

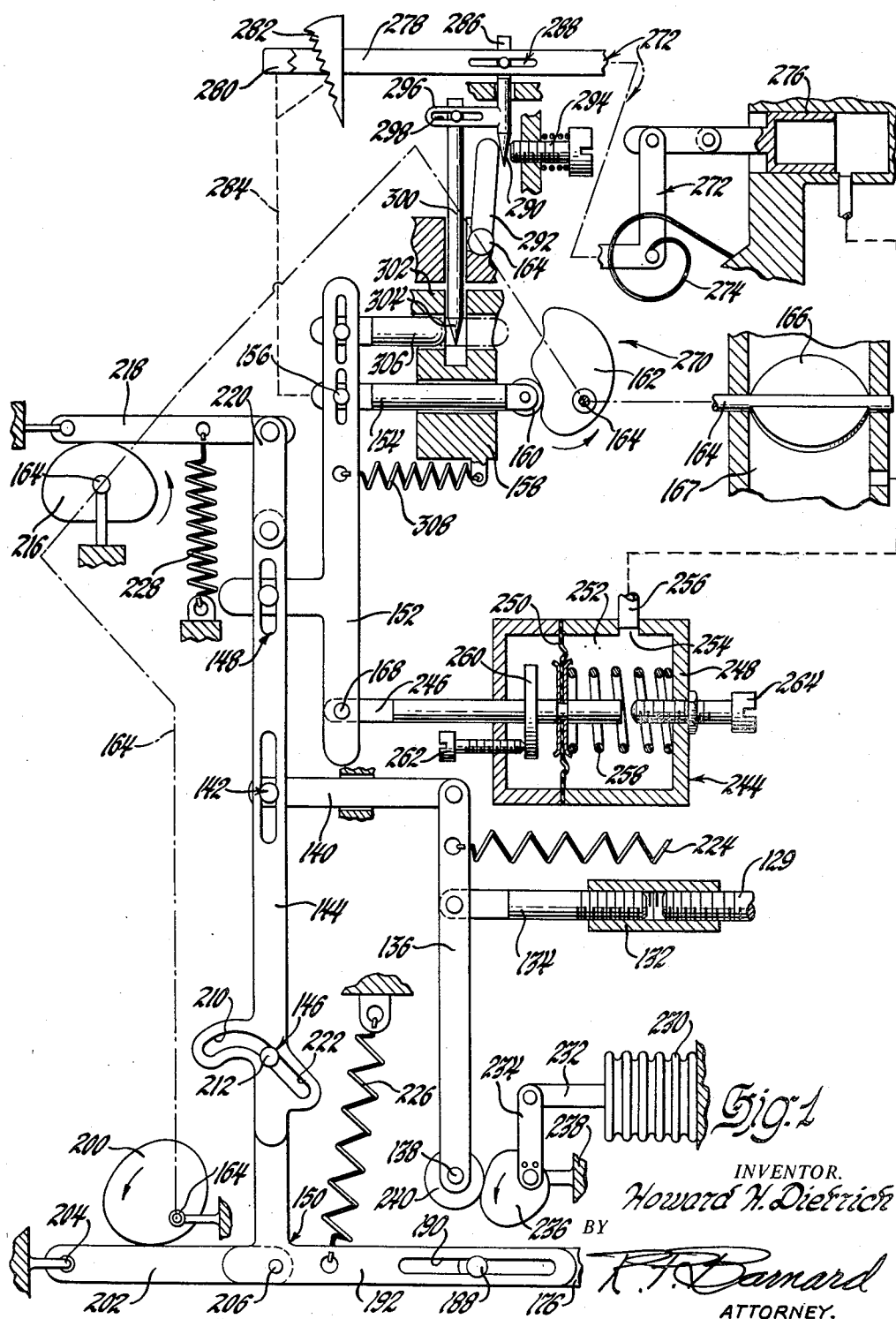
Aug. 23, 1960

H. H. DIETRICH
CHARGE FORMING DEVICE

2,949,903

Filed Aug. 1, 1957

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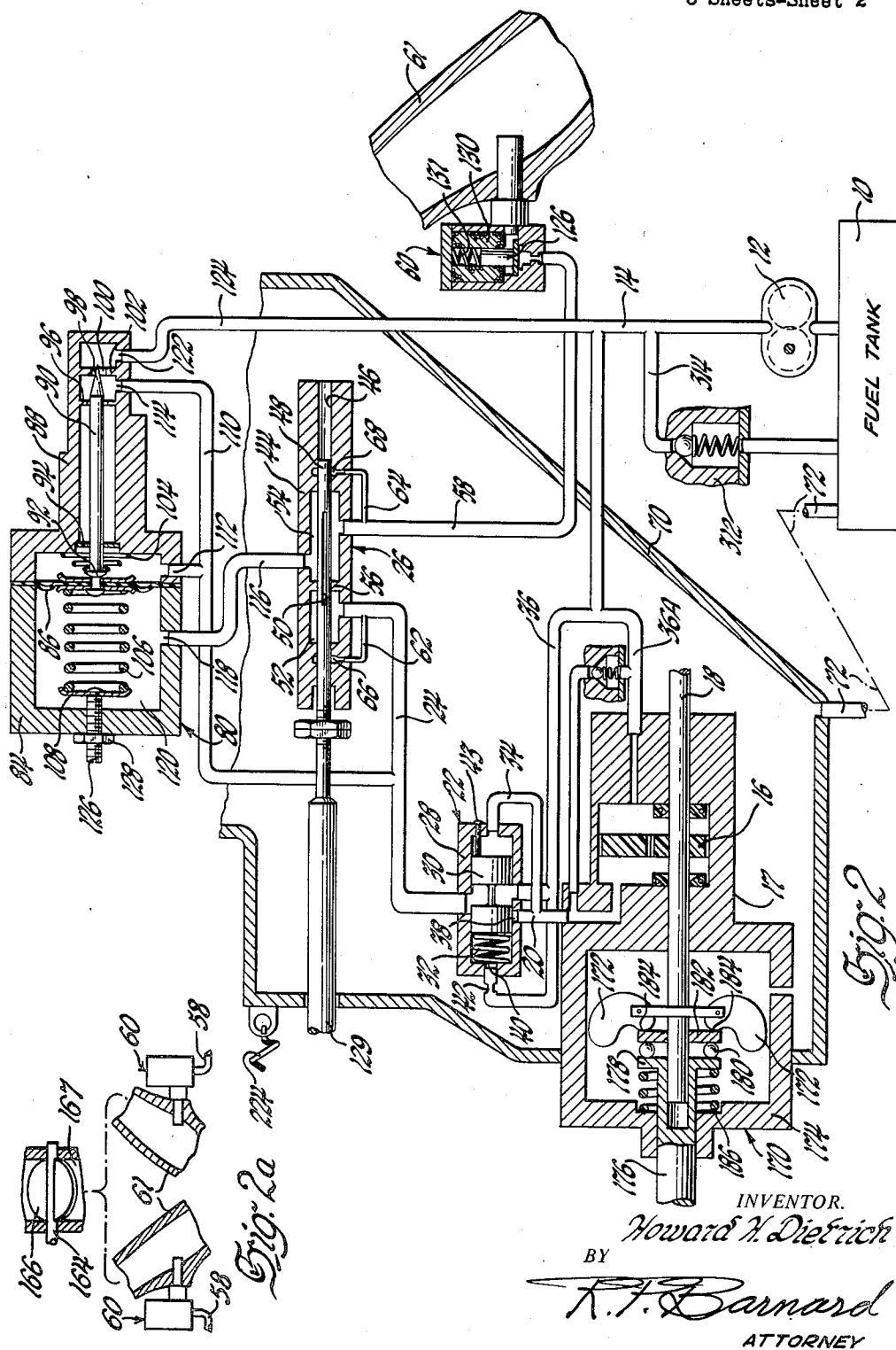
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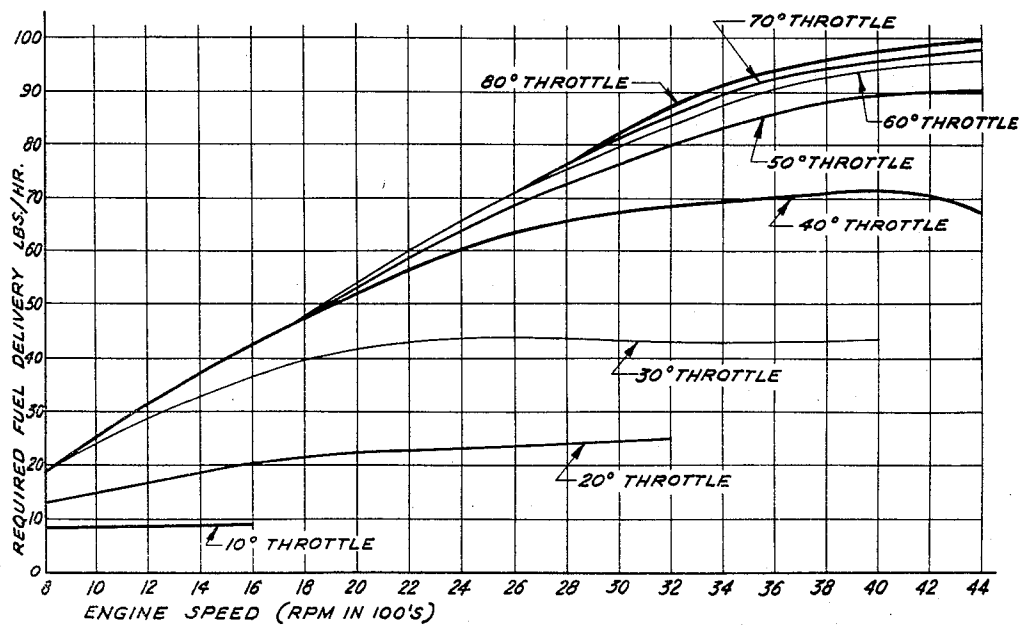
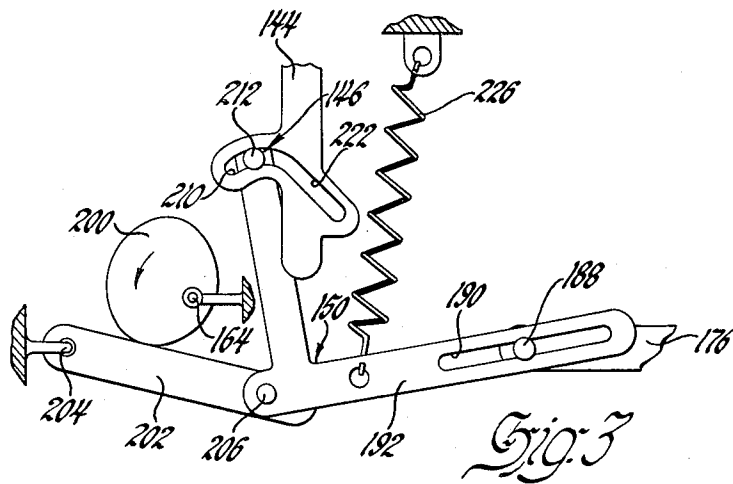


Fig. 4

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2,949,903

CHARGE FORMING DEVICE

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20 Claims. (Cl. 123—119)

The present device relates to a charge forming mechanism for an internal combustion engine and which mechanism may be utilized as a carburetor by employing only one fuel nozzle or as a fuel injection system in which event individual fuel nozzles are provided for each of the cylinders of the engine. In the present description the system will be described as a fuel injection system in which the individual fuel nozzles are provided.

The present charge forming device is of the closed or non-vented type which renders it highly desirable for use with high vapor pressure fuels. In utilizing the present non-vented system the fuel is maintained under pressure preventing vaporization and the attendant vapor lock potential as well as the loss of fuel which accompanies boiling.

It is a further purpose of the present invention to provide a charge forming device in which the quantity of fuel supplied is determined solely by the position of the throttle and engine speed. The present charge forming device has certain advantages over fuel injection systems of the speed-density or mass air flow types in which the quantity of fuel metered to the engine's cylinders is determined by such variables as manifold vacuum or venturi vacuum. Systems controlling the flow of fuel through manifold or venturi vacuum forces have the inherent disadvantage of imposing a hysteresis or time lag in supplying fuel. As a result of the inability of the vacuum controlled systems to respond immediately to changes in demand certain undesirable transient operating conditions arise particularly during idle, off-idle and accelerating operation giving rise to flat spots on the power curve otherwise manifested as a slight lag in power under certain demand conditions.

