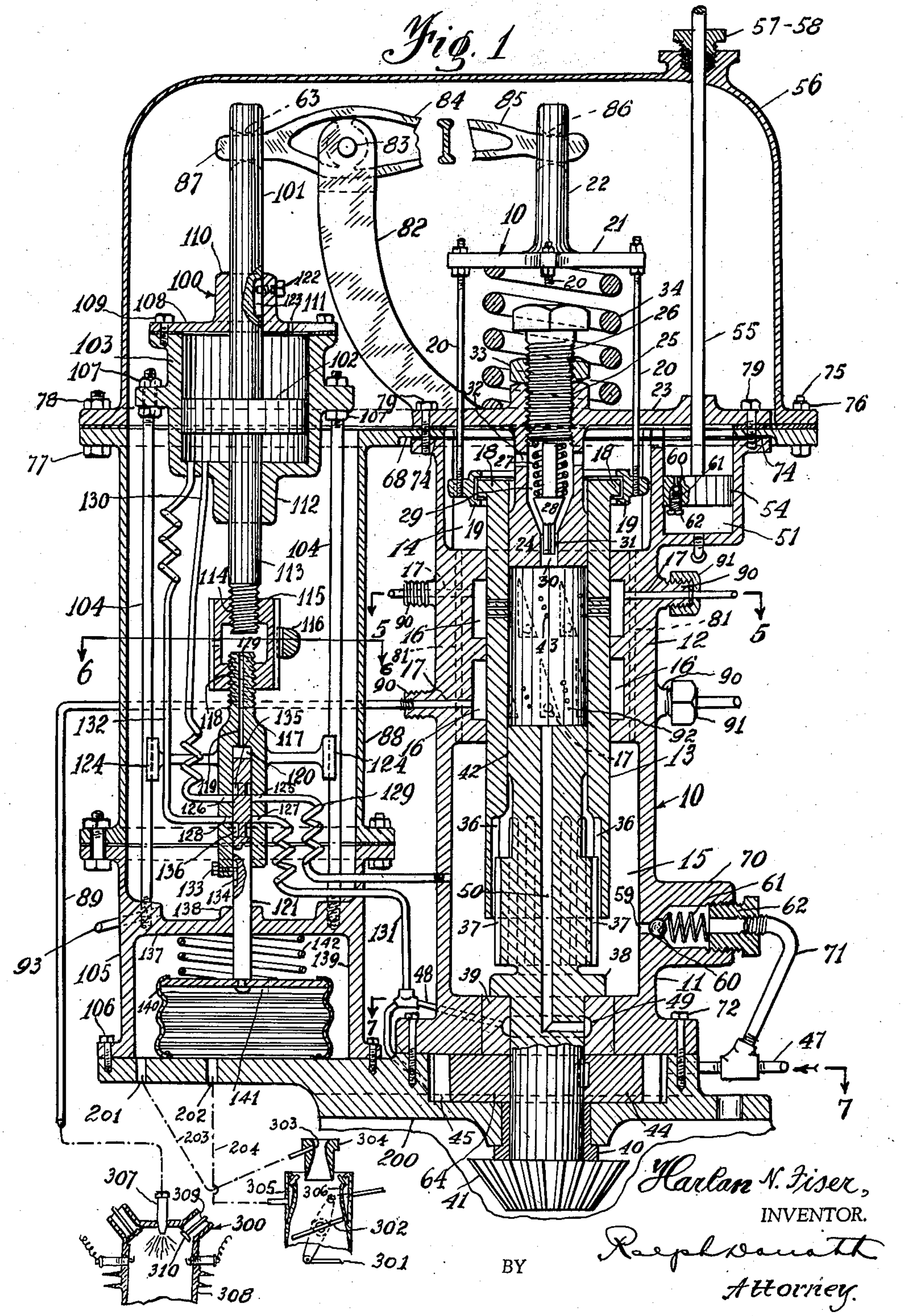
Jan. 6, 1953 H. N. FISER 2,624,326

INJECTION SYSTEM FOR INTERNAL-COMBUSTION ENGINES

Filed Nov. 5, 1947 3 Sheets-Sheet 1



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INJECTION SYSTEM FOR INTERNAL-COMBUSTION ENGINES

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Fig. 2

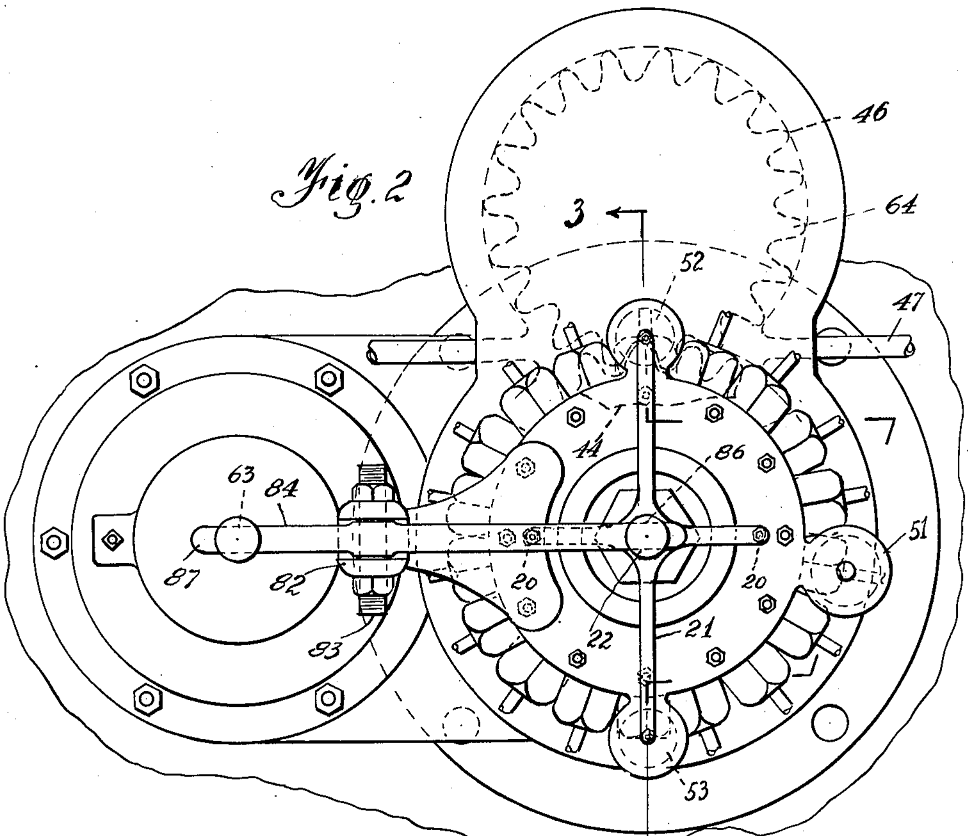
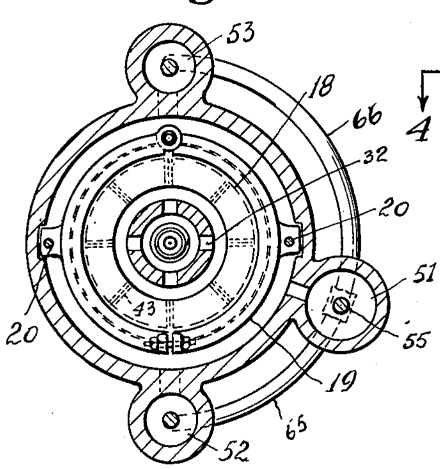


