressure values varying in direct proportion with engine speed variations. The modulating means is comprised of the fulcrumed lever 50 having one end 90 extending through an opening 91 in the housing 83 to engagement between upper and lower flanges 51 and 52, respectively, on the pilot valve stem 45, said one end preferably being bifurcated so as to insure a positive engagement with said stem. The other end 92, of the lever 50, is provided with an adjustable member or bolt 94 which depends from said lever sufficiently to abut the stem portion 95 of a movable element or piston 54 (here shown as a diaphragm) of a fluid pressure operated servomotor indicated at 55. As previously mentioned the servo-motor chamber 56 is in connection by conduit 58 with the cooling water supply conduit 16, and any pressure change of said water supply will be reflected by movement of stem 95 to cause movement of lever 50, with subsequent effect at lever end 90 on the pilot valve stem 45.

It should be apparent that the degree of movement of lever end 90 responsive to movement of lever end 92, is dependent on the position of fulcrum 59 relative to lever 50. For purposes to be later described, the fulcrum member 59 is adjustable, and in the following manner. Said fulcrum member is cylindrical in shape, having its

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outer surface formed to provide a main cylindrical surface 97, and a reduced cylindrical portion 98, thereby providing a shoulder 99. Support member 60 is formed to provide a cylindrical bore having a main cylindrical surface 102 and a reduced cylindrical surface 103, thereby forming a shoulder portion 105. As shown in the drawings, the cylindrical outer surfaces of fulcrum member 59 are so related to the cylindrical surfaces of the bore as to form a cylindrical pocket or space 106 between the shoulders 99 and 105. Disposed in said cylindrical space 106 is a helical spring 107, of the compression type, which urges said shoulders apart, i. e., the spring tends to move fulcrum member 59 outwardly, or to the right as shown in the drawings. Opposed to this spring-urged outward movement of the fulcrum member, so as to limit said movement, is an adjustable stop member 108, comprising a boss or flange 109 fixed to base plate 71, having a bolt 110 threaded therethrough and provided with a set-pin 112 (indicated in outline) for locking said bolt in any desired position of adjustment. It is apparent then, that with member 59 in abutment with bolt 110, movement of the latter will result in movement of fulcrum member 59 whereby to change the length and effect of lever arms 90 and 92, one to the other.

As will be described more fully later, adjustable stop member 86 is preset to produce the proper pressure value at the lower speed limit, stop member 108 is pre-set to determine fulcrum positionment for the proper pressure value at the upper speed limit, and lever 50 acts in response to changes in engine speed to produce, in direct proportion thereto, proper intermediate pressure values, for a given gas of known heat value.

Referring again to Figs. 2 and 3, support member 60 has formed as a part thereof, an upright plate 114, to which are pivotally mounted upper and lower bell cranks, 115 and 116, respectively. Upper bell crank 115 has one arm 118 extending towards the lower bell crank 116, while said lower bell crank has one arm 119 extending toward said upper bell crank, said arms 118 and 119 extending in an over-lapping relation, adjacent a cam member 120, said cam having a handle 122 operatively associated therewith for rotary movement of said cam to either of two positions, as indicated.

Upper bell crank 115 has another arm 123 which extends over housing member 83, and is provided with an adjustable bolt or stop member 124, threaded therethrough, having a set-screw 126. Stop member 86, formed to provide a central bore 127, has a rod 128 disposed therein and which bolt 124 may abut when bell crank 115 is in the proper position (Fig. 3). With bolt 124 properly adjusted, movement of bell crank 115 to the position shown in Fig. 3, will cause rod 128 to move beyond the end 87 of bolt 86, thereby acting upon cup-like member 82 to effect the compression factor of spring 46. In this position, adjusting movement of bolt 124, in or out, will cause like movement of said cup-like member, thereby increasing or decreasing the spring compression factor, as the case may be.