In the present charge forming device, a mechanical control system has been developed which insures immediate response to changes in either or both operator or engine demand. In the present system a fuel metering valve is directly controlled by a plurality of levers and cams which combine to tailor the fuel supply to the exact needs of the engine and desires of the operator. By the unique utilization of levers and cams the present fuel injection system may be easily adapted for use with different engines by merely regulating the levers or by the simple interchange of cams which will tailor the engine's fuel supply to the particular engine operating characteristics. In this way a highly versatile fuel injection system is provided and which additionally is capable of relatively inexpensive manufacture when contrasted with present fuel injection systems.

The details of the present invention as well as other objects and advantages are set forth in the description which follows.

In the drawings:

Figures 1, 2 and 2a are diagrammatic representations of the subject fuel system;

Figure 3 shows a portion of the lever control system as shifted from the position of Figure 1; and

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Figure 4 is a graph indicating fuel requirements vs. engine speed.

In order to simply illustrate the present fuel injection system the various components have been shown diagrammatically. A low pressure make-up fuel pump 12 draws fuel from a fuel reservoir indicated at 10 and supplies it through a conduit 14 to the inlet side of an engine speed responsive high pressure pump 16 disposed in casing 17. High pressure pump 16 is driven by a shaft 18 suitably connected to an engine speed responsive member such as a cam shaft, not shown. Fuel under pressure from high pressure pump 16 is delivered through a conduit 20 to a valve mechanism 22 from which fuel is delivered through a conduit 24 to a fuel metering valve 26.

Valve mechanism 22 includes a casing 28 within which a spindle type member 30 is slidably disposed. A spring element 32 is adapted to bias the valve member 30 to the right, however, the output pressure from pump 16 is conveyed through a branch conduit 34 to the opposite end of the valve element and normally biases the element to a position communicating conduits 20 and 24 for the delivery of high pressure fuel to the metering valve 26. A low pressure branch conduit 36 also communicates with casing 28 through ports 38 and 40. During cranking when the output of high pressure pump 16 is low, the pressure of the pump 12 usually exceeds that of the high pressure pump and spring 32 will bias element 30 to the right, as shown, in which event fuel will be supplied to the metering valve through conduit 36. It will be noted that the action of spring 32 in shifting the valve element 30 to the right is supplemented by the low pressure fuel in conduit 36 which acts on the left end of the element. An orifice 42 disposed in conduit 36 proximate port 40 is solely for the purpose of dampening the pump pulsations. A stop element 43 is disposed in casing 28 to limit the travel of spindle 30.

The fuel metering valve 26 includes a casing 44 having a bore 46 formed therethrough and slidably receiving a valve element 48. Valve element 48 includes a longitudinally extending diametrical slot 50 formed therein and which slot variously extends into chambers 52 and 54 formed in the casing member 44 and separated by a partition or wall 56. Conduit 24 supplies fuel under pressure to chamber 52 while a conduit 58 delivers fuel from chamber 54 to the individual cylinder fuel nozzles 60 disposed in cylinder intake passages 61, only one of which is shown. The quantity of fuel metered to the nozzles 60 is determined by the longitudinal position of slot 50 relative to bore chambers 52 and 54. The principle of operation of the metering valve 26 is based on the concept of changing the area of the metering slot 50 exposed to fuel inlet chamber 52 in accordance with engine speed and throttle position. As the slot 50 moves to the left with the valve element 48 increasing the slot area exposed to the inlet fuel chamber, an increased quantity of fuel will flow from chamber 52 to output chamber 54 and hence to the nozzles 60. It is the area of slot 50 in chamber 52 that determines the quantity of flow since the slot area in chamber 54 is always large enough to pass any fuel quantity metered from chamber 52.

The precise form of the slot 50 is not limited to that shown in the drawings but may be of any configuration consistent with the basic premise that the area of the slot will be capable of varying as a function of engine speed and operator demand by actuating means to be subsequently discussed. In order to insure relatively frictionless operation of the slidable valve element 48 a pair of conduits 62 and 64, which respectively branch off from the fuel inlet and outlet passages 24 and 58, communi-

cate with casing ports 66 and 68 to deliver small quantities of fuel to the casing bore 46 enabling a small amount of fuel to flow between the valve element 48 and the bore for lubrication purposes and to purge the sliding surfaces of any impurities insuring relatively frictionless movement of the valve element. Fuel from passages 62 and 64 flows in both directions along the valve element 48 and the controlled leakage from the valve is returned to the metering casing 70 and back to the fuel supply tank 10 through drain passage 72.

It is intended that the quantity of fuel metered by the valve 26 be solely determined by the change of area of the metering slot 52 as described. To preclude pressure changes across the metering valve 26 from affecting the quantity of fuel metered, valve device 80 is provided for maintaining the pressure drop across the metering valve at a controlled or determinate value. The pressure drop control valve includes a casing having an enlarged portion 84 within which a diaphragm member 86 is peripherally clamped. A reduced portion 88 of the casing is adapted to slidably support a needle type valve element 90 having an enlarged end 92 adapted to abuttingly engage the diaphragm 86. It is imperative that the valve element 90 be mounted substantially without friction in the casing portion 88. Accordingly, the valve element supporting walls 94 and 96 have sufficiently large needle valve supporting openings to insure relatively frictionless support of valve element 90. Further, the enlarged end 92 of the valve element merely abuts the diaphragm 86 and is not fixed thereto preventing the diaphragm from otherwise cocking the valve element 90 which would add frictional resistance to its movement.

The other end 98 of the valve element 90 is tapered and coats with an orifice or opening 100 in casing wall 102 to provide an adjustable orifice. A spring element 104 is disposed intermediate the head portion 92 of the valve element 90 and the casing portion 84 biasing the valve element into engagement with the diaphragm 86. An additional spring element 106 is biased between the diaphragm 86 and adjustable seat 108 supported within casing portion 84 biasing the diaphragm and valve element in a direction restricting flow through orifice 100. Fuel under pressure from the input side of the metering valve 26 is delivered through a conduit 110 to the pressure drop control valve casing at ports 112 and 114. The fuel under pressure from the output side of the metering valve 26 is conducted to casing portion 84 through a conduit 116 which through a port 118 admits this fuel to the chamber 120 defined by the casing 84 and the diaphragm 86. Thus the output pressure from the metering valve 26 and the spring 106 tend to urge the needle valve 90 to the right or flow restricting direction while the input metering valve pressure tends to urge the valve in a leftward or flow increasing direction. Thus as either the metering valve input or output pressure changes, the pressure drop control valve will insure a corresponding change in the other pressure. To illustrate, if the output pressure in conduit 116 increases, the pressure increase in chamber 120 will cause diaphragm 86 to move the needle valve 90 to the right to restrict flow through the orifice 100 which in turn increases the pressure in conduits 110 and 24. While the pressure drop across the metering valve device 80 need not necessarily be constant, the pressure drop control valve will insure that the pressure drop across the valve will in some fixed proportion to other control forces and in this way insures that the metering of fuel through the valve 26 will be determined solely by throttle position and engine speed as will subsequently be discussed. The fuel flow through the orifice 100 will be returned through port 122 and conduit 124 to the pump inlet 36-A.

