

W. L. KENNEDY, SR
FUEL INJECTION DEVICE

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FIG. 1.

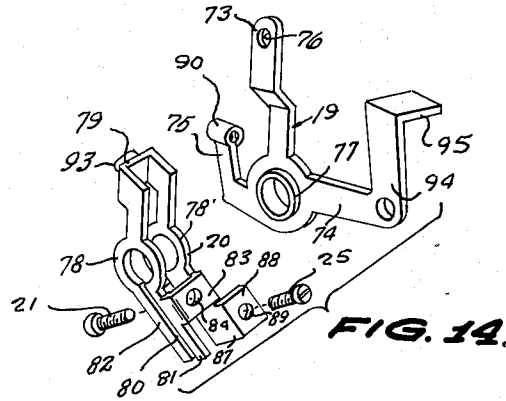


FIG. 2.

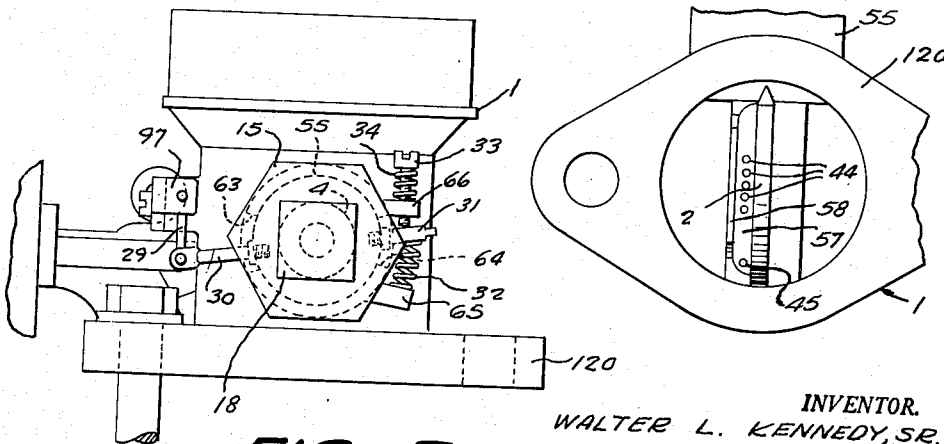


FIG. 3.

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3,132,191

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FIG. 5.

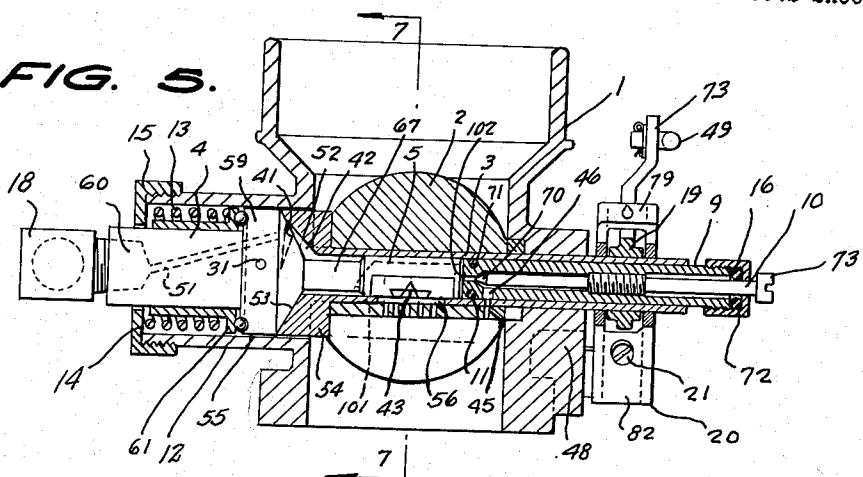


FIG. 6

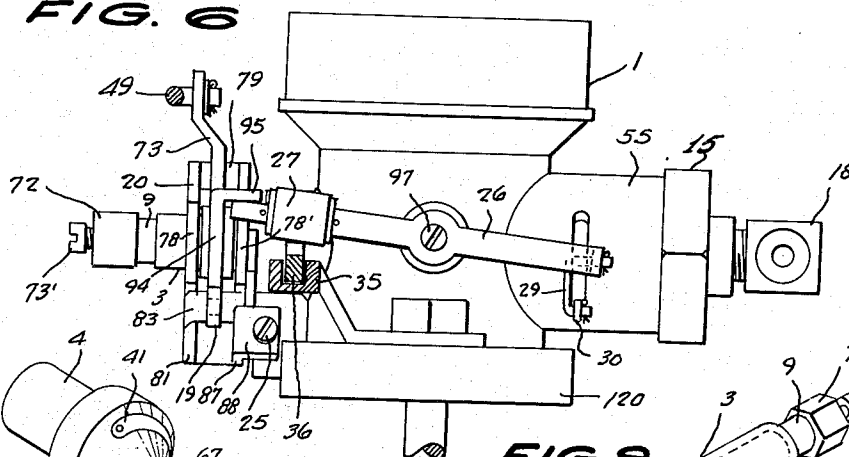


FIG. 9.

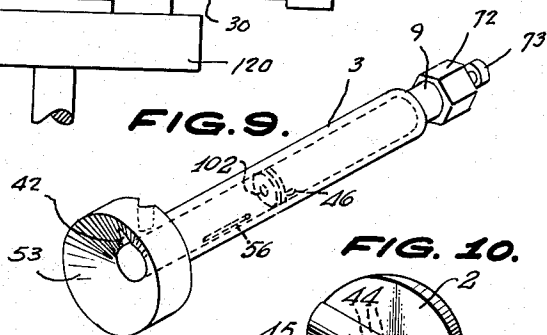


FIG. 10.