Lower bell crank 116 has another arm 130 which extends to a position adjacent the fulcrum 59, and which is provided with an adjustable bolt or stop member 131, threaded therethrough, having a set-screw 132. When bell crank 116 is in the position shown in Fig. 3, adjusting movement of bolt 131, in or out, will cause like movement of said fulcrum member, thereby changing the lever arm ratio of lever 50.

As shown in the drawings, the bell cranks 115 and 116, are under bias through springs 134 and 135, respectively, so as to insure positive and immediate response of said bell cranks to movement of the cam member 120. Also, it should be noted that due to the cam shape, said cam is either effective or ineffective as regards the bell cranks, and is positionable through handle 122 to condition the elements, either as shown in Fig. 2, or as shown

in Fig. 3. As previously pointed out, and as now will be described, Fig. 2 shows the control provision conditioned or set up for use with one particular gaseous fuel, for example, propane, whereas Fig. 3 shows said control provision set-up for use with a different gas, such as methane.

Assume a given engine installation wherein the upper and lower engine speed limits are 1200 R. P. M. and 400 R. P. M., respectively, and two gaseous fuels, propane and methane, are available for supply to said engine. As predetermined by test under the above conditions and with the engine running at no load, it is found when using propane that the gas pressure in supply to the engine throttle valve should closely approximate 10 p. s. i. g. at the minimum engine speed of 400 R. P. M., and about 25 p. s. i. g. at the maximum speed of 1200 R. P. M. The curve P as shown in the graph of Fig. 4, indicates the pressure range for propane, over the engine speed range of 400 to 1200 R. P. M., with the gas pressure in p. s. i. g. being the header pressure in supply to the throttle valve 29.

Now with gas fuel supplied to the pressure regulator device, at say a minimum of 50 p. s. i. g., the engine is started and operated under no load at 400 R. P. M. Referring to Fig. 2, the regulator spring 46 is adjusted by movement of stop member 86 until the spring pressure plus the additional pressure imposed by the speed responsive lever 50 then effective on the pilot diaphragm 44, is such as to set the regulator for determining the gas pressure at the throttle valve (which may be observed, Fig. 1, on a pressure gauge 136 in the conduit 25), at the desired value of 10 p. s. i. g. Whereupon, the engine speed is increased to 1200 R. P. M. at no load. If the pressure on gauge 136 is greater than the desired 25 p. s. i. g. the lever fulcrum 59 then is moved in the direction away from the lever end which is in engagement with the pilot valve stem. This adjustment is made by "threading out" the bolt 110 whereby action of spring 107 causes fulcrum member 59 to move outwardly, or to the right as shown in the drawings. On the other hand, if the pressure is below 25 p. s. i. g., the fulcrum is moved in the opposite direction, or towards the lever end which is in engagement with the pilot valve stem, as by "threading in" bolt 110. After such fulcrum adjustment, the engine is again run at 400 R. P. M., and the spring 46 then adjusted, if necessary, until the gauge pressure reads 10 p. s. i. g. Following this, the engine speed is increased to 1200 R. P. M., and the gauge pressure is then observed. If the pressure is substantially at 25 p. s. i. g., the regulator is in proper adjustment for engine operation over its full speed and load range, with the lever control 50 acting to regulate the pressure of gas supply to the throttle valve within the indicated pressure range, in direct proportion to engine speed. If, however, the gas pressure at 1200 R. P. M. under the no load condition of the engine, is not at the required 25 p. s. i. g. value, then the foregoing described adjustment steps must be repeated until the required pressure conditions are obtained.

When the above adjustments have been made, the control provision 70 is set up to regulate one gaseous fuel, as by example, propane. To condition the control provision for another gaseous fuel, say methane, while yet maintaining the proper settings for propane, requires that handle 122 be rotated clockwise, to the position indicated in Fig. 3. Such handle movement causes like movement of cam member 120, which actuates bell cranks 115 and 116 through the arms 118 and 119, respectively, to the positions shown.