The adjustable spring seat 108 which includes a screw member 126 and a nut 128 provides means for variably

adjusting the pressure drop across the valve device 80 and since flow is proportional to this pressure drop on a percentage basis, the adjustment serves to raise percentage-wise the value of flow under any condition of operation. This fuel flow can be increased for a large engine or decreased for a smaller engine on a percent basis by adjusting the nut and screw 128 and 126.

The individual cylinder fuel nozzles 60 are of the atmospheric type shown generally in copending application Serial No. 512,175, Homfeld et al., filed May 31, 1955, and now abandoned.

Consistent with the desire to provide a closed or non-vented fuel system nozzles 60 are provided with a solenoid controlled valve 126 which will block the drainage of fuel through the nozzles after the engine is shut off. In this manner the fuel system remains charged with fuel for rapid restarting. A spring 131 normally biases valve 126 in a flow blocking direction. A solenoid 130 is connected in the ignition circuit such that when the ignition is closed the solenoid is energized to retract valve 127 permitting normal fuel flow. In lieu of the individual nozzle solenoid valves 127 a single valve may be utilized in conduit 58 to perform the same function.

As already noted, the quantity of fuel supplied by the metering valve 26 to the atmospheric nozzles 60 is determined by the axial position of the valve element 48 within the casing 44 and as further noted as the valve element 48 is moved to the left the quantity of fuel supplied is increased. The remainder of the description will be devoted to the mechanism whereby the longitudinal movement of the valve element 48 is tailored to the demands of the operator as well as engine speed.

Before proceeding to a description of the metering valve control mechanism it would be well to first refer to the curves shown on the graph of Figure 4. The family of curves shown on the graph represent the fuel requirements for given engine speeds with regard to various degrees of throttle opening for a typical engine. These fuel requirements are well established values and it is the purpose of the present invention to provide a control mechanism capable of tailoring the quantity of fuel supplied by the metering valve to the various requirements represented by such curves. With the exception of the 10° throttle opening curve where the fuel requirements remain substantially constant, it is apparent that on the remaining curves that the fuel requirements increase with engine r.p.m. up to an engine speed beyond which the fuel requirements remain substantially constant. To illustrate in referring to the 30° throttle curve it will be seen that as the engine reaches approximately 240 r.p.m. the fuel requirements of the engine remain substantially constant as the engine r.p.m. increases. The fact that the fuel curves for the various throttle positions tend to flatten out or become essentially constant beyond a given engine r.p.m. indicates one important requirement of such a fuel control system and that is that such a control cannot be solely dependent upon throttle position alone. Accordingly, it is necessary that such control system include a means responsive to engine speed for modifying the throttle actuation of the fuel metering valve.

Referring now to the metering valve control mechanism, it will be seen that the slidable valve element 48 includes a portion 129 extending from the metering valve casing 44 and which portion is connected through a threaded coupling 132, Figure 1, to a lever section 134. For the present purposes portion 129, coupling 132 and portion 134 will be considered as a single element. This element is pivotally connected to a lever 136 intermediate its ends and end 138 of which will for the present purposes be considered as a fixed pivot point. The other end of lever 136 is articulated to a lever 140, the other end of which is connected through a pin and slot connection 142 to a lever 144.

The upper and lower ends of lever 144 are likewise

connected through pin and slot connections 146 and 148 respectively to levers 150 and 152. Lever 152 has a lever 154 articulated thereto through a pin and slot connection 156 and which latter lever is slidably mounted in a supporting casing 158. Lever 154 terminates at its other end in a cam follower or roller member 160. Cam roller 160 is adapted to coact with a rotatable cam member 162 fixed upon a shaft 164 which is controlled by the position of the carburetor air throttle 166 disposed in air induction passage 167. For the present, end 168 of the lever 152 will be considered as a fixed pivot.

Thus as the air throttle 166 is opened the cam 162 is rotated in a counterclockwise direction shifting lever 154 to the left similarly pivoting the levers 152 and 144 in a counterclockwise direction about pivotal connections 168 and 146 respectively. Lever 140 is in turn carried to the left rotating lever 136 about pivot 138 causing element 130-134 to move valve element 48 to the left to increase the area of the slot 50 exposed to the fuel input chamber 52. The throttle controlled cam 162 is thus adapted to increase the fuel supply in proportion to the degree of throttle opening. As may be seen on the curves of Figure 4, however, the relationship of fuel to throttle opening must be modified by other control forces to insure the proper fuel-air ratio under all engine speed conditions.

As thus far described, the fuel injection control system is responsive only to throttle position. In order to make the system function in accordance with the illustrative curves of Figure 4, an engine speed controlling device is provided generally at 170 and includes a plurality of speed responsive centrifugally operated weights 172 pivotally mounted on the engine speed responsive shaft 18 also utilized to drive pump 16. The speed controlling mechanism 170 is disposed in an enlarged portion 174 of the pump casing 17. The engine speed responsive shaft 18 terminates within a recess in a coaxially disposed lever 176 slidably supported at one end in the casing portion 174. Lever 176 connects with the speed responsive elements 172 through a flange 178, anti-friction bearing members 180 and an intermediate plate 182 slidably mounted on shaft 18.

As engine speed increases the centrifugal weights 172 are thrown radially outwardly causing the inner cam surfaces 184 to move plate 182, bearings 180 and lever 176 axially to the left against the force of a spring 186 biasing these elements in the opposite direction.

Referring particularly to Figures 1 and 3, lever 176 includes a pin 188 adapted to coact with a slot 190 formed in leg 192 of lever 150 such that when the levers 176 and 192 are axially aligned, as shown in Figure 1, the axial movement of the pin 188 toward the leg 192 of lever 150 will cause the pin to move in the slot 190 resulting in the speed responsive mechanism 170 having no effect on the fuel metering control. The purpose of this lost motion connection can best be understood by referring to the 10° throttle curve of Figure 4 which, as noted, has substantially no slope and is a straight line. Thus with a 10° throttle opening it is not desired to perceptibly increase the quantity of fuel supplied to the engine with increases in engine speed. It is therefore possible to shape the cam 162 to set off an increase in fuel flow to correspond with the values shown on the 10° throttle curve.

