

June 22, 1965

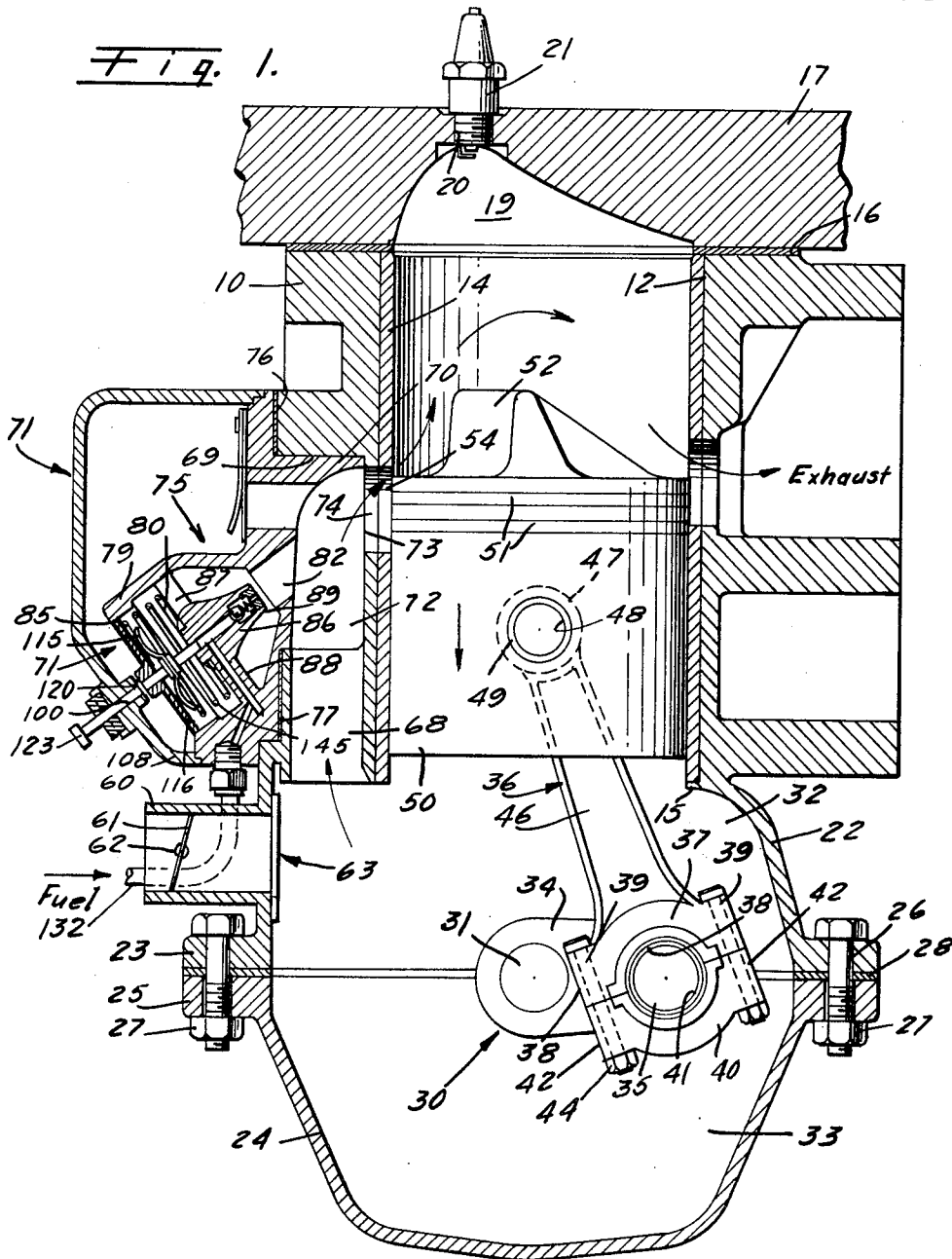
A. GUDMUNDSEN

3,190,271

FUEL-AIR INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Jan. 27, 1964

3 Sheets-Sheet 1



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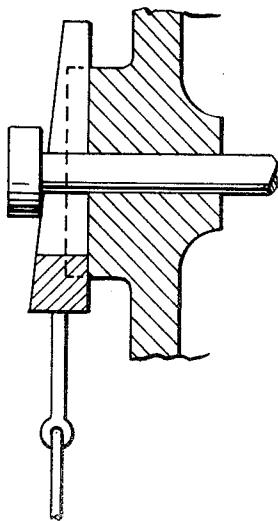
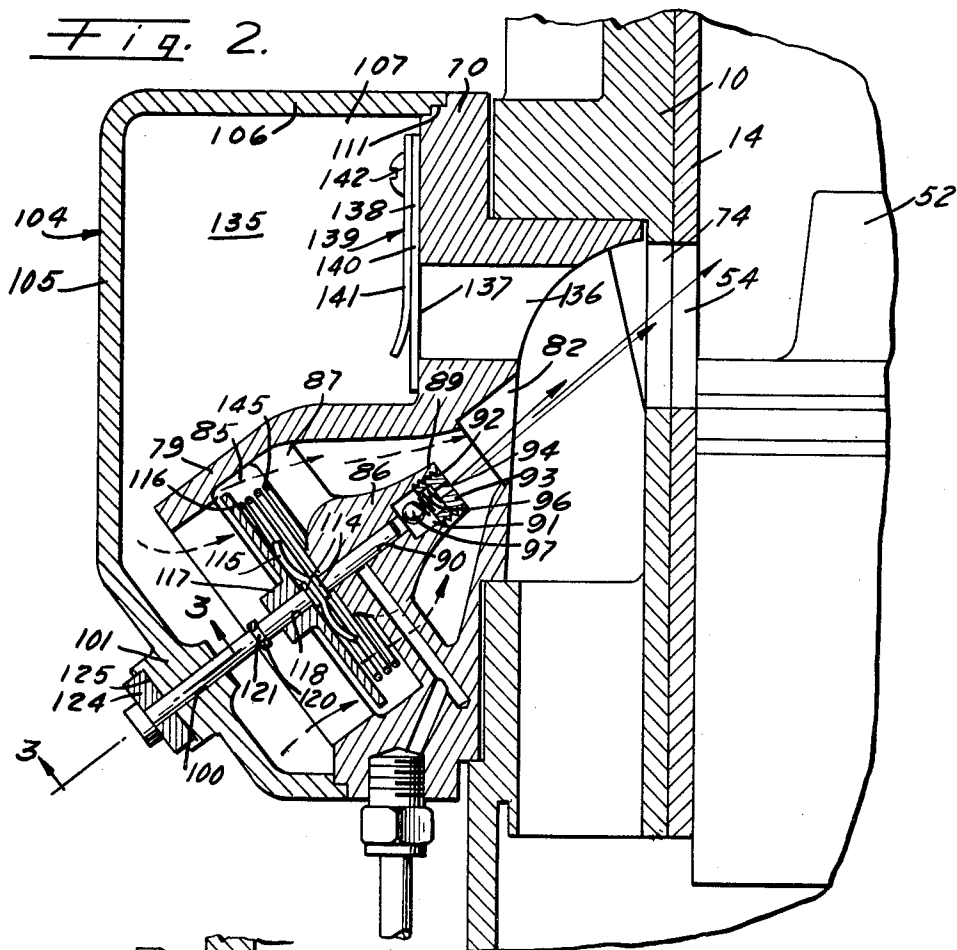
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3 Sheets-Sheet 2