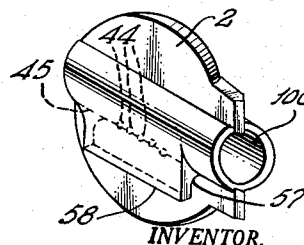
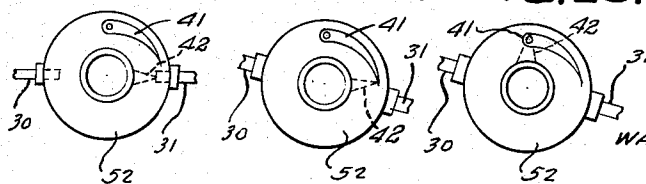


FIG. 8.

FIG. 11. FIG. 12. FIG. 13.



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FIG. 7.

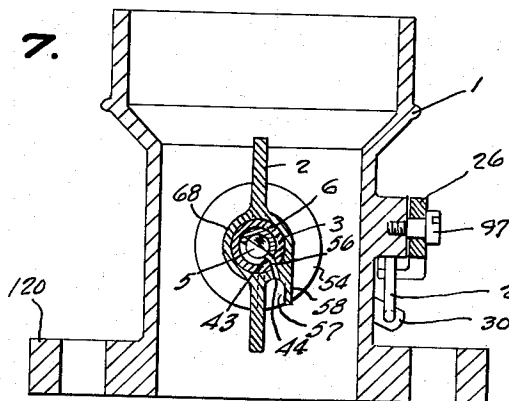


FIG. 16.

FIG. 15.

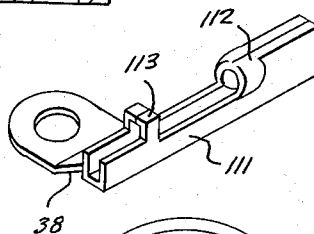
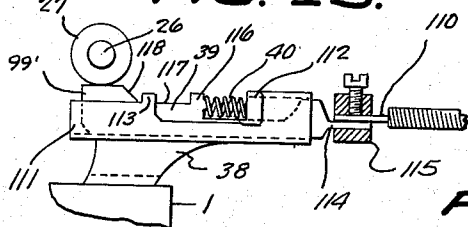


FIG. 18.

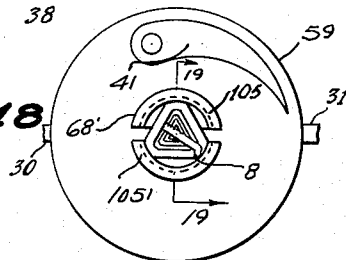


FIG. 17.

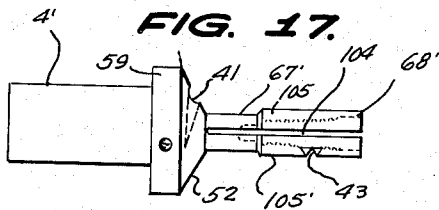


FIG. 19.

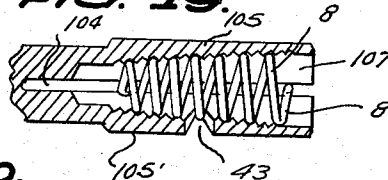
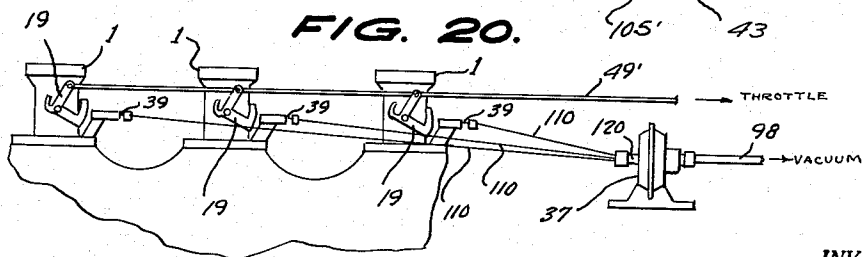


FIG. 20.



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FUEL INJECTION DEVICE

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Filed Mar. 9, 1962, Ser. No. 178,682

8 Claims. (Cl. 261-41)

This invention relates to a fuel injector for internal combustion engines, and more particularly to an improved fuel metering device adapted to be employed in place of a conventional carburetor in an internal combustion engine.

A main object of the invention is to provide a novel and improved fuel injection device for an internal combustion engine, the device being relatively simple in construction, providing accurate metering of the fuel passing therethrough, having very few moving parts, and being adaptable for use with a wide range of engines, such as those employed in automobiles, motor trucks, marine craft, and the like.

A further object of the invention is to provide an improved fuel injection device for internal combustion engines, the device being composed of relatively inexpensive parts, being easy to install, being reliable in operation, and providing improved performance and fuel economy.

A still further object of the invention is to provide an improved fuel injection device for internal combustion engines, the device being relatively compact in size, being durable in construction, being easy to adjust, being substantially leak-proof, and being arranged so that transmission of fuel therethrough is automatically shut off responsive to the stopping of the associated engine.

A still further object of the invention is to provide an improved fuel injection device for an internal combustion engine wherein the rotating parts are self-aligning, wherein substantial sealing areas are provided for parts intended to be in sealing contact with each other, which is arranged to allow precise primary metering of the fuel, which employs parts requiring a minimum amount of internal drilling, so that the parts are not materially weakened and are inexpensive to fabricate, and which is provided with easily accessible means for adjusting the fuel richness, the idle position of the main butterfly valve, and the degree of spring tension exerted between cooperating throttle-actuating arms of the fuel injection device.