Fig. 4



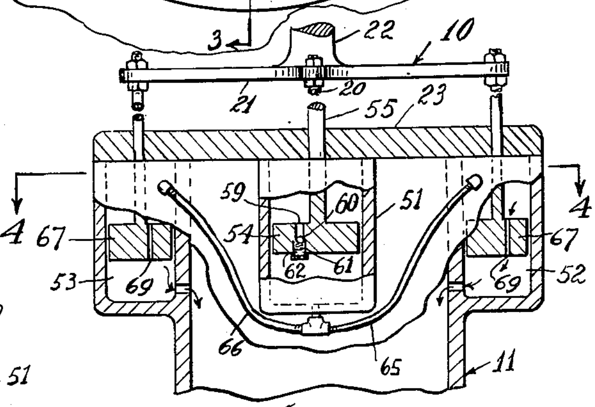


Fig. 3

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Fig. 5

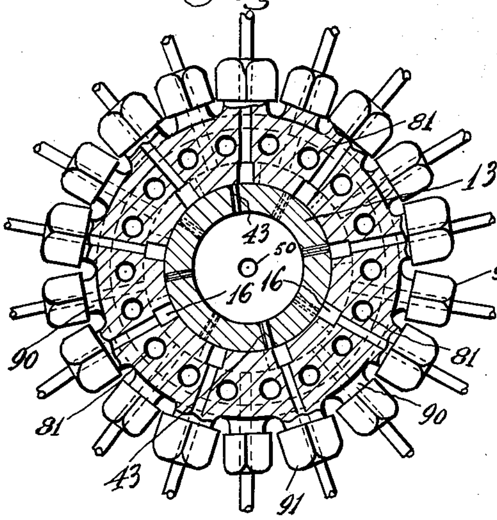


Fig. 6

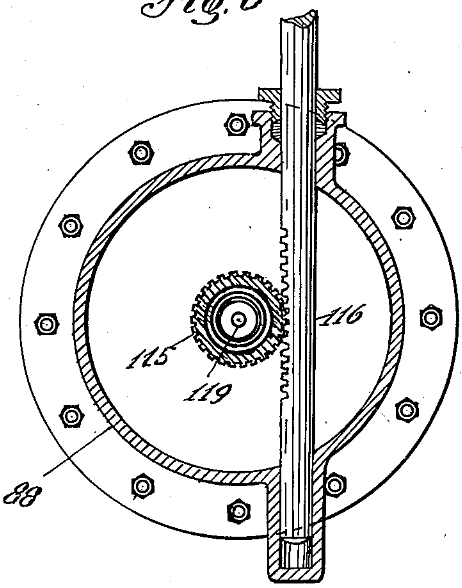


Fig. 7

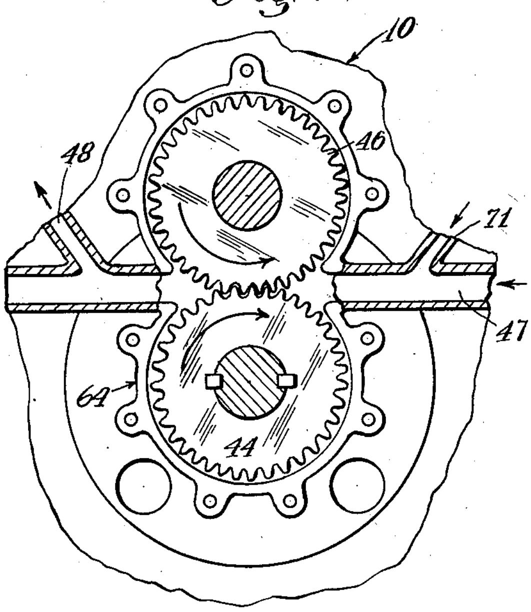
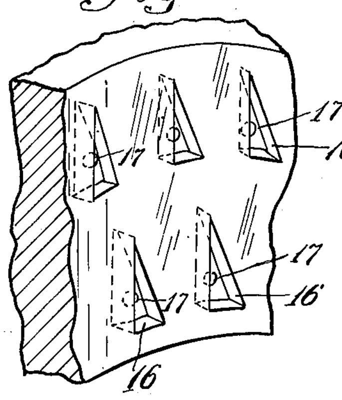


Fig. 8



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INJECTION SYSTEM FOR INTERNAL-COMBUSTION ENGINES

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7 Claims. (Cl. 123—139)

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This invention pertains generally to fuel injection systems of internal combustion engines and more particularly to those where liquid fuel is apportioned by a central metering device to be injected into the combustion chambers of all work cylinders. Present devices of this character are complicated and cumbersome employing a relatively great number of coacting parts, the injury to, or even frictional disturbance of, any one resulting in partial or total failure of the device.

My invention obviates this and other drawbacks by providing a fuel injection system of simple and sturdy construction consisting of the combination of relatively few and mechanically strong structural parts.

I achieve these objects by employing means for supplying fuel under pressure and apportioning and controlling the fuel in response to air-metering means by relatively few parts of simple construction.

Hence one object of my invention is to provide a fuel injection system for internal combustion engines in which fuel is supplied by fuel pump means under higher delivery pressures in quantities in excess of those necessary to be injected into the work cylinders and employing a fuel distributor housing having means to apportion the amount of fuel to be injected into the work cylinders in response to air-metering means provided in the air intake manifold.

Another object of the invention is to provide a fuel injection system in which the amount of fuel relative to that of the air supplied is selectively variable by manual means.

A further object of the invention is to provide a device of the type set forth in which the metering of the fuel is accomplished by the axial positioning of a rotating sleeve in a fuel distributing housing of progressively increasing width which sleeve is provided with sets of radial holes periodically coacting with radial pockets connected to the fuel injectors of the work cylinders for apportioning the fuel injected in response to air-metering means established in the air intake manifold of the combustion engine.