Since each curve for a particular throttle opening has a different slope it is necessary to provide means for adjusting the fuel controlled linkage mechanism for each degree of throttle opening. To this end, a fanning or slope determining cam 200 is provided. Cam 200 like cam 162 is eccentrically mounted on the air throttle shaft 164 and rotates in accordance with the various positions of the air throttle. The fanning cam 200 is connected to the metering control mechanism through a lever 202 which is fixedly pivoted at end 204 and articulated at its other end to the L-shaped lever 150 at 206. As

noted, the fanning cam 200 is eccentrically mounted and in general is adapted to cause the lever 202 to be pivoted in a clockwise direction about pivot point 204 as the air throttle opening increases. The effect of the clockwise movement of lever 202 is best seen in referring to Figure 3 where it will be noted that as the lever moves the pivotal connection 206 downwardly lever 150 is caused to pivot about pin 188 of lever 176. In so inclining the levers 150 and 176, Figure 3, it will be seen that as engine speed increases pin 188 is adapted to now engage the side of slot 190 imparting a counterclockwise movement to lever 150. In this way an additional leftward or metering valve flow increasing movement is imparted to the valve element 48.

As already noted, it is desired when the throttle 166 is open between the 0° and the 10° positions that engine speed have no effect on the quantity of fuel supplied. Accordingly, the fanning cam surface has a substantially constant radius of curvature from its zero degree position to the 10° position. In this way with the throttle opened between the zero and 10° positions the levers 176, 192 and 204 are axially aligned in which event engine speed will not affect the quantity of fuel supplied to the nozzles 60. The surface of cam 200 is suitably contoured, in accordance with the curves of Figure 4, so that throttle opening beyond 10° progressively increases the clockwise movement of the lever 202 thereby, at least initially, increasing the slope of the fuel r.p.m. curve as the degree of throttle opening increases.

As already noted in referring to the curves of Figure 4, as engine speed increases for any given throttle opening the fuel requirements of the engine become substantially constant after a given speed. It is therefore necessary to provide means to insure this type of operation. Accordingly, the pin and slot connection 146 between the lower end of lever 144 and L-shaped lever 150 is formed to provide a run-out slot or cam surface 210. As engine speed increases with increased throttle opening, the L-shaped lever pin 212 will move the lower end of lever 144 in a leftwardly direction, supra, and in so doing will approach the run-out slot 210. The radius of curvature of the run-out slot or cam surface 210 is such that as the pin 212 enters this portion of the slot the radius of curvature of the slot is substantially concentric with the arcuate path of movement of the pin about its pivot point 206 as rotated by the speed responsive device 170. Hence as the pin 212 moves within slot 210 substantially no further leftward movement of the lower end of the lever 144 will take place with increase in speed. Therefore, even though engine speed continues to increase and rotate the lever 150 in a counterclockwise direction, the run-out cam 210 will insure that no further increase in the fuel supplied will take place for a given throttle opening. In this way the fuel-r.p.m. curves for the various degrees of throttle opening are flattened, e.g. slope made to approach zero, conforming to the engine requirements as indicated in the curves of Figure 4.

In order to vary the movement of pin 212 relative to cam slot 210 in accordance with throttle opening and hence the period through which the speed responsive mechanism 170 is operative to increase the fuel supply with increase in engine speed, an additional or peel-off cam 216 is provided. Like cams 162 and 200, cam 216 is connected to the air throttle shaft 164. The peel-off cam 216 is articulated through a lever 218 and intermediate link 220 to metering control lever 144. Lever 218 is fixedly pivoted at one end and is adapted to be rotated in a counterclockwise direction by cam 216 with increases in throttle opening. The counterclockwise movement of lever 218 lifts levers 220 and 144 thereby moving the cam slot 210 relatively away from pin 212 of lever 150. The result of this type of actuation is to maintain the pin 212 in the straight portion of slot 222 for a longer period of time before the pin enters the run-

out or cam slot 210 of lever 144 increasing the speed range over which the speed responsive device 170 is active to modify the fuel supply.

Thus the cams as shown in Figure 1 are in a position indicating a relatively small degree of throttle opening under which circumstance the pin 212 is riding relatively high in slot 222 and is about to enter the run-out cam portion 210 indicating that at small degrees of throttle opening the speed responsive mechanism 170 will have a relatively little effect on the quantity of fuel supplied. However, as engine speed increases with an increase in throttle opening the cams 200 and 216 will respectively be rotated to move pin 212 and run-out cam 210 apart increasing the duration of the engine speed effect on the metering function.

The various cams 162, 200, 210 and 216 are selected and formed in such a way as to tailor the fuel requirements with respect to engine speed and throttle position as shown on the various throttle opening curves of Figure 4. It is apparent that the precise configurations of the cams shown in the drawings are merely illustrative and will be varied for use with a particular type engine.

Springs 224, 226, 228 and 308 are respectively grounded at one end to the various casing members and connected at their other ends to levers 136, 150, 218 and 152 in order to provide a bias on the lever control system to insure the various components are properly positioned.

Inasmuch as the present fuel injection control system is responsive solely to throttle position and engine speed it may be desirable to provide means which will compensate the quantity of fuel supplied to ambient barometric conditions particularly when the system is intended for use in areas having considerable variations in altitude. For this purpose an aneroid bellows 230 is provided. Bellows 230 is connected through links 232 and 234 to a cam member 236 pivotally mounted upon a support 238. Cam 236 is adapted to engage a follower element 240 mounted on the lower end 138 of lever 136. Thus as atmospheric pressure decreases the bellows 230 will expand rotating cam 236 in a counterclockwise direction causing a shorter radius of the cam to engage the follower 240 permitting the spring 224 to move the valve element 48 to the right reducing the quantity of fuel supplied under all operating conditions. Correspondingly an increase in atmospheric pressure would cause the quantity of fuel supplied by the metering valve to be increased by the aneroid bellows 230. Accordingly, the quantity of fuel supplied is automatically compensated for by variations in air density.