A still further object of the invention is to provide an improved fuel injection device for an internal combustion engine, said device being provided with means to prevent transmission of fuel therethrough unless the associated engine is developing vacuum, whereby the supply of fuel to the engine is automatically shut off when the engine is not running or stalled for any reason.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

FIGURE 1 is a perspective view of an improved fuel injection device constructed in accordance with the present invention, shown in normal operating position.

FIGURE 2 is an enlarged side elevational view taken from the left-hand side of the fuel injection device of FIGURE 1.

FIGURE 3 is an enlarged rear end elevational view of the fuel injection device of FIGURE 1.

FIGURE 4 is a fragmentary bottom view of the fuel injection device of FIGURES 1, 2 and 3, showing the butterfly valve thereof in full-throttle position.

FIGURE 5 is a vertical cross sectional view taken substantially on the line 5-5 of FIGURE 2.

FIGURE 6 is a vertical cross sectional view taken substantially on the line 6-6 of FIGURE 2.

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FIGURE 7 is a vertical cross sectional view taken substantially on the line 7-7 of FIGURE 5.

FIGURE 8 is a perspective view of the metering shaft employed in the fuel injection device of FIGURES 1 to 7 with the parts thereof shown in separated positions.

FIGURE 9 is a perspective view of the butterfly valve shaft employed in the fuel injection device of FIGURES 1 to 7.

FIGURE 10 is a perspective view of the butterfly valve element employed in the fuel injection device of FIGURES 1 to 7.

FIGURE 11 is a diagrammatic view showing the relationship between the primary metering slot on the butterfly valve shaft member and the primary metering jet cavity on the conical seat of the metering shaft in the "off" position of the fuel injection device, wherein there is no communication between the fuel supply jet cavity and the primary metering slot.

FIGURE 12 is a diagrammatic view showing the relationship between the primary metering slot in the butterfly shaft and the primary metering jet cavity in the fuel metering shaft in the idle running position of the fuel injection device.

FIGURE 13 is a diagrammatic view similar to FIGURES 11 and 12 but showing the relationship of the primary metering slot in the butterfly shaft and the primary metering jet cavity in the fuel metering shaft in the full-throttle position of the fuel injection device.

FIGURE 14 is a perspective view showing the fixed throttle arm and the floating throttle arm cooperating therewith to rotate the butterfly shaft, as employed in the fuel injection device of FIGURES 1 to 13, the parts being shown in separated positions.

FIGURE 15 is a fragmentary side elevational view of a portion of a modified form of fuel injection device according to the present invention, showing an interlocked bracket and interlock cam cooperating therewith, as employed in an installation where a remote-mounted vacuum cylinder is utilized as a fuel cut-off control element, or in an installation employing multiple fuel injection devices.

FIGURE 16 is a perspective view of the interlock bracket element employed in the arrangement illustrated in FIGURE 15.

FIGURE 17 is a side elevational view of a modified form of metering shaft which may be employed in a fuel injection device according to the present invention.

FIGURE 18 is an enlarged end elevational view of the modified metering shaft illustrated in FIGURE 17 and including the internal spring employed therewith.

FIGURE 19 is an enlarged cross sectional view taken substantially on the line 19-19 of FIGURE 18.

FIGURE 20 is a diagrammatic view showing a multiple arrangement of three fuel injectors operated by a common control rod and provided with a common vacuum-responsive fuel cut-off control chamber, employing interlocked bracket assemblies as illustrated in FIGURES 15 and 16.

Referring to the drawings, and more particularly to FIGURES 1 to 14, the main body of an improved fuel injection device according to the present invention is designated by the reference numeral 1, and the butterfly valve thereof is designated by the reference numeral 2. The butterfly valve 2 is mounted on a butterfly shaft 3 which is rotatably supported at one end portion thereof in an enlarged boss 48 formed in the injector body 1, the shaft 3 being formed at its opposite end with an enlarged annular head portion 54 which is rotatably supported in the laterally projecting cylindrical housing 55 integrally formed with the wall of body 1. As shown in FIGURE 5, the shaft 3 is of tubular construction, and the enlarged head 54 is formed with a conical seat 53

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converging toward the bore of the shaft 3 and formed with a generally triangular primary metering slot or recess 42 adjacent the vertex portion of the seat 53.

The tubular shaft 3 is formed with a longitudinal slot 56 which communicates with a plurality of longitudinally aligned apertures 44 formed in the sleeve portion of the butterfly valve 2 and leading into the low pressure atomization space 57 defined inside a canopy flange 58 provided on the butterfly valve 2, as is clearly shown in FIGURE 7.

Disposed axially in the cylindrical housing 55 is a metering shaft 4 which is formed with an enlarged head portion 59 having a conical face 52 which is rotatably and sealingly engageable against the conical seat 53, the shaft 4 being formed with an internal fuel passage 51 which connects a fuel-receiving cavity 60 at the outer end of the shaft with a primary metering recess or cavity 41 formed in the conical face 52 and being registrable with the metering groove or slot 42 of member 54.

As shown in FIGURE 8, the recess 41 flares in width in the circumferential direction of face 52, being relatively small in width at one end and being of relatively large width at its opposite end, but being arcuately curved so that it will be transversely overlapped by the groove 42 over the working range of rotation of the butterfly valve 2. As shown in FIGURE 11, and as will be presently explained, the primary metering recess 42 does not overlap the metering recess 41 in the normal non-operating condition of the fuel injection device, preventing fuel from reaching the interior of the tubular butterfly shaft 3.