Another object of the invention is to provide a fuel injection system which employs hydraulic control means for utilizing the pressure of the delivered fuel to motivate the axial positioning of the apportioning sleeve in response to pressure differences established by air-metering means in the air intake manifold of the engine.

Still another object of the invention is to provide a fuel injection system which employs re-

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silient pressure responsive means acted upon by air-metering means in the air intake manifold for setting a pilot valve to establish hydraulic communication between a power cylinder and with either side of the fuel pump for properly setting the fuel apportioning means.

Another object of the invention is to provide a fuel injection system having means to vary manually the engine's fuel-and-air intake and the ratio thereof.

Those and other objects of the invention will be clearly evident from the following description of the structure and of the operation of one preferred embodiment of my invention, illustrated by the accompanying drawings in which:

Figure 1 is a semi-diagrammatic cross sectional view of the device showing also diagrammatically and to a smaller scale fragments of the intake manifold and of one of the work cylinders of the engine.

Figure 2 is a top view of the device shown in Figure 1 the outer cover having been removed.

Figure 3 is a partial sectional view on line **3—3** in Figure 2.

Figure 4 is a partial sectional view on line **4—4** in Figure 3.

Figure 5 is a partial sectional view on line **5—5** in Figure 1.

Figure 6 is a partial sectional view on line **6—6** in Figure 1.

Figure 7 is a fragmentary view partially in section on line **7—7** in Figure 1.

Figure 8 is a perspective view of a broken away portion of the fuel distributor housing showing some of the radial, triangular pockets therein.

Same parts are designated by the same characters of reference throughout the several views of the drawings.

Referring now to the drawings by the characters of reference in Figures 1 to 8, the preferred embodiment of the invention shown comprises a distributing unit, generally designated by **10** and a control unit, generally denoted by **100** both being preferably mounted upon a common base **200** that is part of, or rigidly fixed by suitable means to, a stationary part of the internal combustion engine, generally denoted by **300**, fragments of which are diagrammatically indicated to a smaller scale.