If it is desired to provide means for enriching the fuel-air mixture under certain high power demand conditions, a power enrichment device indicated generally at 244 is provided. Device 244 includes a lever 246 mounted within a casing 248 and articulated at one end to the lower end 168 of lever 152 and at the other end to a diaphragm 250. Diaphragm 250 and casing 248 define a chamber 252 which communicates through a port 254 with a source of manifold vacuum through a conduit 256. A spring element 258 is also disposed in chamber 252 and is adapted to bias the levers 246 and 152 in a leftwardly or flow increasing direction until lever flange 260 abuts an adjustable stop 262. Under normal operating conditions, however, the manifold vacuum in chamber 252 is of a sufficiently high value to overcome spring 258 and move the diaphragm 250, lever 246 and lever 152 to the right or in a flow restricting direction. One end of lever 246 is adapted to abut against an adjustable stop crew 264 to determine the normal or economy position of the diaphragm controlled lever 246 and pivot point 168 of lever 152. Stop screw 262 coacts with flange 260 to determine the maximum power position of the power enrichment device 244.

Thus if the accelerator pedal is suddenly depressed opening the throttle valve 166, the manifold vacuum in chamber 252 will drop permitting the spring 258 to shift the levers 246 and 152 to a maximum power position.

While it is possible to provide such a power enrichment device it is also possible to construct the present device without the same inasmuch as the subject mechanical fuel control lever system need not be subject to the acceleration transient lag in fuel supply otherwise present in systems relying on changes in air flow to vary the quantity of fuel supplied.

To provide for cold starting and cold running operation, an enrichment mechanism indicated generally at 270 is provided. Mechanism 270 includes an L-shaped lever 272. A thermostatic element 274 is fixed to lever 272 and is adapted to rotate the lever in a clockwise direction as engine temperature increases. In addition, a manifold vacuum responsive piston 276 is also adapted to rotate lever 272 in a clockwise direction as manifold vacuum increases. In order to prevent excessive opening of the air throttle 166 and consequent damage to a cold engine, leg 278 of lever 272 includes a stop portion 280 adapted to be engaged by the lever 152 in its throttle opening movement. Stop portion 280 is serrated and is adapted to engage with a serrated cam member 282 affixed to lever 152. Stop portion 280 and cam 282 are serrated or stepped to prevent the members slipping relative to each other. The actual location of stop portion 280 and cam 282 would be, as shown by the dash line 284, substantially opposite the cam controlled lever 154. With the engine cold the accelerator pedal in being depressed would cause the opening movement of lever 152 to be limited by stop 280 preventing a cold engine from being run at excessive speeds.

A pin member 286 is supported by leg 278 of lever 272 through a pin and slot connection 288. Pin 286 includes a tapered end 290 adapted to engage with a lever 292 mounted on the throttle valve shaft 164. An adjustable backing screw 294 is also adapted to engage the tapered end 290 of pin 286 to set the minimum idle air adjustment around throttle 166. As engine temperature increases the pin 286 will be moved upwardly by the lever leg 278 permitting the lever 292 to be rotated in a clockwise or throttle valve closing direction reducing the quantity of idle air flow.

An extension or leg 296 is formed on pin 286 and through a pin and slot connection 298 supports an additional pin 300. Pin 300 is slidably supported in casing portion 302 and terminates in a tapered end portion 304 adapted to variably engage one end of a lever 306 articulated at its other end to lever 152. With the engine cold the pin 300 is adapted to fully engage the lever 306 preventing the metering control lever from being returned to its full retracted position by spring 308 and thus increasing the quantity of idle fuel flow. Here again as engine temperature increases the pin 300 will be moved upwardly permitting the levers 154 to engage the fuel set-off cam 162. Thus the enrichment device 270 provides means for individually adjusting the idle air and idle fuel flow with respect to each other.

In order to adjust the normal or warm engine idle fuel flow the adjustable collar 132 connecting levers 130 and 134 may be rotated to vary the length of the connection between the metering valve element 48 and lever 136 thereby adjusting the area of slot 50 exposed to the inlet fuel chamber 52 and hence the quantity of idle fuel flow.

The inlet side of the fuel system is sealed or closed by the makeup or supply pump 12. However, a check valve 312 is provided in a parallel conduit 314 for the purpose of preventing any excessive pressure build-up in the system likely to occur after a hot engine is shut down or when the vehicle is placed in an environment subjected to high ambient temperatures. In the event the maximum desired pressure for the system is approached, valve 312 will open venting the system to reservoir 10.

Consistent with the diagrammatic representation of the subject fuel system, it is to be understood that various structural modifications may be made without departing from the intended scope of the invention as set forth in the hereinafter appended claims.

I claim:

1. A charge forming device for an internal combustion engine comprising a fuel source, pump means for pressurizing the fuel from said fuel source, a fuel metering valve, conduit means connecting said pump means and said fuel metering valve whereby said pressurized fuel is delivered to said valve, said metering valve including an adjustable valve element for varying the quantity of fuel flowing through said valve, a fuel nozzle for supplying fuel to each cylinder of the engine, conduit means communicating said metering valve with each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to the cylinders of the engine, lever means operatively connecting said throttle valve and said metering valve for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means connected to said lever means for increasing the flow of fuel through said metering valve as engine speed increases, and throttle control means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed.

2. A charge forming device for an internal combustion engine comprising a fuel source, pump means for pressurizing the fuel from said fuel source, a fuel metering valve, conduit means connecting said pump means and said fuel metering valve whereby said pressurized fuel is delivered to said valve, said metering valve including an adjustable valve element for varying the quantity of fuel flowing through said valve, a fuel nozzle for supplying fuel to each cylinder of the engine, conduit means communicating said metering valve with each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to the cylinders of the engine, lever means operatively connecting said throttle valve and said metering valve for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means connected to said lever means for increasing the flow of fuel through said metering valve as engine speed increases, and throttle control means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, said throttle control means being adapted to vary the engine speed at which said engine speed responsive means is rendered inoperative.

3. A charge forming device for an internal combustion engine comprising a fuel source, pump means for pressurizing the fuel from said fuel source, a fuel metering valve, conduit means connecting said pump means and said metering valve whereby said pressurized fuel is delivered to said valve, said metering valve including an adjustable valve element for varying the quantity of fuel flowing through said valve, a fuel nozzle for supplying fuel to each cylinder of the engine, conduit means communicating said metering valve with each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to the cylinders of the engine, lever means operatively connecting said throttle valve and said metering valve for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means connected to said lever means for increasing the flow of fuel through said metering valve as engine speed increases, throttle control means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, said throttle control means being adapted to vary the engine speed at which said engine speed responsive means is rendered inoperative, and means for maintaining a controlled pressure drop across said metering valve.