A fuel inlet fitting 18 is connected to the end of the metering shaft 4, being threadedly engaged into the recess 60 and being in communication therewith. A suitable flexible conduit, not shown, connects the fitting 18 to the fuel pump associated with the engine with which the injection device is employed, the fuel pressure line between the fuel pump and the injection device being preferably provided with a fuel pressure regulator to maintain a substantially constant fuel supply pressure. As above mentioned, the conduit connected to the fitting 18 should be sufficiently flexible to allow the shaft 4 to be rotated to the "fuel-off" position of FIGURE 11 in a manner presently to be described.

An annular retaining cap 15 is screw threaded on the end of the cylindrical housing 55, and a coiled spring 14 is provided inside the cylindrical housing 55, the coiled spring 14 bearing between the annular cap member 15 and the end flange 61 of a spring retaining sleeve 13 surrounding the metering shaft 4. As shown in FIGURE 5, ball bearings 12 may be provided between the flange 61 and the enlarged head portion 59 of the metering shaft 4 to facilitate free rotation of the metering shaft 4 with respect to the spring retaining sleeve 13. Spring 14 holds conical surface 52 in sealing contact with conical surface 53, preventing leakage of fuel therebetween.

Diametrically opposed radially extending arms 30 and 31 are secured in and project from the periphery of the enlarged head portion 59, said arms extending through respective peripheral slots 63 and 64 provided in the housing 55. A coiled spring 32 is mounted on a lug 65 formed on the injector body 1, the top end of the spring 32 bearing against the arm 31 and biasing the metering shaft 4 in a counterclockwise direction, as viewed in FIGURE 3, toward engagement with the bottom end of an adjustable stop screw 33 threadedly engaged through a fixed lug 66 on body 1. A retaining spring 34 surrounds the shank portion of the screw 33, bearing between the head thereof and the lug 66. The screw 33 is employed to provide a coarse adjustment of the richness of the fuel mixture under idling conditions.

As shown in FIGURE 8, the metering shaft 4 is formed with a reduced portion 67 and with the hollow end portion 68 which sealingly and rotatably fits inside the bore of the butterfly shaft 3. A semicylindrical block

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5 slidably fits inside an opening 69 formed in the member 68 and is biased outwardly by a pair of coil springs 6, 6 engaging in recesses 70, 70 formed in the block and bearing against the inside of the hollow member 68, whereby the block 5 is biased outwardly into sealing contact with the inside surface of the hollow shaft 3. As shown, the member 68 is located so that a fuel orifice 43 provided in the block 5 is registrable with the slot 56. However, the outside of the orifice 43 is triangular in shape so that the degree of registration between the orifice 43 and the longitudinal slot 56 depends upon the rotated position of shaft 4 with respect to the butterfly shaft 3. Thus, the slot 56 and the orifice 43 cooperate to provide a supplementary metering action generally similar to that provided by the coating metering recesses 41 and 42. Orifice 43 is closed during idling.

Sealingly secured by friction inside the end portion of the shaft 3 opposite the housing member 55 is a sleeve member 9 in which is threadedly engaged the idle adjusting needle shaft 10. A suitable O ring of neoprene or other similar deformable resilient material, shown at 11 is provided at the inner end portion of the sleeve 9, further sealing the sleeve with respect to the inside surface of the hollow shaft 3. The needle valve member 10 has the tapered end portion 70 which may be adjusted with respect to a needle valve seat 71 formed in the inner end portion of the sleeve member 9, to regulate the rate of flow of liquid fuel into the sleeve member 9 from the forward portion of the butterfly shaft 3, the sleeve 9 and the shaft 3 being apertured at 46 in communication with the idle fuel aperture 45 of butterfly valve 2.

A sealing cap 72 is threadedly secured on the outer end of the sleeve member 9, a suitable annular packing ring 16 being provided around the shaft of the needle 10 within the cap 72 to seal the member 10 with respect to the member 9. As will be readily apparent, the needle 10 may be adjusted by means of a slotted external head 73' to provide a desired idle fuel flow adjustment.

Designated at 19 is a throttle lever which is rotatably mounted on the butterfly shaft 3 adjacent the boss 48, the lever being formed with a first arm 73 and the respective laterally extending second and third arms 75 and 74 respectively. The top end of the upstanding arm 73 is apertured at 76 for connection to a conventional accelerator rod 49 which may be operated by the usual accelerator foot pedal. Thus, the accelerator rod 49 is biased to the right, as viewed in FIGURE 2, by suitable spring means, not shown, and of a conventional type, the rod 49 being moved to the left, as viewed in FIGURE 2, responsive to the depression of the associated accelerator pedal.

Designated at 20 is a throttle arm assembly which is clampingly secured on the butterfly shaft 3 adjacent to the floating lever member 19, the member 20 being generally U-shaped in cross section, as shown in FIGURE 14, and being suitably cut away to fit around the member 19 and to receive the bearing sleeve portion 77 thereof between the ring portions 78, 78' of the member 20, the ring portion 78 clampingly engaging the butterfly shaft.

As shown in FIGURE 14, the ring-like elements 78, 78' are integrally formed on the respective side arms of the member 20, being connected by the transversely extending bight portion 79. The opposite arm, namely, the arm associated with the ring-like element 78 is longitudinally slotted at 80 to define upper and lower fingers 81 and 82, the upper finger 81 merging with a transversely extending arm 83 having a tapped opening 84 therein, and the lower finger 82 merging with a transversely extending wall having a central aperture adapted to receive a clamping screw 21 which is threadedly engageable in the tapped opening 84, so that when the screw 21 is tightened the arm 20 will be clamped to

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the butterfly shaft 3. The arm 83 and the opposing wall associated with the lower finger 82 are integral with the top and bottom edges of the arm 87 extending from the ring-like member 78', whereby the arm 87 is integrally related with the fingers 81 and 82.