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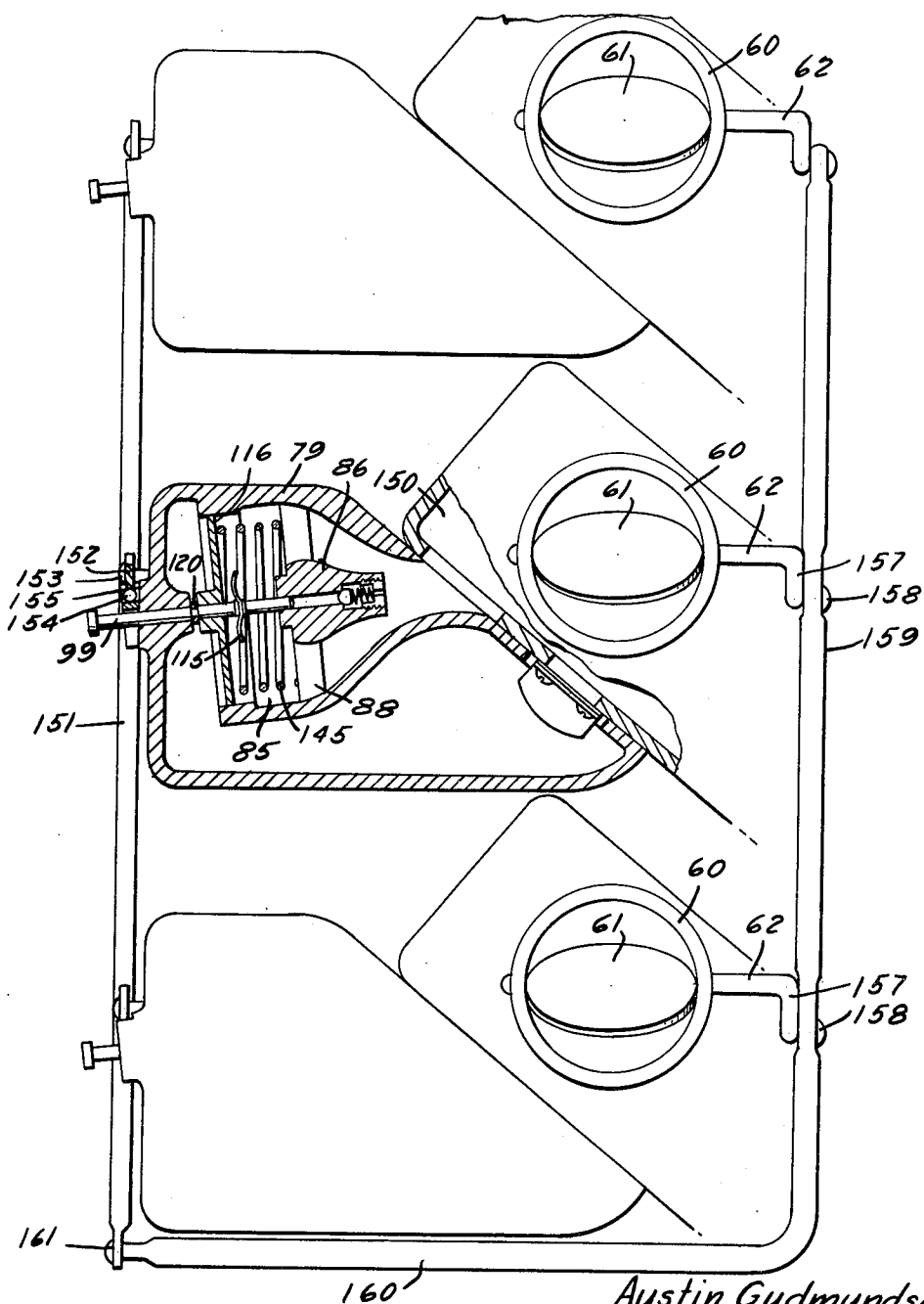
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Fig. 4.

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FUEL-AIR INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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16 Claims. (Cl. 123-29)

This invention relates generally to internal combustion engines and relates more particularly to fuel systems therefor.

While the invention has particular utility in connection with two-cycle internal combustion engines and is shown and described in such connection, it is to be understood that its utility is not confined thereto.

As is well known, with the ordinary two-cycle internal combustion engine the cylinder is scavenged of exhaust gases after the exhaust port opens, by the air-fuel mixture which has been compressed in the crankcase of the engine and directed into the cylinder when the inlet port is uncovered by the piston.

A considerable quantity of this air-fuel mixture is lost out of the exhaust port during the scavenging of the cylinder of burned gases. This, of course, seriously affects the fuel economy of the engine and it is an object of the present invention to eliminate this waste of fuel and increase the fuel economy of said engine.

One way of eliminating this waste of fuel is to use just air in the crankcase without any fuel addition and then scavenge the cylinder of exhaust gases with that air down to a point about bottom dead center, that is, at the end of the down stroke.

At this point of engine operation an atomized quantity of fuel is injected into the inlet port and directed into the cylinder so as to mix with the air then in said cylinder. Thus any waste of the mixture from the cylinder would be merely air and not fuel, since the injection of fuel into the cylinder has been delayed and lags behind the air travel.

Heretofore this has been accomplished by using a standard diesel fuel injector or a gasoline injector such as used on aircraft. However, such injectors are very expensive. Injecting systems of such character require mechanical drives and expensive injector parts which have very close tolerances.

It is therefore another object of the present invention to provide a fuel injection system which does not require a mechanical drive, expensive parts and close tolerances.

It is still another object of the invention to provide an apparatus of this character that is inexpensive to manufacture.

It is a further object of the invention to provide a fuel injector that operates at relatively low pressures.

A still further object of the invention is to provide apparatus of this character that is operated by compressed air from a compressed air storage source.

It is another object of the invention to provide apparatus of this character having a high velocity jet of air into which fuel is squirted or sprayed.

It is still another object of the invention to provide apparatus of this character wherein the high velocity air jet in which is entrained the atomized fuel from the fuel

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nozzle is directed into the transfer or inlet port of the engine cylinder.

It is a further object of the invention to provide apparatus of this character wherein the provision of the high velocity air jet and the discharge of fuel from the fuel nozzle is timed.

It is a still further object of the invention to provide apparatus of this character wherein the timing of the delivery of high velocity air from the air jet in which is entrained the atomized fuel is effected automatically.

Another object of the invention is to provide apparatus of this character having means for controlling the quantity of fuel discharged from the nozzle into the high velocity air jets.

Still another object of the invention is to provide apparatus of this character that is relatively simple in construction.

A further object of the invention is to provide apparatus of this character that is relatively inexpensive to manufacture.

A still further object of the invention is to provide apparatus of this character that is effective and reliable in operation.

It is a further object of the invention to provide a device of this character that is relatively easy to install, remove, and/or service.

It is another object of the invention to provide an improved method for scavenging exhaust gases from an internal combustion engine and supplying fuel to said engine.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detailed description of the accompanying drawings, which represent certain embodiments. After considering these examples, skilled persons will understand that variations may be made without departing from the principles disclosed and I contemplate the employment of any structures, arrangements or modes of operation that are properly within the scope of the appended claims.