4. A charge forming device for an internal combustion engine comprising a fuel source, pump means for pressurizing the fuel from said fuel source, a fuel metering valve, conduit means connecting said pump means and said fuel metering valve whereby said pressurized fuel is

delivered to said valve, said metering valve including an adjustable valve element for varying the quantity of fuel flowing through said valve, a nozzle for supplying fuel to each cylinder of the engine, conduit means communicating said metering valve with each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to the cylinders of the engine, lever means operatively connecting said throttle valve and said metering valve for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means connected to said lever means for increasing the flow of fuel through said metering valve as engine speed increases, and throttle control means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, and means for controlling the pressure drop across said metering valve to preclude fuel pressure variations from affecting the quantity of fuel supplied to the nozzles.

5. A charge forming device for an internal combustion engine comprising a fuel source, first pump means for pressurizing the fuel from said fuel source, second pump means for supplying low pressure fuel to said first pump means, a fuel metering valve, conduit means adapted to connect said first or second pump means with said fuel metering valve, valve means in said conduit means for selectively connecting said first or second pump means with said metering valve, said metering valve including an adjustable valve element for varying the quantity of fuel flowing through said valve, a plurality of fuel nozzles for supplying fuel to the individual cylinders of the engine, conduit means communicating said metering valve with said fuel nozzles, a throttle valve for controlling the quantity of air flow to the cylinders of the engine, lever means operatively connecting said throttle valve and said metering valve for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means connected to said lever means for increasing the flow of fuel through said metering valve as engine speed increases, and throttle control means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed.

6. A charge forming device as set forth in claim 5 in which said valve means is differentially responsive to the pressures from said first and second pump means whereby said valve will connect said second pump means with said fuel metering valve when the fuel pressure from said first pump means drops below a given value.

7. A charge forming device for an internal combustion engine comprising a fuel source, first pump means for pressurizing the fuel from said fuel source, second pump means for supplying low pressure fuel to said first pump means, a fuel metering valve, conduit means adapted to connect said first or second pump means and said fuel metering valve, valve means in said conduit means for selectively connecting said first or second pump means with said metering valve, said metering valve including an adjustable valve element for varying the quantity of fuel flowing through said valve, a plurality of fuel nozzles for supplying fuel to the individual cylinders of the engine, conduit means communicating said metering valve with said fuel nozzles, a throttle valve for controlling the quantity of air flow to the cylinders of the engine, lever means operatively connecting said throttle valve and said metering valve for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means connected to said lever means for increasing the flow of fuel through said metering valve as engine speed increases, throttle control means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, said throttle control means being adapted to vary the engine speed at which said engine speed responsive means is rendered inopera-

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tive, and means for controlling the pressure drop across said metering valve.

8. A charge forming device as set forth in claim 3 in which said pressure drop controlling means comprises a casing, a diaphragm dividing said casing into two chambers, a valve element fixed to said diaphragm for movement therewith and in communication with one of said chambers, passage means communicating said one chamber with the fuel source, an orifice in said passage means with which the valve element coacts, a first conduit connecting the output side of said fuel metering valve with said one chamber, and a second conduit for connecting the input side of the metering valve with the other chamber, the fuel pressure differential in said chambers acting on said diaphragm to cause the valve element to vary the orifice opening and to thereby maintain a controlled pressure drop across said metering valve.

9. A charge forming device for an internal combustion engine comprising air intake passage means for supplying air to the individual cylinders of the engine, a throttle valve disposed in said intake passage for controlling the quantity of air supplied to said cylinders, a nozzle disposed in said intake passage proximate each cylinder of the engine, a source of fuel, pump means for pressurizing the fuel from said fuel source, a metering valve, conduit means communicating said pump means with said metering valve for supplying pressurized fuel thereto, conduit means communicating said metering valve with each of said fuel nozzles, said metering valve including an adjustable element for controlling the quantity of fuel supplied to said fuel nozzle means, a device for controlling the pressure drop across said metering valve, lever means connected to said slidable metering valve element, means operatively connecting said throttle valve and said lever means for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means operatively connected to said lever means for increasing the quantity of fuel flow through said metering valve as engine speed increases, throttle control means for rendering said engine speed responsive means inoperative to increase fuel flow above a given engine speed, said throttle control means being adapted to vary the engine speed at which said engine speed responsive means is rendered inoperative in accordance with the various positions of said throttle valve, and temperature responsive means for limiting the opening of said throttle valve until said engine is sufficiently warm.

10. A charge forming device for an internal combustion engine comprising air intake passage means for supplying air to the individual cylinders of the engine, a throttle valve disposed in said intake passage for controlling the quantity of air supplied to said cylinders, a nozzle disposed in said intake passage proximate each cylinder of the engine, a source of fuel, pump means for pressurizing the fuel from said fuel source, a metering valve, conduit means communicating said pump means with said metering valve for supplying pressurized fuel thereto, conduit means communicating said metering valve with said fuel nozzle means, said metering valve including an adjustable element for controlling the quantity of fuel supplied to said fuel nozzle means, a device for controlling the pressure drop across said metering valve, lever means connected to said slidable metering valve element, means operatively connecting said throttle valve and said lever means for increasing the quantity of fuel flow through said metering valve as said throttle valve opens, engine speed responsive means operatively connected to said lever means for increasing the quantity of fuel flow through said metering valve as engine speed increases, throttle control means for rendering said engine speed responsive means inoperative to increase fuel flow above a given engine speed, said throttle control means being adapted to vary the engine speed at which said engine speed responsive means is rendered inoperative in accordance with the various positions of said throttle valve, and

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engine temperature responsive means coacting with said lever means for limiting the opening of said throttle valve until said engine is sufficiently warm.

11. A charge forming device as set forth in claim 10 in which said temperature responsive means includes means for controlling idle fuel and air flow respectively.

12. A charge forming device for an internal combustion engine comprising a source of fuel under pressure, a fuel nozzle for each cylinder of the engine, a valve for supplying a metered quantity of fuel to each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to said cylinders, control means operatively connected intermediate said throttle valve and said metering valve for controlling the quantity of fuel supplied to said nozzles in accordance with the position of said throttle, engine speed responsive means for modifying the actuation of said control means to increase the quantity of fuel supplied to said nozzles as engine speed increases, and throttle controlled means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed.

13. A charge forming device for an internal combustion engine comprising a source of fuel under pressure, a fuel nozzle for each cylinder of the engine, a valve for supplying a metered quantity of fuel to each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to said cylinders, control means operatively connected intermediate said throttle valve and said metering valve for controlling the quantity of fuel supplied to said nozzles in accordance with the position of said throttle, engine speed responsive means for modifying the actuation of said control means to increase the quantity of fuel supplied to said nozzles as engine speed increases, throttle controlled means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, and means for controlling the pressure drop across said metering valve.

14. A charge forming device for an internal combustion engine comprising a source of fuel under pressure, a fuel nozzle for each cylinder of the engine, a valve for supplying a metered quantity of fuel to each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to said cylinders, control means operatively connected intermediate said throttle valve and said metering valve for controlling the quantity of fuel supplied to said nozzles in accordance with the position of said throttle, engine speed responsive means for modifying the actuation of said control means to increase the quantity of fuel supplied to said nozzles as engine speed increases, throttle controlled means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, and engine temperature responsive means for limiting the opening movement of said throttle until said temperature reaches a given value.

15. A charge forming device for an internal combustion engine comprising a source of fuel, high and low pressure pumps communicating with said fuel source, a fuel nozzle for each cylinder of the engine, a valve for supplying a metered quantity of fuel to each of said fuel nozzles, conduit means adapted to communicate said pumps and said valve, valve means in said conduit means for selectively communicating the high or low pressure pump with the fuel metering valve in accordance with the pressure of the high pressure pump, a throttle valve for controlling the quantity of air flow to said cylinders, control means operatively connected intermediate said throttle valve and said metering valve for controlling the quantity of fuel supplied to said nozzles in accordance with the position of said throttle, engine speed responsive means for modifying the actuation of said control means to increase the quantity of fuel supplied to said nozzles as engine speed increases, and throttle controlled means for rendering said engine speed responsive means inopera-

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tive to increase the fuel flow through said metering valve beyond a given engine speed.

16. A charge forming device as set forth in claim 12 in which said control means comprises a first cam member fixed for rotation with said throttle valve, a lever system operatively interconnecting said cam member and said metering valve to increase the flow of fuel through the metering valve as said throttle is moved in an opening direction, said engine speed responsive means being connected to said lever system through a lost motion connection, a second cam means operatively connected to said throttle and adapted to shift said lever system to a position in which said engine speed responsive means will increase the fuel flow through said metering valve as said throttle opens beyond a given point, a second lost motion connection between said engine speed responsive means and said lever system and which second lost motion connection will for a given throttle position and engine speed render said speed responsive means inoperative to increase the flow of fuel through the metering valve with further increases in engine speed, and a third cam means operatively connected to said throttle valve for varying the engine speed at which said second lost motion connection renders said engine speed responsive means inoperative to modify the fuel flow through said metering valve.

17. A charge forming device as set forth in claim 12 in which said control means comprises a first cam member fixed for rotation with said throttle valve, a lever system operatively interconnecting said cam member and said metering valve to increase the flow of fuel through the metering valve as said throttle is moved in an opening direction, said engine speed responsive means being connected to said lever system through a lost motion connection, a second cam means operatively connected to said throttle and adapted to shift said lever system to a position in which said engine speed responsive means will increase the fuel flow through said metering valve as said throttle opens beyond a given point, a second lost motion connection between said engine speed responsive means and said lever system and which second lost motion connection will for a given throttle position and engine speed render said speed responsive means inoperative to increase the flow of fuel through the metering valve with further increases in engine speed, a third cam means operatively connected to said throttle valve for varying the engine speed at which said second lost motion connection renders said engine speed responsive means inoperative to modify the fuel flow through said metering valve, and means operatively connected to said lever system for compensating fuel flow for changes in ambient pressure.

18. A charge forming device as set forth in claim 12 in which said control means comprises a first cam member fixed for rotation with said throttle valve, a lever system operatively interconnecting said cam member and said metering valve to increase the flow of fuel through the metering valve as said throttle is moved in an opening direction, said engine speed responsive means being connected to said lever system through a lost motion connection, a second cam means operatively connected to said throttle and adapted to shift said lever system to a position in which said engine speed responsive means

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will increase the fuel flow through said metering valve as said throttle opens beyond a given point, a second lost motion connection between said engine speed responsive means and said lever system and which second lost motion connection will for a given throttle position and engine speed render said speed responsive means inoperative to increase the flow of fuel through the metering valve with further increases in engine speed, a third cam means operatively connected to said throttle valve for varying the engine speed at which said second lost motion connection renders said engine speed responsive means inoperative to modify the fuel flow through said metering valve, a servo device connected to the lever system, a spring member biasing said servo and lever system in a fuel flow increasing direction to provide power enrichment, manifold vacuum acting on said servo device and normally biasing said device and lever system in a direction providing more economical use of fuel.

19. A charge forming device for an internal combustion engine comprising a source of fuel under pressure, a fuel nozzle for each cylinder of the engine, a valve for supplying a metered quantity of fuel to each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to said cylinders, control means operatively connected intermediate said throttle valve and said metering valve for controlling the quantity of fuel supplied to said nozzles in accordance with the position of said throttle, engine speed responsive means for modifying the actuation of said control means to increase the quantity of fuel supplied to said nozzles as engine speed increases, and throttle controlled means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, and ambient pressure responsive means for modifying the operation of said control means to vary the fuel supplied by the metering valve in accordance with variations in barometric pressure.

20. A charge forming device for an internal combustion engine comprising a source of fuel under pressure, a fuel nozzle for each cylinder of the engine, a valve for supplying a metered quantity of fuel to each of said fuel nozzles, a throttle valve for controlling the quantity of air flow to said cylinders, control means operatively connected intermediate said throttle valve and said metering valve for controlling the quantity of fuel supplied to said nozzles in accordance with the position of said throttle, engine speed responsive means for modifying the actuation of said control means to increase the quantity of fuel supplied to said nozzles as engine speed increases, and throttle controlled means for rendering said engine speed responsive means inoperative to increase the fuel flow through said metering valve beyond a given engine speed, a manifold vacuum actuated servo device operatively connected to the control means and normally positioning said control means to provide a lean fuel-air ratio, and spring means urging said control means to enrich the fuel-air ratio when manifold vacuum drops below a given value.

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