The arm 87 is formed with an outwardly projecting lug 88 which is provided with a tapped opening 89 to receive an adjustable stop screw 25, said stop screw 25 being engageable with a stop lug 48 on the body 1 to establish the idling position of the butterfly valve 2. A coiled spring 47' surrounds the screw 25, bearing between lug 88 and the head of screw 25 and serving as a means to hold the screw 25 in its adjusted position.

The arm 75 of lever 19 is formed at its end portion with an internally threaded sleeve 90, said sleeve being located so that its axis is directed toward the bight portion 79 of the U-shaped end of lever 20 when the parts 19 and 20 are nestingly interengaged in assembled relationship on the shaft 3, the throttle arm tension adjusting screw 23 being threaded through the sleeve 90 and being locked in adjusted position therein by a lock nut 24. A coiled spring 22 is mounted between the end of screw 23 and the bight member 79, as illustrated in FIGURE 2, the end of screw 23 and the bight member 79 being provided with opposing projections 92 and 93 engaging in the opposite ends of the spring 22 to hold the spring in centered position between screw 23 and member 79. Thus, the spring transmits force from the arm 75 to the bight member 79 when the rod 49 is moved to the right, namely, toward its release position, the force acting on member 79 being transmitted to the arm 73. When the accelerator rod 49 is moved to the left, as viewed in FIGURE 2, force is transmitted directly from the arm 73 to the bight member 79, so that the butterfly shaft 3 is rotated in a positive manner responsive to the movement of rod 49 to the left.

The arm 74 is formed with the upstanding end portion 94 which terminates in the horizontally extending end lug 95. The lug 95 overlies the end of a lever 26 which is pivoted to the body 1 at 97'. The opposite end of the lever 26 is formed with an inwardly directed lug 97 which is connected by a depending link rod 29 to the end of the outwardly projecting arm 30 associated with member 59 of metering shaft 4.

Journalled on the lever 26 adjacent the lug 95 is a roller 27 which overlies a cam bar 36 slidably mounted in a channeled bracket 35 secured on the base flange of body 1. The cam bar 36 is connected to the diaphragm of a vacuum-responsive diaphragm chamber 37, the working space of said chamber being connected by a conduit 98 to the intake manifold of the associated internal combustion engine, whereby vacuum developed by the engine causes the diaphragm of chamber 37 to flex in a manner to move bar 36 to the right, namely, to the position thereof shown in FIGURE 2. When no vacuum is present, the diaphragm of chamber 37 relaxes so that the bar 36 is moved to the left from the position thereof shown in FIGURE 2.

The bar 36 is formed at its end with the upstanding cam projection 99 which is engageable beneath the roller 27 in the manner illustrated in FIGURE 2 responsive to vacuum produced by the internal combustion engine, to hold the lever 19 in a position somewhat rotated counterclockwise, as viewed in FIGURE 2, from its normal position and through link 29 and projection 30 to control the position of metering shaft 4. In this position the arm 73 engages bight member 79 of lever 78 and holds the butterfly shaft 3 in its idling position. This position is illustrated in FIGURE 12, wherein it is seen that shaft 4 is cooperatively positioned relative to shaft 3 such that the small end of the recess 42 overlaps the small end of the recess 41 and a sufficient amount of fuel will be delivered by the injection device to allow the engine to idle. When there is no vacuum, the bar 36 shifts to the left from the position thereof shown in FIG-

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FIGURE 2, allowing lever 19 to rotate clockwise and causing face 52 to rotate clockwise from the position of FIGURE 12 by the action of link 29 and projection 30 as the roller 27 engages the depressed portion of the top edge of bar 36. This is the position illustrated in FIGURE 11.

The arm 74 is formed with an opening 50 at its corner portion to provide a means for connecting the arm 74 to a vertically operating accelerator rod instead of to the horizontally operating accelerator rod 49 shown in dotted view in FIGURE 2.

As shown in FIGURE 13, during normal operation of the vehicle, the accelerator rod 49 may be moved to the left sufficiently to cause lever 19 to rotate butterfly shaft 3 to a position wherein the recess 42 overlaps the widest portion of the recess 41, and wherein the widest portion of the opening 43 is exposed to the butterfly fuel jet orifices 44. This provides maximum flow of fuel through the injection device.

It will be understood that when the ignition system is deenergized, causing the engine to stop, or if the engine stalls, there is no longer any vacuum produced by the engine and the diaphragm of chamber 37 relaxes to cause cam bar 36 to move to the left from the position thereof shown in FIGURE 2, which allows the face 52 to be rotated by lever 26 and link 29 to the cut-off position thereof illustrated in FIGURE 11, terminating the supply of fuel. However, under idling conditions, namely, when the engine is running, although not under load, sufficient vacuum is produced to hold cam portion 99 beneath roller 27 and to control the position of shaft 4 to prevent the released accelerator rod 49 from rotating lever 19 clockwise to a position which provides cut-off of fuel.