Referring to the drawings, which are for illustrative purposes only:

FIG. 1 is a schematic vertical section through one cylinder of a multi-cylinder internal combustion engine embodying the present invention, showing the parts of the injector system in their positions as the engine piston is just beginning to open the transfer port;

FIG. 2 is an enlarged fragmentary sectional view thereof showing the parts of the injector system in their respective positions when the engine piston reaches bottom dead center and the injector is spraying fuel into the atomizing air jet;

FIG. 3 is an enlarged sectional view taken on line 3-3 of FIG. 2;

FIG. 4 is a schematic side view of a multi-cylinder engine showing an alternative arrangement, a portion being broken away to show the injection mechanism.

Referring more particularly to FIG. 1, there is shown a two-cycle internal combustion engine having a block 10 with a cylinder bore 12 therein in which a cylinder liner 14 or sleeve is secured in the cylinder bore 12 against rotation therein in the usual well known manner. It is to be noted that at the lower end of cylinder 12 there is a projecting flange 15 limiting downward movement of the liner 14.

At the upper end of the block there is a gasket 16 of

the usual character and a cylinder head 17 which is disposed on gasket 16 and secured to the block 10 by any suitable well known means such as screws or bolts or the like, not shown.

Head 17 has a recess or combustion chamber 19 formed therein which registers with the upper end of the cylinder, said combustion chamber being of any suitable desired well known configuration. At the upper end of the combustion chamber there is a tapped opening 20 which extends through the head 17 for threadable reception of a spark plug 21.

At the lower end of the block 10 there is an upper crankcase portion 22 which is shown as being formed integrally with said block but which may be separate, to which the block is secured in any well known manner, as by bolts or the like.

A flange 23 extends outwardly of the lower free edge or end of the crankcase portion 22, said flange 23 providing means for attachment of the lower crankcase portion 24 which has an outwardly extending flange 25 about the upper end thereof corresponding to the flange 23. Bolts 26 are received in aligned openings provided therefor in the flanges 23 and 25 and securing nuts 27 are threaded onto the bolts 26. A sealing gasket 28 is disposed between the flanges 23 and 25.

There is a crankshaft, indicated generally at 30, operably disposed in the crankcase defined by the crankcase portions 22 and 24. Crankshaft 30 includes journals 31 which are rotatably mounted in bearings, not shown, of the usual well known character carried by the transverse walls 32 and 33 of the crankcase. The crankshaft includes the webs 34 at the free ends of which there is the usual crank pin 35 to which the inner end of the connecting rod, indicated generally at 36, is operably attached. The inner end of connecting rod 36 is provided with a transverse portion 37 at the end of which is a semi-cylindrical recess 38 which fits onto the crank pin. The portion 37 of the connecting rod has lugs 39 at the sides thereof with openings therein for reception of bolts 39. There is a clamping member 40 having a semi-cylindrical recess 41 and there are lugs 42 at the sides of said clamping member 40 having openings therethrough aligned with the openings in the portion 37 of the connecting rod for reception of end portions of the bolts 39, said end portions projecting beyond the lugs 38 and being externally threaded for reception of nuts 44 whereby the clamping member 40 may be securely attached to the portion 37 of the connecting rod and thereby operably clamp the inner end of the connecting rod to the crank pin 35. The body 46 of the connecting rod is enlarged at 47, said enlarged portion 47 having an opening 48 therein for operable reception of a piston pin or wrist pin 49 which is also mounted in bosses provided therefor within the piston 50, said piston being reciprocally mounted in the cylinder 14.

Piston 50 has grooves adjacent the upper end for reception of piston rings 51 which are disposed in external grooves provided therefor in the piston. This arrangement is well known. Projecting upwardly from the head of the piston is a baffle 52 for deflecting upwardly fluid, such as air and/or fuel mixture, which enters the inlet port 54 in the cylinder defined by the liner 14.

Air is supplied to the crankcase through an air inlet conduit 60 having a control valve, shown as a butterfly valve 61 mounted on a valve shaft 62 journaled in the conduit 60. A reed valve 63 of well known character is disposed at the inner end of the inlet conduit 60 which permits air to flow into the crankcase but which prevents outflow of air through the conduit 60.

There is an air outlet passage 68 through which air from the crankcase passes upwardly, as shown in FIGS. 1 and 2.

Block 10 is provided with a recess 69 with which the outlet end of the air outlet passage 68 communicates, said recess 69 being adapted to receive a boss 70 of in-

jection mechanism, indicated generally at 71. Boss 70 has an air passage 72 having its lower end in communication with the upper end of the outlet air passage 68 and having its upper or discharge end terminating in a port 73 which registers with a port 74 in the block providing a connection between the passage 72 and the transfer or inlet port 54 of the cylinder, the latter port being in the liner 14.

Boss 70 extends into the recess 69 from a body portion, indicated generally at 75 of the injector mechanism, said body portion having a flat side 76 facing the block. A gasket 77 is disposed between the side 76 and the adjacent surface of the block and provides a seal therebetween. The body portion of the injection mechanism is secured to the block by any well known means such as screws, for example, not shown.

The body portion 75 is provided with a housing 79 defining a chamber 80, the axis of said chamber extending upwardly and toward the passage 72 and terminating in a passage 82 of reduced diameter on the axis of the chamber 80 and providing a connection between the upper portion of the chamber 80 and the passage 72.

At its lower end chamber 80 has a cylindrical portion 85 and ahead of said cylindrical portion there is a fuel nozzle 86 supported in the chamber 80 by means of oppositely arranged arms 87 and 88 which are formed integrally with the housing. Fuel nozzle 86 may, of course, be of any suitable shape but is shown as being pear-shaped with the smaller reduced diameter end 89 adjacent to and aligned with the lower or outer end of the passage 82, the upper reduced diameter end 89 of said nozzle being spaced from the adjacent end of passage 82.

Nozzle 86 has an axial bore 90 extending from the lower end and terminating in an axially arranged enlarged recess or counterbore 91 which extends inwardly from the smaller end 89 of said nozzle, the outer end portion 92 of said recess being internally threaded for reception of an externally threaded plug 93 having a fuel discharge orifice 94 therein. Plug 93 has a spring retaining recess 95 for reception of a spring 96. One end of the spring 96 reacts on the bottom of the recess 95 while the opposite end of said spring reacts against a ball 97 which functions as a movable valve member yieldingly urged into seating engagement with the adjacent end of the bore 90 and adapted to close or seal said bore.

Within the bore 90 is slidably disposed a plunger 99 which extends outwardly of the open end of the housing 79 and through bore 100 is a boss 101 which forms an integral part of a wall 102 normal to the axis of the plunger and bore 100, said wall 102 comprising an integral part of a casing, indicated generally at 104. Casing 104 includes an outer wall 105, a top wall 106, and side walls 107. There is also a bottom wall 108 which extends inwardly toward the entrance from the lower end of the wall 102 and terminates in an end portion recessed at 109 for sealing engagement with an adjacent corresponding portion 110 of the body portion 75. The upper wall 106 has a free end portion similarly recessed, as at 111, for sealing engagement with a corresponding portion of the boss 70.

Plunger 99 is provided with a pair of annular flanges 114 spaced apart longitudinally relative to the axis of said plunger and adapted to receive therebetween a central portion of spring fingers 115 which are adapted to engage, or be engaged by the adjacent side of a pulse disc 116 which has a central or axial boss 117 with an axial bore 118 therethrough for operable reception of the plunger. Pulse disc 116 is adapted to be operably received in the cylindrical portion 85 of the housing and there is a snap ring 120 operably disposed in an annular groove 121 in the plunger in operable relationship to the outer, adjacent end of the boss 117 of the pulse disc 116. Outward movement of the pulse disc 116 on the plunger is limited by said snap ring and inward movement of said disc on said plunger is limited by the adjacent flange 114.