The distributing unit **10** is composed of an elongated and preferably vertically disposed distributing housing **11**, having a middle, thick walled portion **12** in which a cylindrical sleeve **13** is rotatably and axially reciprocably mounted. The top portion **14** and bottom portion **15** of distributor housing 11 have inner cavities that are radially larger than the bore of middle housing portion 12 in which sleeve 13 sealingly rotates and reciprocates. The thick walled middle housing portion 12 is provided with a plurality of downwardly widening substantially triangular shaped radial recesses 16 that are outwardly closed with the exception of a hole 17 and are inwardly, toward sleeve 13, entirely open.

The inner cylindrical bore of middle housing portion 12 is machined to a sufficiently close diameter to the outer diameter of sleeve 13 for sealing sliding fit, but it is important to mention that except for excessive leakage, the system is unaffected thereby except for a slight amount of fuel that might leak from one to the other radial recesses or pockets 16.

Sleeve 13 has flange 18 at its top portion which is slidingly engaged by slip ring 19 attached by connecting rods 20 to spider 21 having post 22 upwardly centrally protruding therefrom. The numeral 23 indicates a cover having a downwardly disposed central post 24 which engages slidingly and sealingly the upper portion of the bore of sleeve 13. Cover 23 and post 24 have a central threaded aperture 25 for mounting adjusting screw 26 the lower end of which serves as seat for helical spring 27 urging pressure regulating valve 28 downwardly in cavity 29 of central post 24 toward central hole 30 communicating with the bore of sleeve 13. Adjusting screw 26 mainly serves to limit the movement of the valve 28 also to compensate as leakage develops due to wear.

Regulating valve 28 is suitably shaped to seal off aperture 30 in which valve 28 is guided for reciprocating motion by suitably shaped guide pin 31 protruding downwardly from the tip of valve 28. Central post 24 has side openings 32 communicating with the cavity in the top housing portion 14. Lock nut 33 fixes regulating screw 26 into adjusted position. Return spring 34, compressed between cover 23 and spider 21, tends to return spider 21 and sleeve 13 to their highest position, lifting them upwardly by connecting bars 20 that pass cover 23 through openings and attached to slip ring 19 engaging slidingly sleeve 13 by its flange 18.

Sleeve 13 is provided at its lower end portion with axially extending flutes or splines 36 that slidingly engage flutes or splines 37 of drive shaft 38 that is vertically disposed and mounted in bearings 39 (held in distributor housing 11) and bearing 40 accommodated in base 200. This drive shaft 38 has at its lower end driving means, such as miter gear 41 shown, rigidly fixed thereto while its top portion 42 is machined to fit slidingly the inner bore of sleeve 13.

The lower portion of central post 24 and the upper portion 42 of the drive shaft 38 slidingly and sealingly fit the inner bore of sleeve 13. Should any excessive leakage develop between said portions, the screw 26 may be screwed downwardly thereby limiting the gap between the valve 28 and the valve seat, at the same time equalizing the leakage so as to maintain the pressure to equal the R. P. M. or speed ratio within the sleeve 13.

While post 24 is stationary and shaft 38 is rotating, their vertical distance is constant and it defines a chamber within the inner bore of sleeve 13 which chamber corresponds vertically to the locations of all radial, substantially triangularly shaped recesses or pockets 16 provided in the wall portion 12 of distributor housing 11. Sets of small feed holes 43 are drilled in sleeve 13 within the chamber defined between post 24 and drive shaft 38, preferably on a bias in parallel with the cut-off edge of pockets 16, the number of which sets depends upon the gear ratio between the drive shaft 38 over that of the crank shaft as hereinafter explained. The angular spacing of these sets of feed holes 43 (in case there are more than one set in a row) is equal and so is that of the pockets 16 but these spacings may not be the same. The number of the pockets 16 is the same as that of the work cylinders. The sets of holes 43 in the rotating sleeve 13 engage periodically all the pockets in the same row in succession at successive time periods. The holes in each set 43 are arranged to spread out circumferentially so that when sleeve 13 is moved axially downwardly, the effective cross section and the time period of the fuel supply to pockets 16 is increased; upward motion of sleeve 13 has the contrary effect.

For example, in a four cycle engine having two rows of pockets in the distributor housing (say four pockets in each row for an eight cylinder engine, the pockets being spaced at ninety degrees from each other) and the speed ratio between drive shaft being 1/2 (the drive shaft rotates with half of the number of revolutions per minute than crank shaft), then one set of feed holes 43 will be necessary for each row of pockets or all together two sets in the sleeve 13. If the speed ratio is 1/4 (drive shaft 38 makes ¼ of the number of revolutions per minute than the crankshaft) then two sets of feed holes 43 will be necessary of each row of pockets, the holes being 180 degrees apart. If the speed ratio is 1/8 (drive shaft 38 makes ⅛ of the number of revolutions per minute than the crank shaft) then four sets of feed holes 43 will be necessary for each row of pockets and their spacing will be 90 degrees apart and the total number of feed holes 43 in this case will be eight sets. Thus by increasing the number of sets of feed holes 43 the speed of sleeve 13 may be reduced and with it its wear minimized.

Miter gear 41, keyed to drive shaft 38, is positively driven through known means by the crankshaft (not shown) of an internal combustion engine 300. Drive shaft 38, which is rotatably mounted in bearings 39 and 40, is axially substantially fixed and carries pump impeller 44 keyed thereto between bearings 39 and 40. Impeller 44 is rotatably accommodated within suitable recess 45 provided in base 200.