As will be seen from FIGURES 9 and 10, the butterfly valve 2 is made of a separate casting, being subsequently secured on the butterfly shaft 3 to provide the rigid unitary combination of these two elements illustrated in FIGURE 5. Thus, in the fabrication of the injection unit, only two castings are required, namely, the main body 1 and the butterfly valve body 2. In the assembly of the injection device, the butterfly valve 2 is inserted through the bore of the body 1 and the butterfly shaft 3 is inserted perpendicularly thereto through the housing 55 so as to engage in the bore portion 100 of the butterfly valve body 2. Preferably, the engagement between the shaft 3 and the butterfly valve bore 100 is sufficiently tight so that said elements 2 and 3 will be rigidly united with the butterfly valve 2 abutting the enlarged portion 54 of shaft 3.

In operation, the operator starts the motor by turning on the starting switch, resulting in the diaphragm of the chamber 37 to flex in a manner to move the bar 36 to the right, the position shown in FIGURE 2. The movement of bar 36 to the position shown in FIGURE 2, rocks the lever 26 so as to be depressed toward the projecting arm 30, resulting in movement of the metering recess 41 into registry with the metering recess 42, permitting fuel to flow from the internal fuel passage 51 into and through the registering recesses 41 and 42, into the hollow shaft means or shaft 3, into the reduced portion 67, into the clearance passage 101 provided between the reduced portion 67 and the sealing portion 68 of member 4, into the central bore 102, into the inner end of the idler shaft 9, past the needle valve tip 70, through the registering apertures 45 and 46 into the space 57 provided by the butterfly valve 2, and into the manifold.

Upon accelerating the speed of the motor by applying increasing pressure to the accelerator rod 49, the throttle lever 20 is rotated correspondingly, resulting in the metering recess 42 to be advanced along the metering recess 41 and consequently increasing the flow of fuel therethrough, and simultaneously therewith bringing the metering orifice 43 into registry with the slot 56 and the spaced apertures 44 communicating therewith.

As above described, under idling conditions the recess 41 registers with the recess 42 in the manner illustrated in FIGURE 12, providing a supply of fuel at a rate deter-

mined by the setting of the main fuel richness adjusting screw 33, since the spring 32 urges the arm 31 into abutment with the end of said screw 33. The idling rate is also subject to the fine adjustment provided by the needle member 10, which controls the rate at which liquid fuel flows through the bore 102 to the registering apertures 45 and 46. The idling position of the butterfly valve is controlled by the adjustment of the screw 25, which abuts the lug 48, and which thus determines the angular position of the butterfly valve 2 under idling conditions.

As will be readily apparent, the conical sealing surface 52 and the associated conical sealing surface 53 may be ground to any desired angle, in accordance with the amount of sealing area required. In a typical embodiment of the invention, an angle of 30° was employed for the side slope of the generating cone. The conical surfaces are preferably ground and hardened to provide high resistance to wear, thus minimizing leakage between the surfaces.

FIGURES 17, 18 and 19 illustrate an alternative structure which may be employed to provide sealing engagement between the metering shaft and the hollow butterfly shaft 3. Thus, in FIGURES 17, 18 and 19, the metering shaft is designated at 4' and is provided with the enlarged member 59 having the conical sealing surface 52, as in the previously described form of the invention. The sealing surface 52 is provided with the same tapered recess 41 employed in the previously described form of the invention and has the reduced shank portion 67' and the enlarged generally cylindrical end portion 68' which is longitudinally slotted, by the provision of a median slot 104 which extends through the major portion of the length of the reduced portion 67', whereby two relatively flexible, generally semi-cylindrical segments 105 and 105' are provided. The member 68' is formed with a tapered internally threaded bore 107 in which is threaded a correspondingly tapered coil spring 8, the triangular cross sectional shape of the coil spring 8 being clearly shown in FIGURE 18. The spring 8 acts in a manner similar to the previously described springs 6, 6 to exert an outward spreading force on the sealing member 68' to bias the exterior surfaces of the member 68' into sealing contact with the inside surfaces of the hollow butterfly shaft 3. As shown in FIGURE 17, the lower segment 105' is provided with the generally triangular fuel discharge aperture 43 which cooperates with the jet orifices 44 of the butterfly valve in the same manner as in the previously described form of the invention.

FIGURES 15 and 16 illustrate an alternative form of support for the sliding cam bar employed to control the position of the shut-off lever 26 by engagement with the roller 27 carried on said shut-off lever. This arrangement may be employed where the control element, for example, the vacuum-responsive operating means for the cam bar is located at a remote position with respect to the fuel injection device. Thus, a flexible cable 110 may be employed to connect the diaphragm of the vacuum-responsive device to the cam bar. In the arrangement of FIGURES 15 and 16 a supporting bracket 38 is secured to the base flange of the body 1, said bracket being integrally formed with a channel portion 111. The channel member 111 is integrally formed at one end with a tubular guide sleeve portion 112 and is further formed at an intermediate portion thereof with a generally rectangular arch-like retaining lug 113 which connects the top edges of the opposite side walls of the channel member 111. Slidably disposed in the channel member 111 is the cam bar 39 formed with the elevated end cam portion 99' which is adapted to cooperate with the roller 27 in the same manner as the elevated cam portion 99 of the previously described form of the invention. The cam bar 39 is provided at its forward end with an apertured attachment lug 114 adapted to be clampingly secured to the end of the flexible cable 110 by conventional connecting member 115, as shown in FIGURE 15. The forward portion of the bar 39 is slidably disposed in the tubular guide

portion 112, and a coiled spring 40 is interposed between the exposed rear end of the tubular member 112 and an upstanding lug or shoulder element 116 provided on the bar 39. The spring 40 provides a biasing action which tends to urge the cam bar 39 rearwardly, namely, in a direction opposite to that of the normal tension exerted on the cable 110, so that the cable is normally held in a relatively taut condition. Thus, with the associated internal combustion engine not operating, whereby there is no vacuum, the bar 39 is positioned so that the roller 27 engages on the depressed edge portion 117 of the cam bar 39, causing the arm 30 to be elevated and establishing the cut-off condition illustrated in FIGURE 11. When vacuum is developed, the diaphragm of the associated vacuum-responsive chamber is flexed in a direction to exert tension on the cable 110, causing the cam bar 39 to be moved to the position illustrated in FIGURE 15, namely, wherein the elevated cam portion 99' underlies the roller 27, whereby the lever 26 cannot be rotated beyond a position corresponding to that illustrated in FIGURE 6, namely, cannot restore the cut-off condition of FIGURE 11 until there is no more vacuum.