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At the outer end of the plunger there is an enlarged head or flange 123 beneath which is operably disposed a stroke control element 124 that slides in a groove 125 at the outer end of the boss 101. Stroke control element 124 is wedge-shaped and the head 123 of the plunger 99 is disposed at the outer side of said stroke control element and in engagement with the inclined outer surface 126 thereof. As the stroke control element 124 is moved in the groove 125 the stroke of the plunger is varied to thereby vary the amount of fuel injected by the mechanism.

Fuel is supplied to the bore 90 by way of a lateral bore 128 in the body portion, the bore 128 being connected to a tapped recess 129 in said body portion by way of a passage 130. Recess 129 is provided with an externally threaded fixture 131 which in turn is connected to a source of fuel by means of a conduit 132.

Casing 104 defines a chamber 133 which is connected with the air passage 72 by means of a passage 136, which has an outlet port 137 normal to the plane of the upper inner surface 138 of the boss 70. Outlet port 137 is controlled by means of a reed valve, indicated generally at 139 and comprising a reed valve member 140 backed by a spring 141, said valve member 140 and spring 141 being secured to the boss by means of a screw 142. Reed valves of this character are well known, and hence it is unnecessary to describe same in detail. Suffice it to say that the valve will open to permit fluid from the passage 136 to flow through the port 137 into the chamber 135 but will prevent reverse flow of fluid through said port 137 and passage 136.

The axis of the fuel discharge orifice 94 is in alignment with the port 74 and 54 which may be considered as the transfer or inlet port for the cylinder of the engine.

Fuel is supplied to the bore 99 by any suitable means, such as, for example, a gravity feed. When the injection mechanism is inoperative the parts thereof are positioned as shown in FIG. 1, there being a light spring 145 reacting between the arms 87 of the spider supporting the nozzle 86 and the adjacent flange 114 which yieldingly urges the plunger 99 and pulse disc 116 to said position. Ball valve 97 is then seated at the discharge end of the bore 90 of the nozzle, being yieldingly urged to this position by the spring 96. The upper or inner end of the plunger is then positioned outwardly of the point whereat the bore 128 connects to the bore 90, the plunger then being at its outer limit of movement, limited by engagement of the snap-ring or stop member 120 with the inner end of the boss 101. At this time the outer end of boss 117 of the pulse disc 116 is in engagement with said snap-ring or stop 120. It will be noted that the disc 116 is then positioned adjacent the outer end of the cylindrical portion 85 of the housing and said disc is fitted therein closely enough so as to substantially eliminate fluid flow therepast. The spring fingers 115, which are bowed or arcuately shaped longitudinally, are very slightly spaced from the adjacent side of the pulse disc 116.

Fuel is supplied to the bore 90 by any suitable means, such as, for example, a gravity feed, not shown, or a suitable fuel pump, also not shown. When the injection mechanism is inoperative or at rest the parts thereof are positioned as shown in FIG. 1, said light spring 145 yieldingly urging said disc to said inoperative position. Ball valve 97 is then seated at the discharge end of the bore 90 of the nozzle, being yieldingly urged to this position by the spring 96. The upper end of the plunger 99 is then positioned outwardly of the point whereat the bore 128 connects to the bore 90, the plunger then being at its outer limit of movement, limited by engagement of the snap ring or stop member 120 with the inner end of the boss 101. At this time the outer end of the boss 117 of the pulse disc 116 is in engagement with said snap ring or stop 120. It will be noted that the disc 116 is then positioned adjacent the outer end of the cylindrical portion 85 of the housing and said disc is fitted therein closely enough so as to substantially eliminate fluid flow there-

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past although the fit of said disc in said cylindrical portion 85 is such as to permit the disc to adjust to slight misalignments of the parts. The spring fingers 115, which are bowed or arcuately shaped longitudinally, are very slightly spaced from the adjacent side of the pulse disc 116 when the parts of the mechanism are at rest.

When the piston moves upwardly in the cylinder, air is drawn into the crankcase through the air inlet conduit 60, the quantity of volume of air drawn into the crankcase being determined by the amount of opening of valve 61. As the piston moves downwardly the air thus drawn into the crankcase is compressed therein, air also being compressed in the air outlet passages 68 and 72. The compressed air is also forced through the passage 136 and into the compressed air storage chamber 135. Reed valve 139 permits the air to pass into chamber 135 but prevents that air from the chamber 135 to pass back into the passage 136. Air under the same pressure passes downwardly through the passage 82 and into the chamber 80 defined by the housing 79. Hence, the pulse disc is subjected to the same pressure or equal pressures on opposite sides thereof and no movement thereof is effected.

However, when the upper end of the downwardly moving piston begins to uncover the transfer or inlet port 54 the pressure in the passages 68 and 72 drops. There is an initial rush of compressed air from the passage 72 through the opening 74 and transfer port 54 and thence into the cylinder. This inrushing air strikes the baffle 52 and is deflected upwardly to scavenge the upper ends of the cylinder and the combustion chamber 19 of burnt gases which are forced outwardly of the exhaust port E, which, in accordance with the usual practice, is initially opened or uncovered by the downwardly moving piston before the inlet port 54 is uncovered.

With a drop in pressure in the crankcase and passages 68 and 72, upon the opening of the inlet transfer port 54, there is a comparable drop in pressure in the passage 82 and the chamber 80 of the fuel injection system. The pressure in the chamber 135 is now greater than the pressure in the chamber 80 and the pulse disc 116 is therefore subjected to a greater pressure on the under or outer side than on the upper or inner side and this greater pressure on the pulse disc accelerates said pulse disc upwardly or inwardly relative to the chamber 80, the rate of acceleration, hence the time lag, depending on the mass of the parts to be accelerated. As the pulse disc 116 slides upwardly a short distance on the plunger 99 the leaf or finger-springs 115 are engaged by said disc and put under tension, whereupon the plunger 99 also begins to accelerate under the leaf or finger-spring pressure and is forced upwardly in the passage 90. With this movement the plunger passes the outlet opening of the passage 128, thereby cutting off further supply of fuel to the bore 90 and the fuel ahead of the plunger 99 is forced against the ball valve 97 to effect opening thereof, and a flow of fuel into the chamber 91 finally begins to be discharged from the fuel discharge orifice 94 at about the time the engine piston 50 reaches B.D.C. In the meantime, under the influence of the air compressed in the chamber 135 the pulse disc has been further forced inwardly against the leaf or finger-springs 115 to uncover the inner end of the cylindrical portion 85 so that the air from the chamber 135 rushes past the periphery of said pulse disc, past the nozzle 86 and into the passage 82 just ahead of the fuel admission. In order to guide the pulse disc 116 after it has moved upwardly beyond the inner end of cylindrical portion 85 a plurality of annularly guide spaced ribs 85a are provided at the inner end of said cylindrical portion 85 which are slidably engaged by the periphery of said disc to aid in the maintenance of said disc in operable alignment.

Since the chamber 80 tapers to a reduced diameter at the inner end thereof and the inner end of the nozzle 86 is located within this reduced diameter portion but in

spaced relation to the adjacent wall of the housing, there is a venturi effect produced, the air discharging from the chamber 80 increasing in velocity at the discharge end of said chamber and about the inner end of nozzle 86, thus providing a high velocity air jet.