As best shown in Figure 7, the impeller 44 is shown to be of a spur gear type which engages a similar gear 46, both drawing the fuel from supply pipe 47 and delivering it through duct 48 at a higher pressure.

Duct 48 from the gear pump leads into an annular aperture 49 provided in bearing 39 which communicates with a suitable duct 50 axially disposed in drive shaft 38 and leading to the upper end thereof establishing communication between the delivery duct 48 and the chamber 92 between post 24 and shaft 38 formed within the inner bore of sleeve 13 in which chamber the sets of feed holes 43 are disposed.

As best shown in Figures 3 and 4 the upper portion of distributor housing 11 is shaped to form master cylinder 51 and two operating cylinders 52 and 53. Master cylinder 51 accommodates vertically reciprocably piston 54 attached to piston rod 55 that traverses cover 23 and penetrates outer hood 56 through stuffing box 57 and stuffing box gland 58 to prevent leakage. Piston rod 55 is connected to suitable leverage (not shown) which is operatively attached to the leverage 301 actuating butterfly valve 302, which regulates the air intake in the inlet manifold as it is shown diagrammatically and fragmentarily to a smaller scale in Figure 1. Leverage 301, operating butterfly valve 302 and also piston rod 55, comprises the necessary linkage and bell cranks (not shown) for simultaneous and corresponding setting of butterfly valve 302, piston rod 55, and piston 54 of master cylinder 51 by manipulation of the operator of the internal combustion engine 300.

Piston 54, mounted in master cylinder 51, contains duct 59 leading from one side of the piston to the other and accommodating a check valve arrangement shown to be consisting of ball 60 urged by helical spring 61 into closing position in duct 59; spring 61 being supported by adjustable threaded seat 62 screwed into the lower threaded portion of duct 59. This check valve arrangement is shown to a larger scale at the lower portion of distributing housing 11, accommodated in a suitable cavity of the boss 70 thereof, and serving as a relief valve to admit fuel from the cavity of the lower housing portion 15 through pipe 71 into piping 47 leading to the intake part of gear pump 44, 46 mounted, in recess 45 of base 200. 72 are attachment means such as bolts shown for rigidly fastening distributor housing 11 to base 200. Cover 23 is fastened to distributor housing 11 by bolts 79 and flange extension 68 of shell 88 compressing gasket 74 for sealing the space between the outer hood 56 and the shell 88. Bolts 75 and nuts 76 fasten the hood 56 to the distributing housing 11 and the shell 88. In the middle, thick walled portion 12 of distributor housing 11, one or more ducts 81 connect the cavities of housing portions 14 and 15.

Integral with cover 23 and protruding upwardly therefrom is bracket 82 which pivotally mounts around pin 83 the two armed lever, generally denoted by the numeral 84, one arm being 85 which slidingly engages central post 22 in a suitable aperture 86 formed therein; the second arm 87 of lever 84 slidingly engaging piston rod 101 of control unit 100 in a suitable aperture 63 formed in the piston rod 101.

Piston rod 101 is rigidly fastened to piston 102 which is reciprocably mounted in power cylinder 103 that is rigidly held by posts 104 threaded into control housing 105 which is fixed to base 200 by attachment means such as bolts 106, shown. The ends of posts 104 are threaded and nuts 107 serve to lock the posts to control housing 105 and to booster cylinder 103, respectively. Cover 108 is fastened to cylinder 103 by bolts 109; cover 108 has a central boss 110 with a suitable central bore to properly guide piston rod 101 and is also provided with a hole 111 that connects the space above the piston 102 in cylinder 103 with the atmosphere. The lower portion of power cylinder 103 is provided with a central boss 112 that has a central hole for guiding piston rod extension 113 that protrudes from piston 102 downwardly through power cylinder 103.

The lower end of piston rod extension 113 is provided with threads 114 which are screwed into the central block 115 of a turnbuckle, the block being shaped as a wide spur gear which is engaged by a rack 116, as best shown in Figures 1 and 6. Coaxially disposed with piston rod extension 113 is pilot valve housing 117 that

has at its upper end a threaded portion 118 which is also screwed into central block 115 of the turnbuckle. The threaded portions 114 and 118 have the same pitch but are opposite in direction so that, if one is left-handed, the other is right-handed, consequently by turning central block 115 in one direction, piston rod extension 113 and with it piston 102 and pilot valve housing 117 will both move toward each other, and rotating central block 115 in the other direction, the piston 102 and pilot valve housing 117 will move away from each other.

Pilot valve housing 117 has a central duct 119 leading to a central bore 120 in which pilot valve stem 121 is reciprocably and sealingly mounted. Piston 102 and piston rod 101 are secured against turning by screw 122 threaded into boss 110 and engaging axially extending groove 123 provided in piston rod 101 which groove is of suitable length to permit the necessary stroke for piston 102 upwardly and downwardly from the middle or central position.