The cross member 113 limits the forward movement of the cam bar 39 substantially to the position thereof shown in FIGURE 15, since it is engageable with the inclined front edge 118 of the elevated cam portion 99'.

When the motor is not in operation, for example when its ignition is deenergized or when it stalls, vacuum is no longer available and the spring 40 expands to return the cam bar 39 to a position allowing the roller 27 to descend onto the depressed portion 117 of the top edge of the cam bar, producing the condition illustrated in FIGURE 11, namely, cutting off the supply of fuel to the injection device.

As illustrated in FIGURE 20, a plurality of injection devices may be controlled by a common vacuum responsive device 37 by employing the cam bar supporting structure illustrated in FIGURES 15 and 16 with each of the injection devices. Thus, the diaphragm link 120 of the vacuum chamber 37 may be connected by a plurality of flexible cables 110 to the respective cam bars 39 to control the cut-off of fuel to the respective injection devices and to automatically cut off the supply of fuel thereto when no vacuum is present in the conduit 98 connected to the vacuum chamber 37.

As shown in FIGURE 20, the floating throttle arms 19 of the respective fuel injection devices may be connected to a common throttle control rod 49' for simultaneous control.

The main body 1 of the fuel injection device, in all the various modifications thereof illustrated in the drawings, is open to the atmosphere at its top end and is adapted to be connected at its other end to the intake manifold of an internal combustion engine. For this purpose, the bottom end of the body 1 is provided with a suitably apertured flange 120 adapted to be secured to the intake manifold of an engine in a conventional manner.

While certain specific embodiments of an improved fuel injection device have been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore, it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, hollow shaft means, means to rotatably mount said hollow shaft means transversely in said main conduit, a butterfly valve means secured on said hollow shaft means in said main fuel mixture conduit, said hollow shaft means and butterfly valve means being formed with fuel passage means opening into said conduit, fuel metering

conduit means, means to mount said fuel metering conduit means rotatably in said hollow shaft means, means to connect said fuel metering conduit means to a source of liquid fuel, said fuel metering conduit means and hollow shaft means being formed with cooperating sealing surface means and with registrable ports in said sealing surface means to selectively regulate the flow of fuel from the metering conduit means to the hollow shaft means, a throttle lever rotatably mounted on said hollow shaft means, a throttle arm assembly secured to said hollow shaft means, a cam means slidably mounted on said main conduit, said throttle lever having a first, second and third arms, the first arm of said throttle lever being connectible to an accelerator rod, spring means engaging the second arm of said throttle lever and biasing said fuel metering conduit means toward a position wherein said ports are in registry, the third arm of said throttle lever being engageable with said cam means to control the rotated position of said fuel metering conduit means, vacuum responsive means operatively connected to said cam means, said vacuum responsive means being adapted to be connected to the intake manifold of the associated engine, said throttle lever being engageable with said throttle arm assembly in opposition to said spring means.

2. The fuel injection device according to claim 1 which includes in addition an adjustable stop means on said main conduit opposite said spring means and being engageable with said second arm to limit rotation of said fuel metering conduit means.

3. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, hollow shaft means, means to rotatably mount said hollow shaft means transversely in said main conduit, throttle lever means operatively connected to the hollow shaft means, a butterfly valve secured on said hollow shaft means in said main fuel mixture conduit, said hollow shaft means and butterfly valve being formed with fuel passage means opening into said conduit, fuel metering conduit means, means to mount said fuel metering conduit means rotatably in said hollow shaft means, means to connect said fuel metering conduit means to a source of liquid fuel, said fuel metering conduit means and hollow shaft means being formed with relatively rotatable cooperating sealing surface means, one of said sealing surface means having a tapering port and the other sealing surface means having a tapering port extending in a direction substantially transverse to the first-named port, said ports being registrable in overlapping relation to define a flow-regulating fuel transmission area varying in accordance with the relative rotated positions of the hollow shaft means and the fuel metering conduit means, and vacuum-responsive means connected to said fuel metering conduit means to maintain said fuel metering conduit means in a rotated position wherein said ports are at least partially in registry when said vacuum-responsive means is connected to a source of vacuum.

4. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, hollow shaft means, means to rotatably mount said hollow shaft means transversely in said main conduit, throttle lever means operatively connected to the hollow shaft means, a butterfly valve secured on said hollow shaft means in said main fuel mixture conduit, said hollow shaft means and butterfly valve being formed with fuel passage means opening into said conduit, fuel metering conduit means, means to mount said fuel metering conduit means rotatably in said hollow shaft means, means to connect said fuel metering conduit means to a source of liquid fuel, said fuel metering conduit means and hollow shaft means being formed with relatively rotatable cooperating sealing surface means, one of said sealing surface means having a tapering port and the other seal-

ing surface means having a tapering port extending in a direction substantially transverse to the first-named port, said ports being registrable in overlapping relation to define a flow-regulating fuel transmission area varying in accordance with the relative rotated positions of the hollow shaft means and the fuel metering conduit means, vacuum-responsive means connected to said fuel metering conduit means to maintain said fuel metering conduit means in a rotated position wherein said ports are at least partially in registry circumferentially spaced from said first arm, said hollow shaft means and butterfly valve being provided with fuel idle supply passage means communicatively connecting the interior of said hollow shaft means to the interior of said main conduit, and externally adjustable needle valve means mounted axially in said hollow shaft means and extending into said fuel idle supply passage means.

5. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, hollow shaft means, means to rotatably mount said hollow shaft means transversely in said main conduit, throttle lever means rotatably mounted on said hollow shaft means, means resiliently connecting said throttle lever means to said hollow shaft means for simultaneous rotation in one direction, means non-resiliently connecting said throttle lever means to said hollow shaft means for simultaneous rotation in the opposite direction, a butterfly valve secured on said hollow shaft means in said main fuel mixture conduit, said hollow shaft means and butterfly valve being formed with fuel passage means opening into said conduit, fuel metering conduit means, means to mount said fuel metering conduit means rotatably in said hollow shaft means, means to connect said fuel metering conduit means to a source of liquid fuel, said fuel metering conduit means and hollow shaft means being formed with relatively rotatable cooperating sealing surface means, one of said sealing surface means having a tapering port and the other sealing surface means having a tapering port extending in a direction substantially transverse to the first-named port, said ports being registrable in overlapping relation to define a flow-regulating fuel transmission area varying in accordance with the relative rotated positions of the hollow shaft means and the fuel metering conduit means, and vacuum-responsive means connected to said fuel metering conduit means to maintain said fuel metering conduit means in a rotated position wherein said ports are at least partially in registry when said vacuum-responsive means is connected to a source of vacuum.

6. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, hollow shaft means, means to rotatably mount said hollow shaft means transversely in said main conduit, throttle lever means rotatably mounted on said hollow shaft means, means resiliently connecting said throttle lever means to said hollow shaft means for simultaneous rotation in one direction, means to non-resiliently connect said throttle lever means to said hollow shaft means for simultaneous rotation in the opposite direction, a butterfly valve secured on said hollow shaft means in said main fuel mixture conduit, said hollow shaft means and butterfly valve being formed with fuel passage means opening into said conduit, fuel metering conduit means, means to mount said fuel metering conduit means rotatably in said hollow shaft means, means to connect said fuel metering conduit means to a source of liquid fuel, said fuel metering conduit means and hollow shaft means being formed with relatively rotatable cooperating sealing surface means, one of said sealing surface means having a tapering port and the other sealing surface means having a tapering port extending in a direction substantially

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transverse to the first-named port, said ports being registrable in overlapping relation to define a flow-regulating fuel transmission area varying in accordance with the relative rotated positions of the hollow shaft means and the fuel metering conduit means, vacuum-responsive means connected to said fuel metering conduit means to maintain said fuel metering conduit means in a rotated position wherein said ports are at least partially in registry when said vacuum-responsive means is connected to a source of vacuum, and adjustable stop means on the hollow shaft means engageable with said main conduit to limit rotation of said hollow shaft means in said one direction.

7. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, hollow shaft means, means to rotatably mount said hollow shaft means transversely in said main conduit, throttle lever means operatively connected to the hollow shaft means, a butterfly valve secured on said hollow shaft means in said main fuel mixture conduit, said hollow shaft means and butterfly valve being formed with fuel passage means opening into said conduit, fuel metering conduit means, means to mount said fuel metering conduit means rotatably in said hollow shaft means, means to connect said fuel metering conduit means to a source of liquid fuel, said fuel metering conduit means and hollow shaft means being formed with frusto-conical relatively rotatable cooperating sealing surface means, one of said sealing surface means having a tapering port and the other sealing surface means having a tapering port extending in a direction substantially transverse to the first-named port, said ports being registrable in overlapping relation to define a flow-regulating fuel transmission area varying in accordance with the relative rotated positions of the hollow shaft means and the fuel metering conduit means, and vacuum-responsive means connected to said fuel metering conduit means to maintain said fuel metering conduit means in a rotated position wherein said parts are at least partially in registry when said vacuum-responsive means is connected to a source of vacuum.

8. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, hollow shaft means, means to rotatably mount

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said hollow shaft means transversely in said main conduit, throttle lever means rotatably mounted on said hollow shaft means, means resiliently connecting said throttle lever means to said hollow shaft means for simultaneous rotation in one direction, means non-resiliently connecting said throttle lever means to said hollow shaft means for simultaneous rotation in the opposite direction, a butterfly valve secured on said hollow shaft means in said main fuel mixture conduit, said hollow shaft means and butterfly valve being forced with fuel passage means opening into said conduit, fuel metering conduit means, means to mount said fuel metering conduit means rotatably in said hollow shaft means, means to connect said fuel metering conduit means to a source of liquid fuel, said fuel metering conduit means and hollow shaft means being formed with frusto-conical relatively rotatable cooperating sealing surface means, one of said sealing surface means having a tapering port and the other sealing surface means having a tapering port extending in a direction substantially transverse to the first-named port, said ports being registrable in overlapping relation to define a flow-regulating fuel transmission area varying in accordance with the relative rotated positions of the hollow shaft means and the fuel metering conduit means, vacuum-responsive means connected to said fuel metering conduit means to maintain said fuel metering conduit means in a rotated position wherein said ports are at least partially in registry, and adjustable stop means on the hollow shaft means engageable with said main conduit to limit rotation of said hollow shaft means in said one direction.

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