Movement of bell crank arm 123 causes bolt 124 to contact rod 128, and upon full actuation of said arm, said rod extends beyond the end 87 of stop member 86. As shown in Fig. 3, rod 128 then abuts cup-like member 82 and moves it away from contact with stop member 86, thereby effecting a new compression adjustment of spring 46 independent of the setting of member 86, and

without disturbing the setting of the latter. Also, movement of bell crank arm 130 causes bolt 131 to contact fulcrum member 59, and upon full actuation of said arm, to move said fulcrum away from stop member 110 and toward the lever end which is in engagement with the pilot valve stem.

Assuming the engine installation previously described and with the engine running at no load, it is found when using methane, that the gas pressure in supply to the engine throttle valve should approximate 12 p. s. i. g. at the minimum engine speed of 400 R. P. M., and 37 p. s. i. g. at the maximum speed of 1200 R. P. M. As shown in Fig. 4, the curve M indicates the pressure range for methane for the same 400 to 1200 R. P. M. speed range of the engine. With gas fuel supplied to the pressure regulator device at the minimum of 50 p. s. i. g., the engine is started and operated under no load at 400 R. P. M. As shown in Fig. 3, the regulator spring 46 is adjusted by movement of stop member 124, which acts through rod 128 to move cup-like member 82, until the spring pressure plus the additional pressure imposed by the speed responsive lever 50 then effective on the pilot diaphragm 44, is such as to set the regulator for determining the gas pressure at the throttle valve, at the desired value of 12 p. s. i. g. The engine speed is now increased to 1200 R. P. M. at no load. If the pressure on gauge 136 is greater than the desired 37 p. s. i. g., the lever fulcrum 59 then is moved in the direction away from the lever end which is in engagement with the pilot valve stem. This adjustment is made by "threading out" the bolt 131, whereby action of spring 107 causes fulcrum member 59 to move outwardly. However, if the pressure is below 37 p. s. i. g., the fulcrum is moved in the opposite direction or inwardly, as by "threading in" bolt 131. After such fulcrum adjustment, the engine is again run at 400 R. P. M., and spring 46 then readjusted if necessary, until the gauge pressure reads 12 p. s. i. g. The engine speed is then increased to 1200 R. P. M., and if the pressure is substantially at 37 p. s. i. g., the regulator is properly adjusted for engine operation over its full speed and load range. If, however, the gas pressure at 1200 R. P. M. under the no load condition of the engine, is not at the required 37 p. s. i. g. value, then the foregoing described adjustment steps must be repeated until the required pressure conditions are obtained.

With the above adjustments made, the control provision 70 as shown in Fig. 3 is set up to regulate one gaseous fuel, as methane. As previously described, the control provision as shown in Fig. 2 is set up for a different gaseous fuel, propane for example. It will be observed now that the settings of stop members 86 and 110, as provided for regulation of methane, are independent of the settings of stop members 124 and 131, provided for regulation of propane. Thus, through manipulation of handle 122, the control provision may be conditioned selectively for regulation of one or the other of two different gaseous fuels, as circumstance may require.

In field operation where a suitable supply of methane is available, the control provision would be in the condition shown in Fig. 3, affording engine supply of gas fuel at proper pressures over the full speed and load range with lever control 50 acting to regulate the gas supply pressure to the throttle valve within the indicated range, in direct proportion to engine speed. Should there be an interruption or failure in the supply of methane, movement of handle 122 to the position shown in Fig. 2, would condition or set up the control provision for proper regulation of the gas supply pressure on available propane; which gas could be held in reserve as an emergency supply. It is to be understood, of course, that methane and propane are given by way of example only, and that the control is readily adapted and adjustable to other gaseous fuels suitable for engine operation.