Pilot valve housing 117 has sidewardly extending rigid brackets 124 which are provided with suitable grooves to accommodate posts 104 which acts as guides permitting the pilot valve housing to reciprocate vertically and at the same time preventing any turning motion thereof. Pilot valve housing 117 is provided with radial holes 125, 126, 127 and 128 communicating with inside bore 120 of the pilot valve. Hole 125 is connected through resilient tubing 129 to the cavity of the lower portion 15 of the distributor housing 11; hole 126 is connected by flexible tubing 130 to the inner space of power cylinder 103 underneath of piston 102; hole 127 is connected by flexible tubing 131 to a duct leading to annular groove 49 and bearing 39 of the distributing unit; hole 128 is connected through flexible tubing 132 to the inner space in cylinder 103 underneath piston 102. The attachment of the tubings to the holes and ducts are effected by threaded or other approved means (not shown).

Pilot valve housing 117 carries at its bottom portion a radially disposed set screw 133 which reaches into axial groove 134 provided in pilot valve stem 121 to limit vertical reciprocating motion of valve stem 121 in relation to valve housing 117 so that the annular grooves 135 and 136, suitably located, will not exceed the full open position with radial holes 125, 126, 127 and 128. When the relative position of the valve stem 121 to the pilot valve housing 117 is changed so, that the stem is displaced downwardly from the neutral position, the holes 125 and 126 are communicating with each other through groove 135 forming a connection between the inner space in power cylinder 103 beneath piston 102 and the space within distributing housing portion 15 through flexible tubing 129 and 130.

Conversely, when the relative position of the valve stem 121 and pilot valve housing 117 is changed so, that the stem is moved upwardly from the neutral position, then holes 127 and 128 communicate through annular groove 136 connecting the space in power cylinder 103 underneath piston 102 with the delivery side of the fuel pump 64 through flexible tubings 131 and 132.

The control unit housing 105 has an integral plate 137 having a central boss 138 with a suitable central hole to admit pilot valve stem 121 into the inner cavity 139 of control housing 105. In this inner cavity, concentrically to the valve stem 121, is mounted pressure responsive means, shown to be bellows 140 that is air tightly and coaxially to valve stem 121 mounted on base plate 200. A plate 141 is rigidly fixed to both valve stem 121 and bellows 140 so that any movement of the bellows will move the valve stem 121 within pilot valve housing 117. A spring 142 urges plate 141 and valve stem 121 downwardly.

Base 200 is provided with an opening 201 communicating with space 139, outside bellows 140, and with opening 202, communicating with the space inside bellows 140. Hole 201 is connected by tubing 203 to the most restricted lowest pressure area 303 of a central venturi 304 mounted in the air intake (not shown) of the internal combustion engine and hole 202 is connected by tubing 204 to the highest pressure area 305 of a second, larger venturi 306 through which all air, needed to form the proper explosive mixture for the engine, has to pass. These venturis, respectively the air pressures at their highest and lowest pressure areas at 305 and 303 serve as air metering means for the air intake of the engine, as is well known in the art.

From opening 17 in each radial triangular pocket 16 tubing 89 leads to one fuel injector 307 mounted in one of the work cylinders 308 (shown diagrammatically) while air is admitted into the cylinder through air inlet 309 regulated by intake valve 310, shown diagrammatically and fragmentarily in Figure 1 to a smaller scale. The ends of tubing 89 are preferably flared out and attached to suitably threaded bosses 90 by a corresponding nut 91.

The device operates as follows:

For starting the engine a fuel priming device is employed which is conventional hence is not shown. The engine, while running, drives positively by known means (not shown) miter gear 41 and the rigidly attached drive shaft 38 with a definite relationship to the speed of the crankshaft, depending upon the number of sets of feed holes 43 as hereinbefore explained. Impellers 44 and 46 keyed on drive shaft 38 will deliver the fuel, fed through pipe 47 from the fuel tank into the pump, through the annular cavity 49 and axial duct 50 into the chamber formed by drive shaft 38 and central post 24 in sleeve 13. The pressure developed in this chamber by the fuel pump will be somewhat larger than the pressure of the valve spring 27 urging regulating valve 28 towards its seat in post 24. This spring pressure can be selectively adjusted by turning the set screw 26.

It will be noted that at full speed the pump delivers 3 to 4 times the amount of fuel that the engine consumes, therefore, at idling speeds the pump delivers only a small quantity of fuel so that the spring 27 holds valve 28 partially closed to maintain the minimum operating pressure in the sleeve 13. As the engine speeds up the output of the pump increases in proportion and valve 28 is forced open until it seats itself against pressure set screw (primarily a leakage compensating means), therefore, determining the maximum size of the valve opening 30. As the engine further speeds up and the output of the fuel pump increases in proportion, more fuel will be forced through the same size valve opening 30 causing an increase in pressure in sleeve 13 in proportion to the increase in engine and pump speed.

The fuel is expelled through openings 43 into pockets 16 and from there, via tubing 89 through fuel injectors 307, injected into the work cylinders in the proper time intervals necessary for introduction of the fuel, depending on the shape of the pockets 16 and of the axial position of sleeve 13, respectively of that of the feed holes 43.

The excess fuel delivered by the fuel pump is expelled through orifices 30 and 32 into the cavity in portion 14 of the distributor housing from which it flows through ducts 81 into the lower cavity in housing portion 15 whence through the relief valve contained in boss 70 (said valve comprising ball 60, weak spring 61, connecting threaded fitting 62) and through tubing 71, the fuel is returned into pipe 47 for reintroduction into the fuel pump.

When the operator opens the throttle 302 of the butterfly valve the engine receives more air as the resistance against the airflow is decreased, and the flow of air is increased, causing an increased pressure difference between the cross sections 303 and 305 in the venturis 304 and 306, hence in space 139 outside the bellows 140 relative that in the space inside thereof. As the result the bellows 140 will be expanded and moved upwardly and with it valve stem 121 in pilot valve housing 117. As a consequence radial openings 127 and 128 will be put in communication with each other through groove 136 and high pressure fuel will flow through flexible tubings 131 and 132 into the space below piston 102 in power cylinder 103. As a result piston 102 and piston rod 101 will be lifted vertically, lever 84 will be pivoted around pin 83 and spider 21 by its post 22 moved downwardly against the pressure of spring 34. Posts 22 connected rigidly to spider 21, will move downwardly together with slip ring 19 and sleeve 13 which is rotating with its flange 18 sliding in slip ring 19 all the time. Sleeve 13 having been moved axially downwardly, holes 43 sweep by a lower, hence wider portion of the pockets 16, hence the holes will communicate with the pockets through longer arcs delivering to them a correspondingly greater amount of fuel, consequently the delivered fuel through tubing 89 to injectors 307 and into the work cylinders will be also correspondingly greater. The final result is that the increased airflow through the venturis brings about automatically an increase of the fuel supply affected by the control and distributing units.

Conversely, by closing butterfly valve 302, the pressure difference between cross sections 303 and 305 and between the outside and the inside spaces of bellows 140 becomes less, spring 142 compresses the bellows and pushes plate 141 and valve stem 121 downward, holes 125 and 126 and through them flexible tubings 130 and 129 will communicate through annular groove 135 bringing about an opposite result to that hereinbefore described namely sleeve 13 will be axially lifted and the amount of the injected fuel reduced.

To adjust the relationship between the pilot valve stem 121 and pilot valve housing 117 and for the corresponding positioning of sleeve 13 an adjusting mechanism is provided consisting of the central block 115 of a turnbuckle coacting with a rack 116 and of a leverage (not shown) manipulated by the operator. By changing the position of rack 116, central block 115 is turned selectively in either direction and with it the relative distance between piston 102 and pilot valve housing 117 is changed, thereby varying the ratio of fuel and air to which the automatic control was beforehand set.

Linkage 301, controlling butterfly valve 302, is connected to piston rod 55 in a suitable manner (not shown) so that opening of the butterfly valve

302 will be always accompanied by moving piston 54 downwardly toward the bottom of the master cylinder 51. As a result of such piston movement the fuel will be pressed through tubing 65 and 66 into actuating cylinders 52 and 53 above pistons 67 forcing these pistons and with them the connected spider 21 downwardly. The descending spider 21 moves through posts 20 and slip ring 19, sleeve 13 downwardly increasing thereby the amount of the injected fuel, hence master piston 54 and butterfly valve 302 work always in unison and for increased air intake a correspondingly increased fuel intake will be momentarily provided, thus giving the accelerating pump action. The return motion of sleeve 13 and of spider 21 to the control of piston 102 is caused by spring 34 which forces spider 21 and pistons 67 upwardly threby causing the entrapped fuel above pistons 67 to be forced downwardly through drilled metering holes 69 in pistons 67. These metering holes 69 are of such size that they will cause the accelerating pump action to diminish at a rate to compensate for the lag in the automatic control responsive to the air metering means in the air intake manifold of the engine.

Any leakage of fuel within the hood 56 and the shell 88 may be drained by means of a drain pipe 93 which is connected to the fuel tank (not shown) and any leakage in the distributing unit 10 is returned to the fuel pump 64 through check valve and pipe 71 shown in Figure 1.

From the foregoing description taken in connection with the accompanying drawings, it will be seen that my invention provides a fuel injection system of the character described which provides a single injection unit which feeds the fuel in metered quantities to any number of cylinders of an engine instead of providing a fuel injection device for each cylinder as is conventionally done.

It is obvious that those skilled in the art may vary the details of construction and arrangements of parts without departing from the spirit of my invention, and therefore I do not wish to be limited to such features except as may be required by the appended claims.

I claim:

1. In an internal combustion engine having a plurality of work cylinders, a crank shaft and an air intake manifold provided with air metering means, a fuel injection system comprising pump means receiving fuel from a supply line and delivering it under pressure in quantities at all times substantially in excess of those necessary to be injected into the work cylinders, drive means for positively motivating said pump by said crank shaft, fuel metering means rotatable with said pump means receiving fuel from said pump and regulating the amount delivered to the work cylinders, by-pass means between the pump and the fuel metering means removing a portion of the fuel delivered by the pump, piston means receiving the fuel from the by-pass means and actuated thereby, connections between said piston means and said fuel metering means so constructed and arranged that when an increased quantity of fuel enters the by-pass means the fuel metering means permits a greater quantity of fuel to enter the work cylinders, valve means in the by-pass means regulating the amount of fuel passing through the by-pass means, control means regulating the position of the valve means, said control means being responsive to the amount of air passing through the air metering means and manually operable ratio varying means regulating the amount of fuel relative to that of air supplied to the work cylinders.