The fuel discharge from the nozzle orifice 94 is sprayed into this high velocity air jet flowing from the chamber 80 into the passage 82, thence into passage 72 and through the ports 74 and 54 of the cylinder of the engine. The fuel thus discharged into the high velocity air jet is highly atomized thereby. This high velocity rich mixture jet of air and fuel is directed into the engine cylinder transfer port 54 during a period from B.D.C. of the piston to a position near the closure of the inlet ports. Final mixing of the fuel-air jet with the fresh air in the cylinder takes place during the compression of the stroke, when it is then ignited to drive the piston downwardly, and the cycle is repeated.

Thus the present invention provides a *timed* fuel injection system for two-cycle engines and there is employed a pulse pump driven by stored compressed air from the crankcase. The low pressure fuel nozzle sprays into the high velocity atomizing air jet that blasts through the outlet of chamber 80, passage 82, passage 72, and thence through the transfer port as the piston rises from bottom dead center to a position closing said transfer.

In FIG. 1 the piston is just beginning to open the transfer port 54 and the compressed atomizing air from the charged air storage chamber 135 is just starting to accelerate the pulse disc 116 and the fuel plunger. The mass of the pulse disc and plunger assembly determines the rate at which they will be accelerated, hence the time lag of injection at the designed engine operating power and speed. Thus, inertia of the disc and plunger assembly delays injection until the engine piston reaches bottom dead center. As the piston reaches bottom dead center the pulse injector is beginning to spray fuel into the atomizing air jet.

The pulse disc releases the atomizing air at the bottom of the piston stroke just before the piston reaches bottom dead center and the fuel sprays into the high velocity atomizing air jet, flowing past the nozzle 86 and into the passage 82. The finger-springs continue to drive the fuel plunger after the pulse disc reaches the end of its stroke, the fuel spray beginning at bottom dead center of the piston and ending before the transfer port is closed as the piston moves upwardly in the cylinder.

The quantity of fuel injected per stroke is determined by the stroke control element 124 wherein the slidable ramp 126 operated by a rod 152 stops the head 123 on the lower end of plunger 99 thus limiting its stroke. Rod 152 is operably connected to the engine air inlet throttle valve 61 in a manner to schedule the fuel-air ratio according to common practice.

In the arrangement shown in FIG. 4, there is shown a portion of an engine having a plurality of cylinders with a fuel supply system therefore.

As is common practice in two-cycle engines, the crankcase is separated into compartments, there being a compartment for each cylinder. In FIG. 4 there is shown crankcase parts 150a, there being one of such parts for each of the crankcase chambers. The parts 150a are hollow and define a chamber 150 which carries the air inlet 60. The air inlet conduit 60 is of similar character to the conduit 60 in FIG. 1 and there is, of course, the reed valve 63 at the inner end of said inlet conduit 60.

The interior 150 of the part 150a of the crankcase is provided with an opening 150b through which fuel is discharged from the discharge nozzle 86 into the air stream entering the crankcase through the inlet conduit 60, it being noted that the fuel nozzle 86 is so aligned relative to the conduit 60 that the fuel discharged by said nozzle 86 is directed into the air stream flowing into the crankcase from said inlet conduit 60.

The stroke control elements 124 of the fuel injection

mechanisms are connected together for simultaneous movement by means of a rod 151 operatively connected with the respective stroke control elements 124. The connecting means between each of the stroke control elements and the rod 151 includes a link 155 having a laterally turned end portion 153 which extends through an opening provided therefor in the free end of the rod 152.

The air valves 61 are also interconnected for simultaneous and corresponding movement relative to each other. For this purpose the throttle shafts 62 are provided with laterally turned end portions 157 and the latter are provided with outwardly turned end portions 158 which are operably received in openings provided therefor in a rod 159, the latter rod serving as an interconnecting link or element. Rod 159 is provided with a laterally turned part 160 which has an end portion operably received in an opening provided therefor in a flattened portion 161 at the free end of rod 151. With this arrangement not only do the stroke control elements move simultaneously with each other but also simultaneously with the air valves 61 so that there is a suitable relationship maintained between the quantity of fuel discharged into the crankcase and the quantity of air entering the crankcase through the air inlet conduit 60. Hence the fuel-to-air ratio for the engine is maintained.

The invention and its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction and arrangement of the parts of the invention without departing from the spirit and scope thereof or sacrificing its material advantages, the arrangement hereinbefore described being merely by way of example and I do not wish to be restricted to the specific form shown or uses mentioned except as defined in the accompanying claims, wherein various portions have been separated for clarity of reading and not for emphasis.

I claim:

1. A fuel-air injection system for two-cycle internal combustion engines having a cylinder, a crankcase, a piston reciprocable in the cylinder, a crankshaft in said crankcase, a connecting rod operably connecting the piston to the crankshaft, said cylinder having an exhaust port and also having an inlet transfer port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement, said crankcase having a fluid inlet, a check valve controlling said inlet permitting fluid to flow into the crankcase through said inlet but preventing outflow of fluid through said inlet, a manually controlled valve controlling the flow of fluid into the crankcase through said inlet, and an air transfer passageway connecting the crankcase with the inlet transfer port of the cylinder, comprising:

(A) a housing defining a cylindrical chamber having an outlet portion at the inner end, said outlet portion being of reduced diameter and connected with the air transfer passageway between the crankcase and the inlet transfer port of the cylinder, said outlet being aligned with the inlet port of the cylinder, said housing also having a pulse disc cylinder at the outer end thereof;

(B) a fuel nozzle within said chamber having its inner end extending into the outlet portion but in spaced relation to the walls thereof, to thereby provide a restriction for effecting a high velocity air jet at the discharge end of the said fuel nozzle, said nozzle having a fuel bore in alignment with said outlet portion and the inlet transfer port of the cylinder, there being a counterbore at the inner discharge end of said nozzle;

(C) a plug secured in the outer end portion of said counterbore, said plug having a calibrated fuel discharge orifice therein;

(D) a ball valve in said counterbore adapted to seat on the outer end of said fuel conducting bore;