It is apparent from the foregoing description, and with reference to the accompanying drawings, that the present

invention provides a control provision operable automatically to determine the gas supply pressure at values in direct proportion to engine speed. Furthermore, said invention provides suitable structure whereby the same control provision can be pre-set to accommodate any two different gaseous fuels without further or subsequent setting of said control provision other than operation of selector means for determining the setting to be made effective for either of two given fuels.

While the foregoing specification sets forth the invention in somewhat specific detail, it is to be understood that many variations and modifications may be resorted to without departing from the broad aspects of the invention as defined by the following claims.

Having now described the invention, what is claimed is:

1. In an internal combustion engine operable on gas fuel and having a fluid pressure system in which the pressure of fluid therein is proportional to engine speed, a fuel supply system including a conduit for engine delivery of gas fuel under pressure, a throttle valve in said conduit, a pressure regulator device in the conduit, said device including a control element conditionable for regulating the device to determine the pressure of gas fuel in supply to the throttle valve, settable adjusting means for conditioning said control element, settable auxiliary means responsive to the fluid pressure in said fluid pressure system, operable on said control element to alter the conditioning thereof by said adjusting means, in accordance with engine speed, adjustable stop means for said auxiliary means, and lever means operatively associated with said adjusting means and said adjustable stop means, jointly, for determining the settings thereof.

2. In an internal combustion engine operable on gas fuel and having a fluid pressure system in which the pressure of fluid therein is proportional to engine speed, a fuel supply system including a conduit for engine delivery of gas fuel under pressure, a throttle valve in said conduit, a pressure regulator device in the conduit, said device including a control element conditionable for regulating the device to determine the pressure of gas fuel in supply to the throttle valve, settable adjusting means for conditioning said control element, first lever means operatively associated with said adjusting means for determining the setting thereof, settable auxiliary means responsive to the fluid pressure in said fluid pressure system, operable on said control element to alter the conditioning thereof by said adjusting means, in accordance with engine speed, adjustable stop means for said auxiliary means, second lever means operatively associated with said adjustable stop means for determining the setting of the auxiliary means, and cam means for actuating said first and second lever means.

3. In an internal combustion engine operable selectively on one or another gas fuel and having a fluid pressure system in which the pressure of the fluid therein is proportional to engine speed, a gas fuel supply system including a conduit for engine delivery of gas under pressure, a throttle valve in said conduit, a fuel pressure regulator in the conduit and adjustable for determining fuel pressure in supply to the throttle valve, said regulator providing an adjustment control element, settable spring means imposing a control force on said control element, at least two alternatively effective spring setting means for said spring, pivotal lever means in operative connection to said control element and effective, in accordance with variations in fluid pressure in said fluid pressure system, to regulate said control element, said lever means including a selectively positionable fulcrum lever support, at least two alternatively effective position determining means for said fulcrum lever support, and means operable selectively for simultaneously rendering one of said spring setting means and one of said position determining means effective and ineffective.

4. In an internal combustion engine according to claim

3, wherein the said selectively operable means includes a pair of pivotal lever elements and lever actuating cam means common to said lever elements.

5. In an internal combustion engine operable selectively on one or another gas fuel and having a fluid pressure system in which the pressure of the fluid therein is proportional to engine speed, a gas fuel supply system including a conduit for engine delivery of gas under pressure, a throttle valve in the conduit, a fuel pressure regulator in the conduit and adjustable for determining fuel pressure in supply to said throttle valve, said regulator providing a pressure adjustment control element, settable spring means imposing a control force on said control element, regulating means operable in response to fluid pressure variations in said fluid pressure system, for imposing an additional control force on said control element varying in proportion to engine speed variations, said regulating means including a pivotal lever engaging said control element and a movable lever fulcrum support positionable along the lever, adjustable means for determining one position of said fulcrum support along the lever, a pivotal member including an adjustable element for determining another position of said fulcrum support along the lever, an adjustable element for determining one setting of said spring means, means including a second pivotal member and an adjustable element for determining another setting of said spring means, and an actuator common to said pivotal members.