2. In an internal combustion engine having a plurality of work cylinders, a crank shaft and an air intake manifold provided with air metering means, a fuel injection system comprising pump means receiving fuel from a supply line and delivering it under pressure in quantities substantially in excess of those necessary to be injected into said work cylinders, a fuel distributor housing, a drive shaft rotatably mounted therein, means for positively motivating said shaft by said crank shaft, a sleeve rotatably and axially reciprocably mounted in said housing and receiving fuel from said pump, means for driving said pump means and for rotating said sleeve by the drive shaft, means in said housing so constructed and arranged as to vary the quantity of fuel injected into each work cylinder according to axial position of the sleeve therein, bypass means between the pump and the sleeve receiving portion of the fuel delivered by the pump, piston means receiving the fuel from the by-pass means and actuated thereby, connections between said piston means and said sleeve means so constructed and arranged that an increased amount of fuel entering the by-pass means causes the piston to move the sleeve axially relative to the housing so as to deliver a variable quantity of fuel to the work cylinders, valve means in the by-pass means regulating the amount of fuel through the by-pass means, control means regulating the position of the valve means, said control means being responsive to the amount of air passing through the air metering means and manually operable ratio varying means regulating the amount of fuel relative to that of air supplied to the work cylinders.

3. In an internal combustion engine having a plurality of work cylinders, a crank shaft, and an air intake manifold provided with air metering means, a fuel injection system comprising fuel pump means receiving fuel from a supply line and delivering it under higher pressure in quantities substantially in excess of those necessary to be injected into the work cylinders, a fuel distributor housing, a drive shaft rotatably mounted in said housing, means for positively driving said shaft by said crank shaft, a sleeve rotatably and axially reciprocable mounted in said housing and receiving fuel from said pump, means for driving said pump means and for rotating said sleeve by said drive shaft, radial openings in the wall of said sleeve coacting periodically with radial open pockets in the wall of said housing, connecting means for transmitting fuel from each of said pockets to one of said work cylinders, bypass means between the pump and sleeve receiving a portion of the fuel delivered in quantities substantially in excess of those necessary to be injected into said work cylinders, a fuel distributor housing, a drive shaft rotatably mounted therein, a spider axially reciprocably mounted on said fuel distributor housing and slidingly engaging said sleeve for conveying the axial movement of said spider to said sleeve, piston means receiving the fuel from the bypass means and actuated thereby, connections between the said piston means so constructed and arranged that an increased amount of fuel entering the by-pass means causes the piston to move the sleeve axially relative to the housing so as to deliver a varying quantity of fuel to the work cylinders, valve means in the by-pass means reg-

ulating the flow of fuel therein, control means regulating the position of the valve means, said control means being responsive to the amount of air passing through the air metering means and manually operable ratio varying means regulating the amount of fuel relative to that of air supplied to the work cylinders.

4. In an internal combustion engine having a plurality of work cylinders, a crank shaft and an air intake manifold provided with air metering means, a fuel injection system comprising fuel pump means from a supply line and delivering it under higher pressure of the fuel delivered by the pump, piston means receiving the fuel from the by-pass means and actuated thereby, connections between the said piston means and sleeve means so constructed and arranged that an increased amount of fuel entering the by-pass means causes the piston to move the spider axially with respect to the housing and thereby move the sleeve axially relative to the housing so as to deliver a variable quantity of fuel to each work cylinder depending upon the position of the radial openings in the sleeve with respect of the pockets in the housing, a return spring mounted between the spider and the housing tending to urge the spider toward the position in which the radial openings in the sleeve are cut off from the pockets, valve means in the by-pass means regulating the flow of fuel therein, control means responsive to the amount of air passing through the air metering means regulating the position of said valve and manually operable varying means regulating the amount of fuel relative to that of air supplied to the work cylinder.

5. A fuel injection system according to claim 4 in which the valve means comprises a pilot valve stem attached to the air pressure responsive means, said valve stem being disposed in a pilot valve housing that is operatively connected to said ratio varying means, said pilot valve stem and valve housing being mounted for axial reciprocating motion relative to each other, two annular grooves in said stem coacting with radial openings in said pilot valve housing and inlet and outlet connections from the annular grooves to the by-pass means.

6. A fuel injection system according to claim 4 in which the ratio varying means consists of a turnbuckle having a central block with central coaxial left and right threads, the one operatively engaging a threaded portion of said valve means, the other engaging a threaded rod on said piston, said central block being provided with gear teeth operatively engaging a rack mounted for hand operation.

7. A fuel injection system according to claim 4 in which there is provided means connected with the spider for momentarily increasing the amount of fuel injected into the work cylinders each time the spider is moved against the force of the return spring to increase the flow of fuel through the radial openings in the sleeve into the pockets in the housing.

HARLAN N. FISER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,087,296	Parsons	July 20, 1937
2,103,126	Sugihara	Dec. 21, 1937
2,270,263	Butler	Jan. 20, 1942
2,388,669	Baker	Nov. 13, 1945
2,453,329	Lee, II	Nov. 9, 1948