- (E) yielding means urging said ball valve into seating engagement with the discharge end of said nozzle fuel bore;
- (F) means defining a fuel inlet passageway communicating with the nozzle bore intermediate the end thereof;
- (G) a casing defining a compressed air storage chamber having a wall spaced from the outer end of said housing and generally parallel to the plane of said outer end of the housing, said wall having a bore therethrough in axial alignment with the bore of said nozzle;
- (H) a pair of parallel, laterally spaced walls defining a recess at the outer side of said casing wall;
- (I) a plunger in said bore of the casing wall and the bore of said nozzle, the inner end of said plunger being normally spaced outwardly of the junction of the fuel inlet passageway and the nozzle bore, the outer end of said plunger having a head thereon;
- (J) a pulse disc slidably disposed on said plunger, leaf spring means secured to said plunger inwardly of the pulse disc and including a pair of resilient, oppositely extending spring fingers normally spaced from the inner side of the pulse when the mechanism is at rest;
- (K) a stop means on said plunger outwardly of the pulse disc limiting outward movement of the pulse disc on said plunger and also limiting outward movement of said plunger by engagement with the portion of the wall of said casing preventing said pulse disc from moving out of the pulse disc cylinder;
- (L) means on said plunger limiting inward movement of the pulse disc on said plunger;
- (M) a wedge-shaped plunger stop slidable in the recess between said parallel walls, said wedge-shaped plunger stop having a longitudinally extending slot therein in which the plunger is received, the head of said plunger being adapted to engage said plunger stop when said plunger is actuated inwardly, said pulse disc being movable longitudinally inwardly by fluid pressure in said compressed air storage chamber beyond the inner end of said pulse disc cylinder;
- (N) and a light spring yieldingly urging the pulse disc outwardly.
2. A fuel-air injection system for two-cycle internal combustion engines having a cylinder, a crankcase into which air is drawn and compressed, a crankshaft, a piston in said cylinder and operably connected to the crankshaft, said cylinder having an exhaust port and also having an inlet transfer port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement, a manually controlled valve controlling the flow of fluid into the crankcase, and an air transfer passageway connecting the crankcase with the inlet transfer port of the cylinder, comprising:
- (A) a housing defining a chamber having an outlet portion at the inner end of reduced size and connected with the air transfer passageway, said outlet being aligned with the inlet port of the cylinder, said housing also having a pulse disc cylinder at the outer end thereof;
- (B) a fuel nozzle within said chamber having its inner end extending into the outlet portion to thereby provide a restriction for effecting a high velocity air jet at the discharge end of the said fuel nozzle, said nozzle having a fuel bore in alignment with said outlet portion and the inlet transfer port of the cylinder;
- (C) a check valve for the fuel bore for permitting fuel discharge therefrom but preventing reverse fluid flow in said bore, there being a calibrated fuel discharge orifice for said fuel nozzle;
- (D) means defining a fuel inlet passageway communicating with the nozzle bore intermediate the end thereof;

- (E) a casing defining a compressed air storage chamber having a wall spaced from the outer end of said housing, said wall having a bore therethrough in axial alignment with the bore of said nozzle;
- (F) a plunger in said bore of the casing wall and the bore of said nozzle, the inner end of said plunger being normally spaced outwardly of the junction of the fuel inlet passageway and the nozzle bore;
- (G) a pulse disc slidably disposed on said plunger, leaf spring means secured to said plunger inwardly of the pulse disc and including a pair of resilient, oppositely extending spring fingers normally spaced from the inner side of the pulse when the mechanism is at rest;
- (H) stop means on said plunger outwardly of the pulse disc limiting outward movement of the pulse disc on said plunger and also limiting outward movement of said plunger and preventing said pulse disc from moving out of the outer end of the pulse disc cylinder;
- (I) means on said plunger limiting inward movement of the pulse disc on said plunger;
- (J) plunger stop means for limiting inward movement of said plunger, said pulse disc being movable longitudinally inwardly by fluid pressure in said compressed air storage chamber beyond the inner end of said pulse disc cylinder;
- (K) and a light spring yieldingly urging the pulse disc outwardly.
3. A fuel-air injection system for two-cycle internal combustion engines having a cylinder, a crankcase into which air is drawn and compressed, a crankshaft, a piston in said cylinder operably connected to the crankshaft, said cylinder having an exhaust port and also having an inlet transfer port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement, a valve controlling the flow of fluid into the crankcase, and an air transfer passageway connecting the crankcase with the inlet transfer port of the cylinder, comprising:
- (A) a housing defining a chamber having an outlet portion at the inner end of reduced size and connected with the air transfer passageway, said housing also having a pulse disc cylinder at the outer end thereof;
- (B) a fuel nozzle within said chamber having a calibrated fuel discharge orifice at its inner end which extends into said outlet portion but in spaced relation to the walls thereof, to thereby provide a restriction for effecting a high velocity air jet at the discharge end of the said fuel nozzle into which fuel from said nozzle is discharged, said nozzle having a fuel bore therein;
- (C) a check valve for said nozzle fuel bore;
- (D) means for supplying fuel to said nozzle bore;
- (E) means defining a compressed air storage chamber;
- (F) a plunger in the bore of said nozzle;
- (G) a pulse disc slidably disposed on said plunger, spring means secured to said plunger inwardly of the pulse disc and engageable by said disc;
- (H) stop means for limiting outward movement of the pulse disc on said plunger and outward movement of said plunger, said stop means also preventing said pulse disc from moving outwardly from the pulse disc cylinder;
- (I) means for limiting inward movement of the pulse disc on said plunger;
- (J) means limiting inward movement of said plunger, said pulse disc being movable longitudinally inwardly by fluid pressure in said compressed air storage chamber to a position at least beyond the inner end of said pulse disc cylinder;
- (K) and a light spring yieldingly urging the pulse disc outwardly.
4. In a two-cycle internal combustion engine:
- (A) a cylinder;

- (B) a crankcase into which air is drawn and compressed;
- (C) a crankshaft;
- (D) a piston in said cylinder operably connected to the crankshaft, said cylinder having an exhaust port and also having an inlet transfer port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement;
- (E) a valve controlling the flow of fluid into the crankcase;
- (F) an air transfer passageway connecting the crankcase with the inlet transfer port of the cylinder;
- (G) means defining a chamber having an outlet portion at the inner end, said outlet portion being of reduced diameter and connected with the air transfer passageway, said housing also having a pulse disc cylinder at the outer end thereof, said cylinder opening into said chamber;
- (H) a fuel nozzle adapted to discharge fuel into said outlet portion;
- (I) a check valve controlling fuel discharge from said nozzle;
- (J) means defining a compressed air storage chamber;
- (K) a plunger for forcing fuel from the discharge end of said fuel nozzle when moved in a fuel discharge direction, said plunger also being movable in a retracting direction;
- (L) a pulse disc slidably disposed on said plunger and normally disposed in said pulse disc cylinder;
- (M) yielding means forming a resilient connection between the pulse disc and said plunger;
- (N) stop means limiting retractive movement of the pulse disc on said plunger and preventing said pulse disc from moving out of the pulse disc cylinder, said stop means also limiting retractive movement of said plunger;
- (O) means limiting operative movement of the pulse disc to a position beyond the inner end of the pulse disc cylinder;
- (P) adjustable stop means adjustably limiting fuel discharge movement of said plunger, said pulse disc being movable longitudinally in a direction to actuate the plunger in the discharge direction by fluid pressure in said compressed air storage chamber;
- (Q) a light spring yieldingly urging the pulse disc outwardly;
- (R) and means interconnecting the adjustable stop means and the valve controlling flow of fluid into the crankcase.
5. In a two-cycle internal combustion engine:
- (A) a cylinder;
- (B) a crankcase into which air is adapted to be drawn and compressed;
- (C) a crankshaft;
- (D) a piston in said cylinder operably connected to the crankshaft, said cylinder having an exhaust port and also having an inlet port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement;
- (E) a fluid volume control valve controlling the flow of fluid into the crankcase;
- (F) an air transfer passageway connecting the crankcase with the inlet port of the cylinder;
- (G) means defining a chamber having an outlet end portion of reduced diameter and connected with the air transfer passageway, said means also having a pulse disc cylinder at the opposite end thereof opening into said chamber;
- (H) a fuel nozzle adapted to discharge fuel into said outlet portion;
- (I) means defining a compressed air storage chamber;
- (J) a plunger for forcing fuel from the discharge end of said fuel nozzle when moved in a fuel discharge direction, said plunger also being movable in a retracting direction;