6. In an internal combustion engine selectively operable on any one of several given gas fuels differing in heat value, a gas fuel supply system for the engine, said system including a gas pressure regulator adjustable for determining the gas pressure in the engine supply system, said regulator having an adjustment control element, first adjustable means imposing a control force on said control element, second adjustable means including an actuator subject to engine speed variations, for imposing on said control element an additional control force variable in proportion to variations in engine speed, means operatively associated with each of said first and second adjustable means for determining a first adjusted condition of each thereof whereby to condition the regulator for determining the pressure of one given gas fuel in the engine supply system, and other means operatively associated with each of said first and second adjustable means for determining a second adjusted condition of each thereof whereby to condition the regulator for determining the pressure of another given gas fuel in the engine supply system.

7. In an internal combustion engine according to claim 6, characterized further by means operable selectively for rendering the said other means effective and ineffective to determine the said second adjusted condition of the said first and second adjustable means.

8. In a fuel supply system for an internal combustion engine operable on gas fuel and having a fluid pressure system wherein the fluid pressure is proportional to engine speed, a pressure regulator device in the fuel system for determining the pressure of gas fuel supply for the engine, said device including a control element regulatable to condition the device for determining the gas supply pressure, adjustable spring means imposing a control regulating force on said control element, adjustable auxiliary means imposing on said control element an additional regulating force proportional to engine speed, the last said means comprising a pivotal member in operative engagement with said control element, a positionable fulcrum member pivotally supporting said pivoted member, spring means urging said fulcrum member in one direction, first adjustable stop means operatively disposed adjacent the fulcrum member in opposing relation to said spring-urged fulcrum movement, second adjustable stop means operatively disposed adjacent the fulcrum member in opposing relation to said spring-urged fulcrum movement, lever means operatively associated with said second

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adjustable stop means for moving said second adjustable stop means into and out of an effective relation with said fulcrum member, and fluid pressure operated means connected to the pivotal member and responsive to fluid pressure variations in said fluid pressure system, for pivotally actuating said pivotal member.

9. In a fuel supply system for an internal combustion engine operable on gas fuel and having a fluid pressure system wherein the fluid pressure is proportional to engine speed, a pressure regulator device in the fuel system for determining the pressure of gas fuel supply for the engine, said device including a control element regulatable to condition the device for determining the gas supply pressure, a spring member for imposing a control regulating force on said control element, adjusting means associated with said spring member for altering its control regulating force, said last means including a first adjustable stop member for operative engagement with said spring member, a movable rod extending through said stop member, a second adjustable stop member operatively disposed adjacent said rod and movable into abutment with the rod, effective to displace the rod into an engaging relation with the spring and thereby to move said spring away from engagement with the first adjustable stop member, lever means operatively associated with the second adjustable stop member for moving said second adjustable stop member into and out of displacement-effecting relation with said rod, and adjustable auxiliary means imposing an additional regulating force on said control element, said auxiliary means including a pivotal lever in operative connection to said control element, lever pivot means adjustable intermediate the ends of the lever, and lever operating means connected to the lever and operable auto-

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matically in accordance with fluid pressure variations in said fluid pressure system.

10. In a fuel supply pressure regulator having a pressure adjustment control element, the combination with said regulator of a settable spring imposing a control force on said regulator control element, an adjustable member for determining one control setting of said spring, separate means including an adjustable element, operable to and from an effective position determining another control setting of said spring, means including a pivotal lever in engagement with said control element, for imposing an additional control force on the control element, and a lever fulcrum support positionable along said lever for regulating the control force imposing effect of the lever on said control element, adjustable means for determining one position of said fulcrum support along the lever, separate means including an adjustable element, operable to and from an effective position determining another position of the fulcrum support along the lever, and means for operating the said separate means to and from said effective positions thereof.

11. The combination as defined by claim 10, wherein the last said means includes an actuating member common to the said separate means for conjoint operation of the separate means selectively to and from the said effective positions thereof.

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