- (K) a pulse disc slidably disposed on said plunger and normally disposed in said pulse disc cylinder;
- (L) yielding means forming a resilient connection between the pulse disc and said plunger;
- (M) stop means limiting retractive movement of the pulse disc on said plunger and retractive movement of said plunger;
- (N) means limiting operative movement of the pulse disc to a position beyond the inner end of the pulse disc cylinder;
- (O) adjustable stop means adjustably limiting fuel discharge movement of said plunger, said pulse disc being movable longitudinally in a direction to actuate the plunger in the discharge direction by fluid pressure in said compressed air storage chamber;
- (P) and means interconnecting the adjustable stop means and the valve controlling flow of fluid into the crankcase.
6. In a two-cycle internal combustion engine:
- (A) a cylinder;
- (B) a crankcase into which air is adapted to be drawn and compressed;
- (C) a crankshaft;
- (D) a piston in said cylinder operably connected to the crankshaft, said cylinder having an exhaust port and also having an inlet port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement;
- (E) a fluid volume control valve controlling the flow of fluid into the crankcase;
- (F) a fluid transfer passageway connecting the crankcase with the inlet port of the cylinder;
- (G) means defining a chamber having an outlet end portion at the inner end, said outlet portion being of reduced diameter and connected with the crankcase, said means also having a pulse disc cylinder at the opposite end thereof, opening into said chamber;
- (H) a fuel nozzle adapted to discharge fuel into said outlet portion;
- (I) means defining a compressed air storage chamber;
- (J) a plunger for forcing fuel from the discharged end of said fuel nozzle when moved in a fuel discharge direction, said plunger also being movable in a retracting direction;
- (K) a pulse disc slidably disposed on said plunger and normally disposed in said pulse disc cylinder;
- (L) yielding means forming a resilient connection between the pulse disc and said plunger;
- (M) stop means limiting retractive movement of the pulse disc on said plunger and retractive movement of said plunger;
- (N) means limiting operative movement of the pulse disc to a position beyond the inner end of the pulse disc cylinder;
- (O) adjustable stop means adjustably limiting fuel discharge movement of said plunger, said pulse disc being movable longitudinally in a direction to actuate the plunger in the discharge direction by fluid pressure in said compressed air storage chamber;
- (P) and means interconnecting the adjustable stop means and the valve controlling flow of fluid into the crankcase.
7. In a two-cycle internal combustion engine:
- (A) a cylinder;
- (B) a crankcase into which air is adapted to be drawn and compressed;
- (C) a crankshaft;
- (D) a piston in said cylinder operably connected to the crankshaft, said cylinder having an exhaust port and also having an inlet port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement;
- (E) a fluid volume control valve controlling the flow of fluid into the crankcase;

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- (F) a fluid transfer passageway connecting the crankcase with the inlet port of the cylinder;
- (G) means defining a chamber having an outlet end portion at the inner end, said outlet portion being of reduced diameter and connected with the crankcase, said means also having a pulse disc cylinder at the opposite end thereof, opening into said chamber;
- (H) a fuel nozzle adapted to discharge fuel into said outlet portion;
- (I) means defining a compressed air storage chamber;
- (J) a plunger for forcing fuel from the discharged end of said fuel nozzle when moved in a fuel discharge direction, said plunger also being movable in a retracting direction;
- (K) a pulse disc slidably disposed on said plunger and normally disposed in said pulse disc cylinder;
- (L) yielding means forming a resilient connection between the pulse disc and said plunger;
- (M) stop means limiting retractive movement of the pulse disc on said plunger and retractive movement of said plunger;
- (N) means limiting operative movement of the pulse disc to a position beyond the inner end of the pulse disc cylinder;
- (O) and adjustable stop means adjustably limiting fuel discharge movement of said plunger, said pulse disc being movable longitudinally in a direction to actuate the plunger in the discharge direction by fluid pressure in said compressed air storage chamber.
8. In a fuel system for internal combustion engines having a cylinder with an inlet port and a fluid conduit for delivery of fluid to said port:

- (A) means defining a chamber having an outlet adapted to discharge a relatively high velocity jet of air therefrom into said conduit means of the engine, said means also having a pulse disc cylinder at the outer end thereof opening into said chamber;
- (B) a fuel nozzle adapted to discharge fuel into said high velocity jet of air;
- (C) means defining a compressed air storage chamber;
- (D) a plunger for forcing fuel from the discharge end of said fuel nozzle when moved in a fuel discharge direction, said plunger also being movable in a retracting direction;
- (E) a pulse disc disposed on said plunger and normally disposed in said pulse disc cylinder;
- (F) stop means limiting retractive movement of said pulse disc and plunger;
- (G) means limiting operative movement of the pulse disc to a position beyond the inner end of the pulse disc cylinder;
- (H) and stop means limiting fuel discharge movement of said plunger, said pulse disc being movable longitudinally in a direction to actuate the plunger in the discharge direction by fluid pressure derived from said compressed air storage chamber.

9. In a fuel system for two-cycle internal combustion engines having a cylinder with an inlet port, and a crankcase into which air is drawn, compressed and delivered to said inlet port:

- (A) means for effecting a relatively high velocity air jet;
- (B) a fuel nozzle for discharging fuel into said high velocity air jet;
- (C) and means including a pressure responsive element subjected on one side to air pressure derived from said crankcase when air is compressed therein and subjected on the other side to air anterior to said inlet port, said pressure responsive element being actuated by pressure on said one side upon a drop of pressure on said other side for effecting timed discharge of fuel from said fuel nozzle.

10. A low pressure fuel-air injection mechanism for two-cycle internal combustion engines, comprising:

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- (A) a housing defining a cylindrical chamber having an outlet portion at one end, said outlet portion being of reduced diameter, said housing also having a pulse disc cylinder at the opposite end thereof;
- (B) a fuel nozzle within said chamber having its inner end extending into the outlet portion but in spaced relation to the walls thereof, to thereby provide a restriction for effecting a high velocity air jet at the discharge end of the said fuel nozzle, said nozzle having a fuel bore in alignment with said outlet portion, there being a counterbore at the inner discharge end of said nozzle;
- (C) a plug secured in the outer end portion of said counterbore, said plug having a calibrated fuel discharge orifice therein;
- (D) a ball valve in said counterbore adapted to seat on the outer end of said fuel conducting bore;
- (E) yielding means urging said ball valve into seating engagement with the discharge end of said nozzle fuel bore;
- (F) means defining a fuel inlet passageway communicating with the nozzle bore intermediate the ends thereof;
- (G) a casing defining a compressed air storage chamber;
- (H) a plunger in the bore of said nozzle, the inner end of said plunger being normally spaced outwardly of the junction of the fuel inlet passageway and the nozzle bore;
- (I) a pulse disc slidably disposed on said plunger, leaf spring means secured to said plunger inwardly of the pulse disc and including a pair of resilient, oppositely extending spring fingers normally spaced from the inner side of the pulse when the mechanism is at rest;
- (J) stop means on said plunger outwardly of the pulse disc limiting outward movement of the pulse disc on said plunger and also limiting outward movement of said plunger, preventing said pulse disc from moving out of the outer end of the pulse disc cylinder;
- (K) means on said plunger limiting inward movement of the pulse disc on said plunger;
- (L) adjustable means limiting inward movement of said plunger and pulse disc, said pulse disc being movable longitudinally inwardly by fluid pressure in said compressed air storage chamber beyond the inner end of said pulse disc cylinder;
- (M) and a light spring yieldingly urging the pulse disc outwardly.
11. A fuel-air injection mechanism for two-cycle internal combustion engines, comprising:
- (A) a housing defining a chamber having an outlet portion of reduced size, said housing also having a pulse disc cylinder at the other end thereof;
- (B) a fuel nozzle within said chamber having its discharge end extending into an outlet portion of said chamber, said nozzle having a fuel bore therein.
- (C) a check valve for the fuel bore for permitting fuel discharge therefrom but preventing reverse fluid flow in said bore, there being a calibrated fuel discharge orifice for said fuel nozzle;
- (D) means defining a fuel inlet passageway communicating with the nozzle bore intermediate the ends thereof;
- (E) a casing defining a compressed air storage chamber;
- (F) a plunger in the bore of said nozzle, the forward end of said plunger being normally spaced outwardly of the junction of the fuel inlet passageway and the nozzle bore;
- (G) a pulse disc slidably disposed on said plunger, leaf spring means secured to said plunger forwardly of the pulse disc and including a pair of resilient, oppositely extending spring fingers normally spaced from the inner side of the pulse when the mechanism is at rest;

- (H) stop means on said plunger rearwardly of the pulse disc limiting rearward movement of the pulse disc on said plunger and also limiting rearward movement of said plunger and preventing said pulse disc from moving out of the rearward end of the pulse disc cylinder;
- (I) means on said plunger limiting forward movement of the pulse disc on said plunger;
- (J) plunger stop means for limiting forward movement of said plunger, said pulse disc being movable longitudinally forward by fluid pressure in said compressed air storage chamber beyond the forward end of said pulse disc cylinder;
- (K) and a light spring yieldingly urging the pulse disc rearwardly.
12. In a fuel-air injection mechanism for two-cycle internal combustion engines:
- (A) a housing defining a chamber having an outlet portion of reduced size to provide an air jet, said housing having a pulse disc cylinder at the other end thereof;
- (B) a fuel nozzle within said chamber having a calibrated fuel discharge orifice at its discharge end for discharging fuel into said air jet, said nozzle having a fuel bore therein;
- (C) a check valve for said nozzle fuel bore;
- (D) means for supplying fuel to said nozzle bore;
- (E) means defining a compressed air storage chamber;
- (F) a plunger in the bore of said nozzle;
- (G) a pulse disc slidably disposed on said plunger, spring means secured to said plunger forwardly of the pulse disc and engageable by said disc;
- (H) stop means for limiting rearward movement of the pulse disc on said plunger and rearward movement of said plunger, said stop means also preventing said pulse disc from moving outwardly from the rear of said pulse disc cylinder;
- (I) means for limiting forward movement of the pulse disc on said plunger;
- (J) means limiting forward movement of said plunger, one side of said pulse disc being subject to fluid pressure in said compressed air storage chamber for movement forwardly to a position at least beyond the forward end of said pulse disc cylinder;
- (K) and a light spring yieldingly urging the pulse disc rearwardly.
13. In a fuel injection mechanism for internal combustion engines:
- (A) means defining a chamber having an outlet adapted to discharge a jet of air therefrom, said means also having a pulse disc cylinder at the other end thereof, having one end opening into said chamber;
- (B) a fuel nozzle adapted to discharge fuel into said jet of air;
- (C) means defining a compressed air storage chamber;
- (D) a plunger for forcing fuel from the discharge end of said fuel nozzle when moved in a fuel discharge direction, said plunger also being movable in a retracting direction;
- (E) a pulse disc disposed on said plunger and normally disposed in said pulse disc cylinder;
- (F) stop means limiting retractive movement of said pulse disc and plunger;
- (G) means limiting operative movement of the pulse disc to a position beyond said one end of the pulse disc cylinder;
- (H) said pulse disc being movable longitudinally in a direction to actuate the plunger in the discharge direction by fluid pressure derived from said compressed air storage chamber.
14. In a fuel injection mechanism for internal combustion engines:
- (A) means defining a chamber having an outlet adapted to discharge a jet of air therefrom, said means also having a pulse disc cylinder connected therewith;

- (B) a fuel nozzle adapted to discharge fuel into said jet of air;
- (C) means defining a compressed air storage chamber;
- (D) and means, including a pulse disc normally disposed in said pulse disc cylinder for effecting discharge of fuel from said fuel nozzle, said pulse disc being movable by fluid pressure derived from said compressed air storage chamber to effect discharge of fuel from said fuel nozzle and to effect movement of said disc beyond said one end of said pulse disc cylinder to thereby admit air from said compressed air chamber into the first mentioned chamber.
15. In a fuel injection mechanism for two-cycle internal combustion engines having a cylinder and a crankcase into which air is drawn and delivered into said cylinder:
- (A) means defining a chamber having an outlet adapted to discharge a jet of air into said crankcase, said means also having a pulse disc cylinder connected therewith;
- (B) a fuel nozzle adapted to discharge fuel into said jet of air;
- (C) means defining a compressed air storage chamber;
- (D) and means, including a pulse disc normally disposed in said pulse disc cylinder, for effecting discharge of fuel from said fuel nozzle, said pulse disc being movable by fluid pressure derived from said compressed air storage chamber to effect discharge of fuel from said fuel nozzle and to effect movement of said disc beyond said one end of said pulse disc cylinder to thereby admit air from said compressed air chamber into the first mentioned chamber.
16. In a two-cycle internal combustion engine:
- (A) a cylinder;
- (B) a crankcase into which air is drawn and compressed;
- (C) crankshaft;
- (D) a piston in said cylinder operably connected to the crankshaft, said cylinder having an exhaust port and also having an inlet transfer port positioned therein to be uncovered by said piston when the latter approaches its innermost limit of movement;
- (E) a valve controlling the flow of fluid into the crankcase;
- (F) an air transfer passageway connecting the crankcase with the inlet transfer port of the cylinder;
- (G) means defining a chamber having an outlet portion at the inner end, said outlet portion being of reduced diameter and connected with the crankcase, said housing also having a pulse disc cylinder at the outer end thereof, said cylinder opening into said chamber;
- (H) a fuel nozzle adapted to discharge fuel into said outlet portion;
- (I) a check valve controlling fuel discharge from said nozzle;
- (J) means defining a compressed air storage chamber;
- (K) a plunger for forcing fuel from the discharge end of said fuel nozzle when moved in a fuel discharge direction, said plunger also being movable in a retracting direction;
- (L) a pulse disc slidably disposed on said plunger and normally disposed in said pulse disc cylinder;
- (M) yielding means forming a resilient connection between the pulse disc and said plunger;
- (N) stop means limiting retractive movement of the pulse disc on said plunger and preventing said pulse disc from moving out of the pulse disc cylinder, said stop means also limiting retractive movement of said plunger;
- (O) means limiting operative movement of the pulse

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- disc to a position beyond the inner end of the pulse disc cylinder;
- (P) adjustable stop means adjustably limiting fuel discharge movement of said plunger, said pulse disc being movable longitudinally in a direction to actuate the plunger in the discharge direction by fluid pressure in said compressed air storage chamber;
- (Q) a light spring yieldingly urging the pulse disc outwardly;
- (R) and means interconnecting the adjustable stop means and the valve controlling flow of fluid into the crankcase.

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FRED E. ENGELTHALER, *Primary Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,190,271

June 22, 1965

Austin Gudmundsen

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 46, after "which" insert -- must --; column 4, line 48, for "is" read -- in --.

Signed and sealed this 22nd day of March 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents