March 18, 1958 W. STRUMBOS 2,827,030

FUEL INJECTION MEANS FOR INTERNAL COMBUSTION ENGINES

Filed Nov. 22, 1955 4 Sheets-Sheet 1

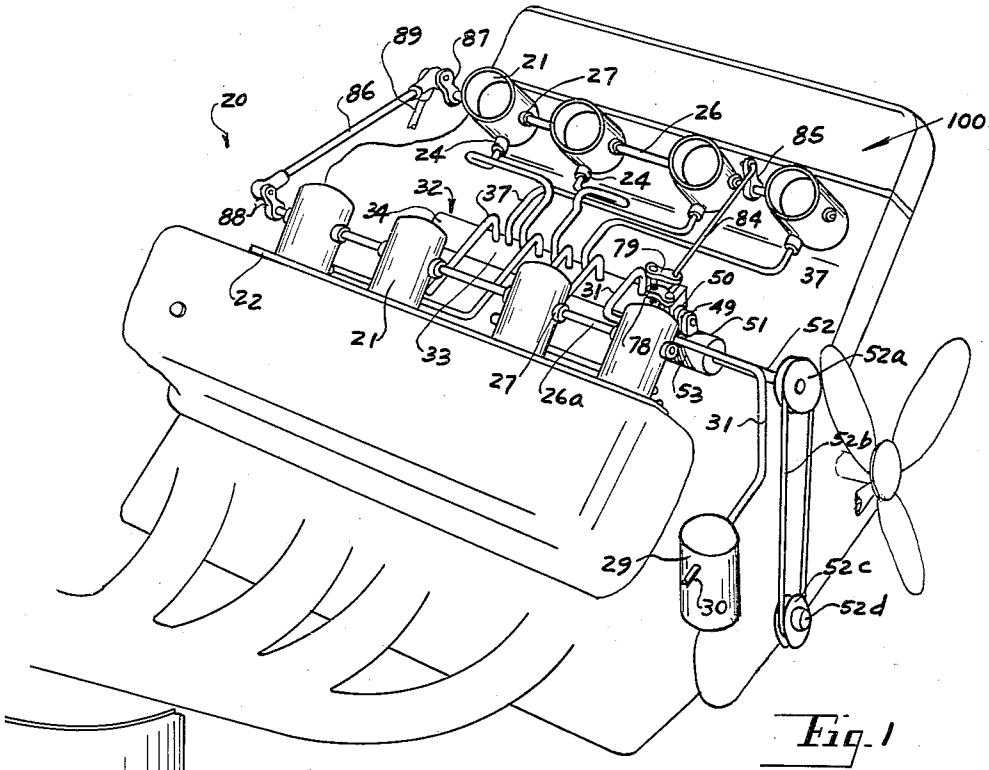


Fig. 1

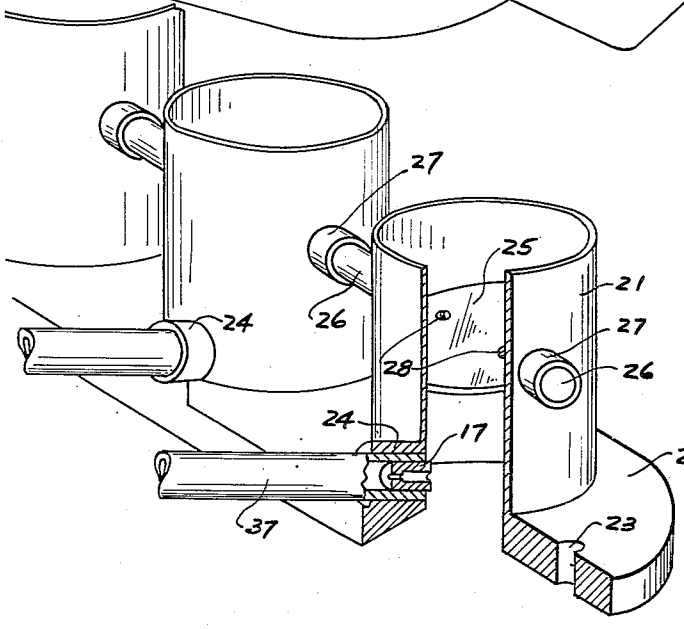


Fig. 2

INVENTOR.
WILLIAM STRUMBOS

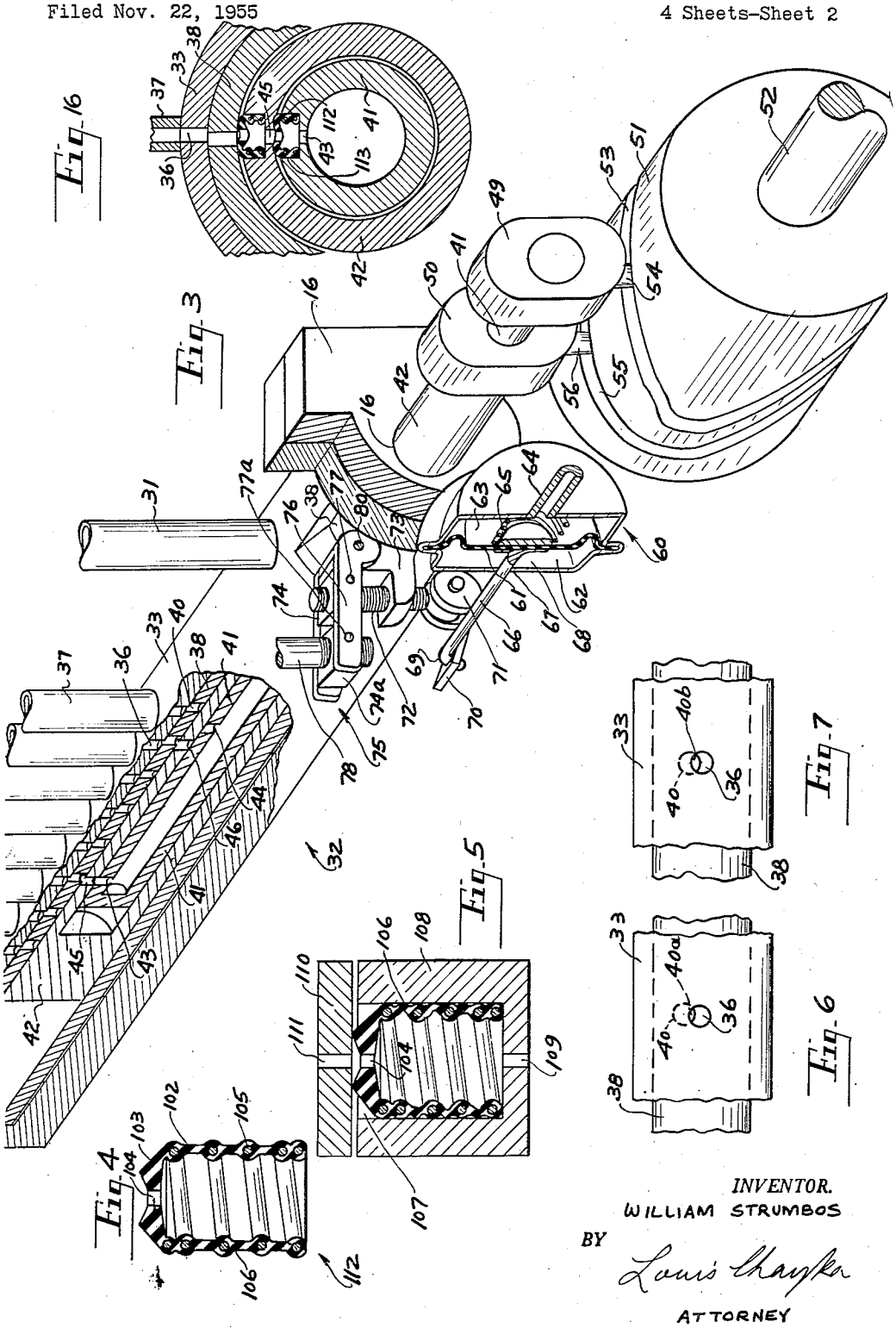
BY Louis Chayka

ATTORNEY

March 18, 1958 W. STRUMBOS 2,827,030

FUEL INJECTION MEANS FOR INTERNAL COMBUSTION ENGINES

Filed Nov. 22, 1955 4 Sheets-Sheet 2



INVENTOR.
WILLIAM STRUMBOS
BY
Louis Chayka
ATTORNEY

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FUEL INJECTION MEANS FOR INTERNAL COMBUSTION ENGINES

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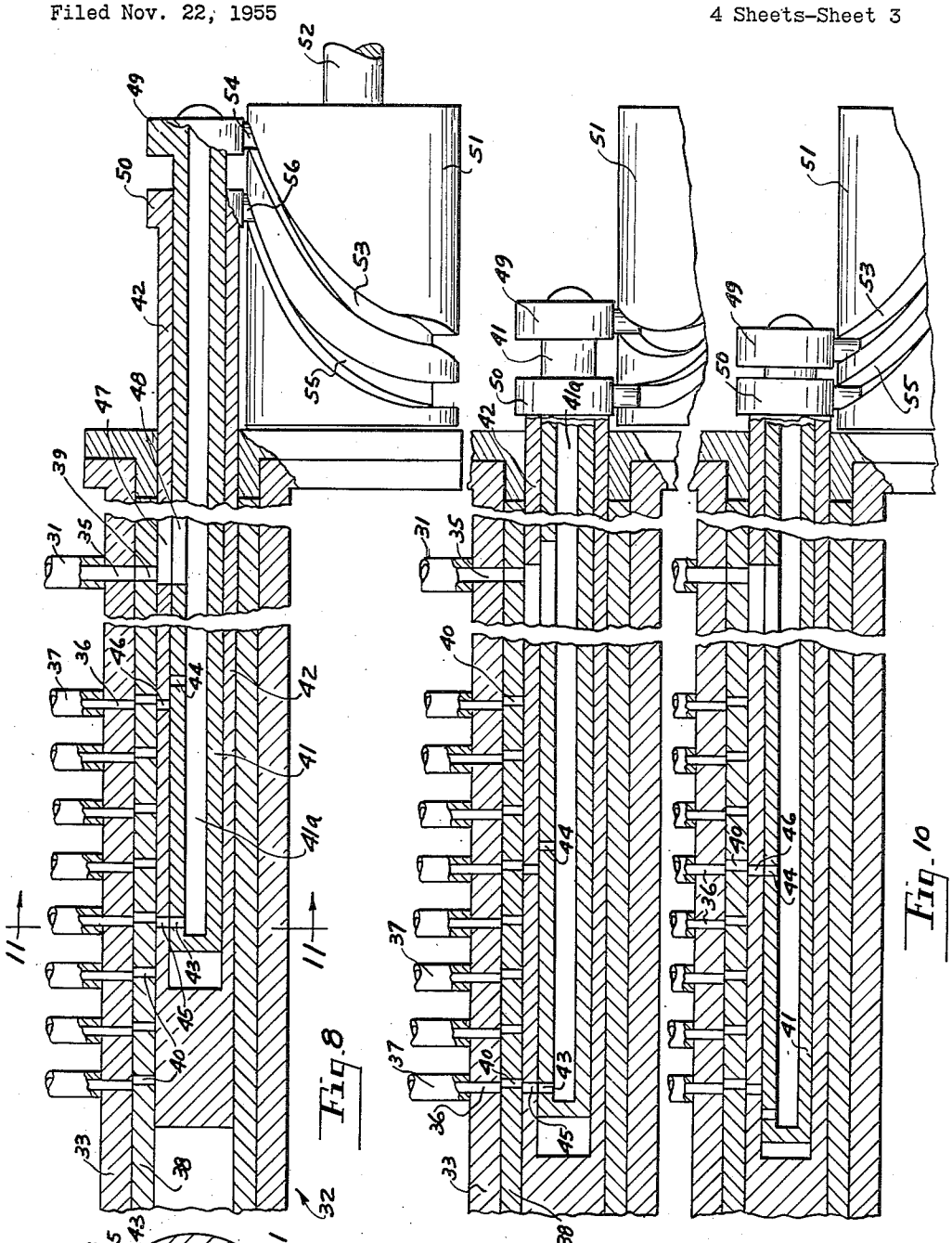


Fig. 8

Fig. 10

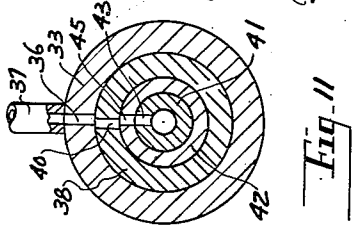


Fig. 11

Fig. 9

INVENTOR.
WILLIAM STRUMBOS
BY Louis Chayka
ATTORNEY

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FUEL INJECTION MEANS FOR INTERNAL COMBUSTION ENGINES

Filed Nov. 22, 1955 4 Sheets-Sheet 4

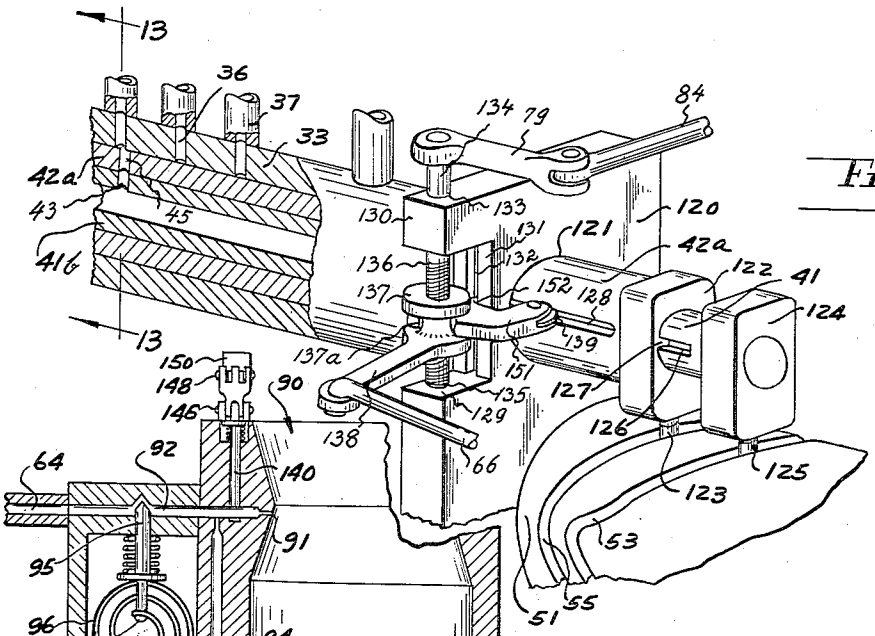


Fig. 12

Fig. 15

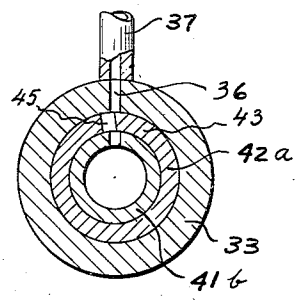


Fig. 13

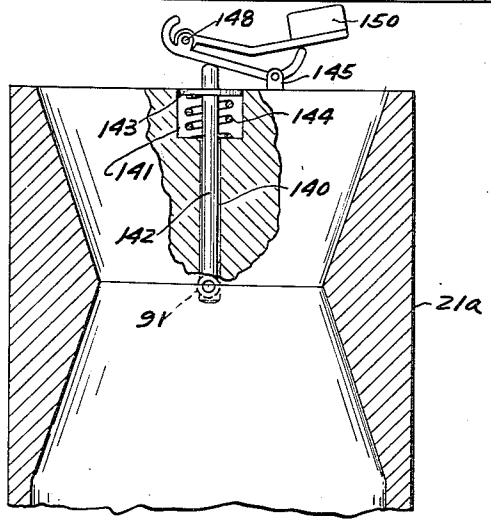


Fig. 14

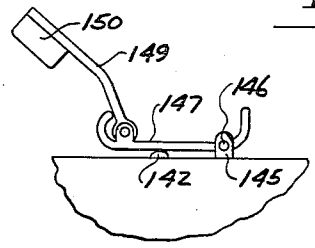


Fig. 14a

INVENTOR.
WILLIAM STRUMBOS
BY Louis Chayka
ATTORNEY

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FUEL INJECTION MEANS FOR INTERNAL COMBUSTION ENGINES

William Strumbos, Livonia, Mich.

Application November 22, 1955, Serial No. 548,297

8 Claims. (Cl. 123—139)

It has been recognized in the automotive industry that the carburetor means of supplying fuel to individual cylinders of an engine has a number of drawbacks. Some of them pertain to the unsatisfactory mixture of fuel and air under varied throttle settings, some to the unequal volume of said mixture as delivered to the individual cylinders because of the varied lengths of passages in the intake manifold, and some to the deterioration of said mixture under low velocities of movement of said mixture.

It has also been recognized that a delivery of a fuel mixture to each cylinder by injection would overcome some of the above drawbacks, but that such injection presents its own problems. A practical injection system now in use employs piston means for each cylinder, the system requiring a special valve in each cylinder to prevent the fuel from being backed up once the piston has been set operating, also for spring means of high tension to prevent combustion pressures in the cylinder from opening the valve through which the fuel is delivered.

Another obstacle to a more popular use of the injection system is the high cost of means employed therefor, due to the fact that some elements employed in the injection system have to be finished to tolerances measured by units of one-millionth of an inch. This is necessary to prevent leakage, in view of the high pressures under which the fuel is to be forced into individual cylinders.

It is the object of my improvement to eliminate individual plungers for delivery of fuel to the engine and to eliminate, thereby, some of the problems associated with the use of said pistons.

It is, further, the object of the improvement to provide a fuel-injection system in which the high precision in the making of the component elements is not essential, and which, therefore, is more adaptable for mass production. To achieve this object and to prevent leakage of fuel at points at which such leakage would be likely to occur, I employ a sealing member which has an inventive novelty and usefulness of its own.

I shall now describe my improvement with reference to the acompanying drawings in which:

Fig. 1 is a perspective view of an engine block, the view including means of my structural design for injection of a fuel mixture into the individual cylinders of said engine;

Fig. 2 is a fragmentary perspective view, partly in section, of an intake riser manifold forming a part of my injection system;

Fig. 3 is a fragmentary perspective view, partly in section, of a fuel-regulating unit, or regulator, and means to convey fuel to the cylinder of the engine, the view including a cam mechanism to operate movable elements within said regulator;

Fig. 4 is a longitudinal sectional view of a sealing member for passageways in my system;

Fig. 5 is a longitudinal sectional view of the same member in a radially-expanded state;

Fig. 6 is a fragmentary plan view of a metering sleeve upon a fuel-delivery element;

Fig. 7 is a fragmentary plan view of the same sleeve in a different operative position;

Figs. 8, 9, and 10 are longitudinal sectional views of a regulator unit for delivery of fuel to individual cylinders of the engine, the views showing elements of the regulator in different operative stages;

Fig. 11 is a transverse sectional view on line 11—11 of Fig. 8;

Fig. 12 is a perspective view, partly in section, of a modified regulator for delivery of fuel to cylinders of the engine, the view including modified means to control the metering sleeve;

Fig. 13 is a sectional view on line 13—13 of Fig. 12;

Fig. 14 is a side elevational view of a cut-off device for an air duct leading to the vacuum control means for delivery of fuel to the cylinders of the engine;

Fig. 14*a* is a side elevational view of the same device, with elements thereof in different operative positions;

Fig. 15 is a vertical sectional view of a riser having therein a venturi passage, the view including means responsive to variations of temperature and atmospheric pressure to control a vacuum port leading from said venturi passage;

Fig. 16 is a sectional view of the regulator, the view being analogous to that shown in Fig. 11 but including sealing means of my construction.

Similar numerals refer to similar parts throughout the several views.

The engine shown in Fig. 1 and generally identified by numeral **20** is of the internal combustion, four cycle type, including a V-block containing eight cylinders in two banks of four. The cylinders, not shown, contain reciprocating pistons connected by intermediate means to a crankshaft.

Associated with each cylinder, but mounted externally thereof, is a cylindrical riser **21**, there being four such risers for each component part of said V-block. The risers for each part of the block have a common base **22** provided with aperture **23** for application of screws so that they may be secured as a unit upon the respective part of said block in such a manner that each riser is open at the bottom into the inlet passage of a cylinder of the engine.

Each of the risers includes an externally-projecting nipple **24** to which I shall refer in the course of this specification, and contains at a level midway the height of the riser, a throttle plate **25**, as shown in Fig. 2. The throttle plates in all the risers are mounted upon a common shaft **26** which passes diametrically through all the risers, being journalled in short bearings **27** projecting radially from the walls of the respective risers. Numeral **28** indicates screws by means of which the throttle plates within the respective risers are secured to the shaft.

I shall now refer to elements employed by me to deliver, through intermediate means, fuel charges to individual cylinders. Some of said elements are shown in Fig. 1 where numeral **29** indicates a pump adapted to draw liquid fuel by means of a pipe **30** from a source of supply which is not shown. From the pump a pipe **31** leads to a distributing and timing device, hereinafter called a regulator, shown in part in Fig. 3 and generally identified by numeral **32**. As shown in Fig. 1, the regulator is located on top of the engine block between the two banks of the risers **21** and is supported at one end by a standard **16**, as shown in Fig. 3.

The regulator includes a stationary housing, or a stator **33**, having the form of a horizontally-disposed cylinder closed at one end, as shown at **34** in Fig. 1. The wall of the stator is provided, as shown in Fig. 8, with an inlet port **35** for connection to the above-said pipe **31**, and with a plurality of radial outlet ports **36**. The ports are located in a spaced relation to each other along a straight

line. Each of the ports opens into a separate tube or line 37 which leads to a nipple 24 on one of the risers 21, the line terminating within said nipple with a fuel-injection nozzle 17 for discharge of fuel into the riser.

It will be understood that there are as many outlet ports 36 in said stator 33 as there are cylinders in the engine, one port 36 being connected to one riser by means of one of said lines 37.

Located within the stator and being all along its length in a sliding contact with the inner surface thereof is a metering cylinder or sleeve 38 which at one end is provided with a radial opening 39 located immediately below the intake port 35. In addition thereto, the metering sleeve contains the same number of radial apertures 40 as the stator has outlet ports 36, one aperture being located under each outlet port. The sleeve is capable of a limited rotary movement about its axis, the movement being controlled by means which I shall describe in the course of this specification.

Located axially within the metering sleeve 38 is an assembly of two members in a telescopic relation to each other, one of said members, the inner one, serving as a cylindrical valve 41, while the outer member 42 serves as a timing sleeve. The valve 41, having an axial bore 41*a*, is closed at both ends, but contains in its wall two radial orifices 43 and 44, the orifices being longitudinally spaced from each other along a straight line, on the top portion of the horizontally-disposed valve. Similarly, two orifices 45 and 46 are located within the top portion of the wall of the timing sleeve 42, but the spacing between said orifices differs from the spacing between the orifices of the valve, and while the valve 41 and the timing sleeve 42 are capable of longitudinal movement with relation to each other, only one orifice in the valve may be brought at one time into register with one orifice in the timing sleeve.

In addition to the two orifices, the timing sleeve 42 is provided, at one end, with an oblong slot 47 right under the inlet port 35 in the stator 33. Similarly, the sliding valve 41 contains an oblong slot 48, the two slots opening into each other, as best shown in Fig. 8.

To complete the description of the regulator, I wish to add that the sliding valve 41 is provided with an outwardly-extending flange 49 at one end, and that the timing sleeve 42 has a similar flange 50 in a parallel relation to said flange 49. Located under one end of the regulator is a barrel cam 51 mounted upon and keyed to a shaft 52 which, by means of a pulley 52*a* and a belt 52*b*, is operatively connected to pulley 52*c* driven by the crankshaft 52*d* of the engine in such a manner that the barrel cam will complete one full revolution about its axis for every two complete revolutions of the crankshaft. Preferably, sprockets may be substituted for the pulleys and a chain for the belt.

The cam contains two grooves. One, 53, defines a complete loop set obliquely to the shaft 52 for engagement with the flange 49 of the sliding valve 41. For this purpose the portion of the flange extending into the groove carries a roller 54. The other groove 55 is in a similar operative engagement with the flange 50 of the timing sleeve 42; however, the groove 55 is deflected from said groove 53. The cam, as will be presently described, is to impart a reciprocating longitudinal movement to the slide valve and a similar movement to the timing sleeve, but the extent of the longitudinal movement of one is to be different from that of the other.

Disposed externally of the regulator 32, as shown in Fig. 3, and secured to said standard 16, is a mechanism for the operation of the metering sleeve 38 within said regulator. The mechanism includes a circular container generally identified by numeral 60, the container having therein a flexible diaphragm 61 dividing the container into two adjoining chambers, 62 and 63, respectively.

The last-named chamber contains an opening leading to a vacuum line 64. A coiled spring 65, axially disposed within the chamber 63, bears against the diaphragm and keeps it in an outwardly-expanded position. A rod 66, affixed to the central portion of the diaphragm within the chamber 62, slidingly passes outwardly through an opening 67 in the one wall 68 of said chamber 62.

The outer end 69 of the rod is pivotally connected to one end of an arm 70 which, by means of a bifurcated end 71, is pivotally joined to the lower end of a pin 72, the pin being threaded into a stationary bracket 73. Seated upon said pin is a rectangular nut 74, and pivotally mounted thereon is a rocker, generally identified by numeral 75. The rocker is composed of two oblong side members 76 straddling said nut 74. Each side member, midway its length, is pivotally connected to one side of the nut by a pin 77.

At one end the rocker is pivotally secured to the metering sleeve by means of a pin 80. At the opposite end the rocker contains a nut 74*a* which is pivotally held between side members 76 by means of pins 77*a*.

Threaded into the nut 74*a* from above, as shown in Fig. 1, is a short shaft 78 which at the top is keyed to one end of a short arm 79. The other end of the arm is connected, by means of a rod 84, to an arm 85 which is keyed to the aforesaid throttle shaft 26 in one bank of risers 21. A rod 86, connected at one end to a crank 87 at the end of said crankshaft 26, leads to a similar crank 88 keyed to shaft 26*a* at the other bank of the risers, while a link 89, connected to said crank 87, will serve, by a downward pull, to impart simultaneously a limited rotary movement to the throttle shafts 26 and 26*a*, respectively.

I shall now refer to Fig. 15 which shows a modified riser 21*a*, this being one in the series of risers 21 described above. The riser 21*a* contains a venturi passage 90 and is provided with two ports. One of them, marked 91, leads from the constricted portion of the venturi passage into a horizontal duct 92 and into a tube 64, and through said tube to chamber 63 shown in Fig. 3. The other port 93 is located slightly above the level of shaft 26, supporting the throttle plate 25, and leads to said horizontal duct 92 through a vertical bore 94 in the wall of the riser.

The duct 92 is controlled by a needle valve 95 which is actuated, in part, by a laminated bi-metallic spring 96. The spring is contained in a cylindrical housing 100 which is integrally connected, along one side, to said riser 21*a* in a parallel relation thereto.

At the upper end the spring is connected to the lower end of the needle valve 95, while the opposite end of said spring is connected to the upper end of an aneroid bellows 99. Two openings 101 in said housing 100 serve as a means of exposing the bellows to normal atmospheric pressure.

For a purpose to which I shall refer in the case of this specification, I have also provided in said riser 21*a* a cut-off device for the passageway leading from port 91 to said duct 92. As best disclosed in Figs. 14 and 15, the wall of the riser 21*a* is provided with a vertical bore 140 opening at its lower end into said duct 92. At its upper end the bore opens into a circular socket 141. Fitting into the bore, for a sliding movement therein, is a rod 142 which at its upper portion is provided with an annular flange 143. Disposed within the socket and bearing from below against said flange is a spring 144.

Mounted upon the top of said riser, adjacent the socket 141, is a bracket 145, and pivotally connected thereto, as shown at 146, is a lever 147 which at a point spaced from its pivotal connection at 146 bears from above against the upper end of said rod 142. Hinged to the lever, at its end remote from its pivotal connection at 146, as shown at 148, is an arm 149 which, at its outer end, carries a weight 150.

At this juncture I wish to point out that parts of the mechanism and means employed by me for delivery of fuel to the individual cylinder of the engine may be made

without the need of the extreme limits of tolerance required in the fuel-injection system depending upon the piston type of injectors. However, to insure leakage-proof connections at points where a leakage might occur, I have developed a sealing unit shown in Figs. 4 and 5.

The sealing unit or seal, generally identified by numeral **112**, is composed of a cylindrical member **102** made of pliable rubber and open at both ends. In the species shown in the drawings, one end includes a cone-shaped seal ring **103** containing an axial passage **104**. Imbedded in the wall and forming a supporting structure therefor is a helical spring **105** in which the individual coils are widely spaced from each other, leaving relatively thin webbing **106** therebetween. The seal is placed in a socket **107** in one member **108**, the bottom of which socket contains a duct **109** opening into said cylinder **102** at the fully open end thereof, while the cone-shaped end is in a position adjoining another member **110** having a duct **111** designed for operation with said duct **109**.

Such relative position of members **108** and **110** occurs in the regulator **32**, as illustrated in Fig. 16, where the slide valve **41** is provided with a seal **112** seated in a socket **113** within an expanded portion of orifice **43**, shown in Fig. 16. Another such seal is shown in the timing sleeve **42** in the expanded portion of the orifice **45**.

The operation of the seal is quite obvious. In the absence of fluid pressure, the spring **105** maintains the seal in intimate contact with the members being sealed. When fuel, under pressure, reaches the interior of the seal, it will expand it radially, causing the flexible webbing between the individual coils of the spring to bear tightly against the wall of the socket in which the seal is located. Simultaneously, the seal ring end of the seal will be pressed firmly against the adjoining member disposed crosswise to the axis of the seal and having a duct, such as duct **111**, in register with the aperture or duct **104** in said cone. Thus, a possible leak at the junction of the member which contains the seal and the member which is in contact with the seal ring portion of the seal is eliminated.

It must be pointed out that the seal ring **103** may be of various configurations and may be employed at both ends of the seal to suit the application and to insure a leakproof seal. The seal ring itself may be fabricated of various substances to obtain desired performance characteristics.

Now I shall describe the manner in which fuel is delivered to the respective cylinders of the engine:

As already stated herein, the fuel to be delivered to the cylinders is first delivered under pressure, by a pump **29**, to the regulator **32**. More specifically, the fuel is conveyed, as shown in Figs. 1 and 8, from the pump through a pipe **31** to port **35**, through the opening **39** in the metering sleeve **38**, and through slots **47** and **48** into the interior bore of the slide valve **41**. The slide valve is operatively connected at one end by means of flange **49** with groove **53** in the barrel cam **51** so that as a result thereof the valve, during the rotation of the barrel, will be moved reciprocally back and forth within the timing sleeve **42**. The latter, as described herein, is operatively connected, by means of flange **50**, to another groove **55** in the same barrel cam, whereby a reciprocal longitudinal movement is imparted to said timing sleeve, but in a manner to secure a relative longitudinal movement between the valve **41** and the timing sleeve **42**.

It will be kept in mind that fuel delivered into valve **41** is to be conveyed at equally-spaced intervals to each of the eight cylinders of the engine, and that this has to be done in the time required for one single revolution of the barrel cam **51**. In order to shorten the longitudinal sliding movement of the valve from which fuel is to be delivered to the cylinders through the eight ports **36** arranged in a single row, as shown in Fig. 3, the valve is provided with two orifices **43** and **44**, each being designed to deliver fuel to four cylinders only. It is for the same purpose that the timing sleeve has also two orifices **45** and **46**. Thus, in the course of the rotation of the cam, orifice **43** will be brought into register with orifice **45** in the timing sleeve and with an aperture **40** in the metering sleeve, which aperture is located directly below a port **36** opening into a pipe **37**, as shown in Fig. 9.

It will be noted that while orifices **43** and **45** are in register with said aperture **40** and a port **36**, all other ports **36** will be out of communication with the interior of said valve **41**, as said orifices will be out of register with all the remaining apertures **40**.

Another instance when the respective orifices of the valve **41** and of the timing sleeve are in register with one of the passageways **40** is shown in Fig. 10. While the drawings disclose the sliding valve and the timing sleeve at certain stages of the operation, it will be understood that in the course of one complete rotation of the barrel cam each of the ports **36** will be momentarily open in a manner shown in Figs. 9 and 10 for reception of fuel from the interior of valve **41**.

It is during said momentary opening of the respective port **36** that the fuel will enter said port and, passing through pipe **37**, will be sprayed through the nozzle **17** into the interior of the respective riser **21**, as shown in Fig. 2. Within the riser, the fuel will be dispersed through the volume of air below the throttle plate **25**.

For normal driving conditions of the vehicle, the throttle plate will admit enough air for approximately complete combustion of the fuel charge delivered to the riser and therefrom to the cylinder below said riser.

If, for an increase of speed of the engine without a corresponding increase in the throttle setting, more fuel is needed, it is delivered to the risers automatically from the regulator **32**. This is effected automatically in the following manner:

With the increased speed of the engine, the increased vacuum pull of the engine will draw the diaphragm in chamber **63** in the casing **60** in the direction of tube **64** which is connected with the interior of the riser **21***a*. The vacuum must be strong enough to overcome the tension of spring **65**. Rod **66**, connected to the diaphragm, will impart a limited rotary movement to the vertical pin **72** to actuate the rocker **75** and, thereby, to impart a limited rotary movement to the metering sleeve **38** which is provided with the above-said apertures **40**.

The consequences of the rotary movement of the metering sleeve are shown in Figs. 6 and 7 where a portion of the metering sleeve **38**, provided with apertures **40**, is shown with a portion of the stator **33** provided with an outlet port **36**. Fig. 6 shows the relative location of the respective port **36** and the respective aperture **40** during a lighter load upon the engine when said port **36** and the aperture **40** are so out of register that only a small passage **40***a* is left leading from one to the other. Fig. 7 shows how a larger opening **40***b* is provided by a limited rotation of the metering sleeve.

When, for a relatively higher speed, the throttle plates are opened in the conventional manner by means of the accelerator pedal, fuel in larger charges may be delivered to the risers and through the risers to the cylinders of the engine.

The accelerator pedal, which is not shown, is connected, as already stated, to shafts **26** and **26***a*, and serves to tilt the throttle plates in all the risers **21** to admit more air to each of them. Rod **84**, connected to shaft **26** by means of an arm **85**, operates arm **79** on the vertical shaft **78** to impart to the shaft a rotary movement. As the shaft **78** is threaded into one end of the rocker **75**, this will serve to depress the rocker and, thereby, to impart a limited rotary movement to the metering sleeve to a degree which will bring each aperture **40** in the metering sleeve into a

fuller register with the ports 36, as shown in Fig. 7. This, in turn, will permit a larger charge of fuel to be delivered into each of the risers and through them into each of the cylinders.

The regulator 32 is co-ordinated with the throttle plates to provide the various fuel-air ratios required for efficient engine operation; an economical mixture for usual operating conditions, a richer mixture when the demand is for greater speed or power, and a still richer mixture for idling. The vacuum ports 91 and 93 located in the wall of the riser provide a balanced vacuum for actuating the metering sleeve to compensate for variations in engine load and power. Under idling conditions, the throttle plates are nearly closed and a relatively high manifold vacuum will exist at port 93. This serves to exert a pull on diaphragm 61, enriching the mixture.

In conditions of deceleration, the throttle plates will be nearly closed and a relatively high manifold vacuum will exist as it does at idle. However, during deceleration, to promote fuel economy, a weak mixture is desired. It is for this purpose that I have provided the cut-off mechanism already described herein and shown in Figs. 14 and 14*a*.

Under the effects of inertia during a deceleration, arm 149, with the weight 150, will swing forwardly, as shown in Fig. 14*a*, causing the arm 147 to depress the rod 142 and to block said port 91. The device is pivoted in a manner that cancels out the effects of road shocks and bumps. The spring 144 serves to return the cut-off rod to its normal position when the force of inertia is removed. This spring also prevents the cut-off from affecting the mixture for idle when the vehicle is stopped on a downgrade. This device, of course, may be used elsewhere in the system to accomplish the same purpose; it may be placed in the fuel inlet line to shut off the supply of fuel to the regulator during deceleration.

A modified regulator analogous to that shown in Fig. 3 is shown in Fig. 12. It includes the same housing 33 with a plurality of outlet ports 36, each leading to a separate tube 37, as shown in Fig. 8. The modified regulator includes a sliding valve 41*b* and a timing sleeve 42*a* analogous to valve 41 and sleeve 42, respectively, but differs from the regulator shown in Fig. 3 by reason of the fact that it contains no separate metering sleeve corresponding to sleeve 38 shown in Fig. 8.

The housing 33 is supported at one end by a standard 120 which has the form of a thick plate provided with a transverse circular opening 121. Projecting through said opening is one end of said timing sleeve 42*a*, the sleeve terminating with a flange 122. The flange includes, at its lower end, a roller 123 fitting into a groove 55 in the barrel cam 51. The cylindrical valve 41*b*, which is disposed slidingly within said timing sleeve 42*a*, projects outwardly beyond said flange 122 and is provided with its own flange 124. A roller 125, carried by said flange 124, extends into groove 53 in said barrel cam 51. Attention is invited to the fact that the wall of said valve 41*b* contains a horizontal groove, as shown at 126, and that a key 127, which is integrally part of the flange 122, enters into said groove. This serves to prevent a rotary movement of the valve about its axis with reference to the timing sleeve 42*a*. The timing sleeve is similarly provided with a horizontally-extending groove 128 to which I shall presently refer.

A part of the standard 120 is cut out to leave a rectangular space defined, from below, by a horizontal ledge 129, at the top by an arm 130 disposed parallel to the ledge in a spaced relation thereto, and by a vertical wall 131 extending from the ledge to the arm. The wall is provided with a vertical groove 132.

The arm 130 contains a vertical bore 133 for reception of a shaft 134, the lower end of which fits into a bearing 135 in said ledge 129. The shaft includes a threaded portion 136. Mounted on that portion, for rotation thereabout, is a collar 137. The collar, which is provided with an annular groove 137*a*, is equipped with a radial arm 138, the outer end of which is connected to rod 66. The rod is the same as that shown in Fig. 3 and leads to the diaphragm 61 already described in the course of this specification.

Extending radially from said collar 137, and engaged with the groove 128 by means of a roller 139, is a member 151 which at the opposite end has an arcuate jaw for a sliding contact with the surface of said collar within said groove 137*a*.

As it is important that the member 151 be prevented from rotation with said collar, said member includes a spur 152 projecting into the vertical groove 132. Secured to the upper end of the shaft 134 is a radial arm 79 which is identical with that shown in Fig. 1 and which, by means of a rod 84 and auxilary means, is connected to the accelerator pedal of the automobile vehicle in which the engine is equipped with the above-said regulator.

It will be understood that the valve 41*b* and the timing sleeve 42*a* are each reciprocated by the barrel cam 51, as described with reference to the regulator shown in Figs. 3 and 8, and that an orifice 43 in the valve 41*b* may be opened through an orifice 45 in the timing sleeve into an outlet port 36 in the housing 33.

As the quantity of fuel to be forced out into said port may have to be varied according to the required load upon the engine, the quantity may be decreased or increased by a limited rotation of the timing sleeve 42*a* about its axis. In order to describe the metering function of the timing sleeve, it will be first assumed that an orifice 43 in the valve is in full register with an outlet port 36. It will be also assumed that one orifice 45 in the timing sleeve 42*a* has been brought, in the course of its operation, opposite said orifice 43 in the valve 41*b*, as shown in Fig. 13. Since the housing 33 is stationary and the valve cannot be rotated about its axis, and since the timing sleeve is capable of being rotated about its axis, it is possible, by a limited rotary movement of the timing sleeve, to have all three openings, that is, orifices 43 and 45 and the port 36, in full axial alinement, or to have the timing sleeve turned so that its orifice 45 will be only partly open into both the port 36 and the orifice 43. This would leave but a limited passageway for release of fuel from the sliding valve. This is shown in Fig. 13 where the orifice 45 is only partly in register with said port 36 and with the orifice 43 in the valve 41*b*.

The limited rotation of the timing sleeve may be effected either by said rod 66 actuated by the diaphragm 61 or by said radial arm 79 which, by intermediate means, may be actuated by the accelerator pedal.

In the first case, as the rod 66 is actuated by the diaphragm 61, the rod imparts a limited rotary movement to the collar 37, and as the latter is mounted upon a threaded portion of the shaft 134, the collar will be elevated by said rotation or lowered, depending upon the direction of the movement of said rod 66. As the collar acts upon the sleeve 42*a* by means of the member 151, the rise of the collar will turn the sleeve in one direction, while the lowering of the collar will turn the sleeve in the opposite direction.

The same variation in the vertical position of the sleeve may be effected by rotation of the shaft 134. This may be effected by said arm 79 extending radially from the top of the shaft, which arm, as described above, is connected, by intermediate means, to the accelerator.

In general, the regulator shown in Fig. 12 acts in the same manner as the regulator shown in Figs. 3 and 8, with this difference: That the sleeve 42*a* serves the double purpose of functioning as a timing sleeve and as a metering sleeve.

It will be understood that some changes may be made in the structure of the mechanical means shown by me without departing from the inventive concept disclosed herein.

What I, therefore, wish to claim is as follows:

1. In a piston-type internal combustion engine including a riser associated with each cylinder of the engine for admission of air thereinto, a fuel-injection system comprising a stationary oblong casing having a cylindrical bore therein and a plurality of spaced outlet ports leading outwardly from said bore, a cylindrical hollow valve axially disposed in the bore of the casing for a sliding movement therein, a sleeve in a telescopic relation with the valve, both the valve and the sleeve being provided with orifices in their respective walls, engine-driven means to reciprocate longitudinally said valve and said sleeve to bring the orifices of the valve and the sleeve in register with single ports, one at a time, in a predetermined sequence, pipe means leading from the ports to the risers, nozzle means at the end of the pipe means opening into the risers, one port being connected to one riser, and engine-driven pump means to deliver fuel under pressure into the cylindrical valve.

2. In a piston-type internal combustion engine including a riser associated with each cylinder of the engine for admission of air thereinto, a fuel-injection system comprising a stationary oblong casing having a cylindrical bore therein and a plurality of spaced outlet ports leading outwardly from said bore, a cylindrical hollow valve axially disposed in the bore of the casing for a sliding movement therein, a sleeve in a telescopic relation with the valve, both the valve and the sleeve being provided with orifices in their respective walls, engine-driven means to reciprocate longitudinally said valve and said sleeve to bring the orifices of the valve and the sleeve in register with single ports, one at a time, in a predetermined sequence, pipe means leading from the ports to the risers, nozzle means at the end of the pipe means opening into the risers, one port being connected to one riser, means to impart to one of the members in the casing a limited rotary movement about its axis to bring its orifices into or out of full register with the outlet ports, and engine-driven pump means to deliver fuel under pressure into the cylindrical valve.

3. In a piston type internal combustion engine including a plurality of cylinders, an oblong housing provided with a cylindrical bore and with a plurality of spaced outlet ports along its length, a cylindrical timing sleeve axially fitting into the bore of the housing, the timing sleeve being provided, along its length, with orifices spaced from each other, a hollow cylindrical valve fitting axially into the timing sleeve, the valve having an inlet for fuel and having orifices in its wall for registry with the orifices in the timing sleeve, but in a different spacing, means to deliver fuel under pressure to the valve through said inlet, engine-driven means to reciprocate longitudinally the valve within the timing sleeve and to bring the orifices of the valve, one by one, into register with the orifices of the timing sleeve, engine-driven means to longitudinally reciprocate the timing sleeve to bring its orifices, one by one, with each outlet port in the housing to impart a limited rotary movement to the timing sleeve about its axis to bring its orifices selectively into full register or out of full register with the outlet ports, and pipe means leading from the outlet ports towards the cylinders.

4. In a piston type internal combustion engine including a plurality of cylinders, an oblong housing provided with a cylindrical bore and with a plurality of spaced outlet ports along its length, a cylindrical timing sleeve axially fitting into the bore of the housing, the timing sleeve being provided along its length with orifices spaced from each other, a hollow cylindrical valve fitting axially into the timing sleeve, the valve having an inlet for fuel and having orifices in its wall for registry with the orifices in the timing sleeve, but in a different spacing, means to deliver fuel under pressure to the valve through said inlet, engine-driven means to reciprocate longitudinally the valve within the timing sleeve and to bring the orifices of the valve, one by one, into register with the orifices of the timing sleeve, engine-driven means to longitudinally reciprocate the timing sleeve to bring its orifices, one by one, with each outer port in the housing, means responsive to the vacuum pull in the cylinders and operatively connected to the timing sleeve to impart a limited rotary movement thereto about its axis to bring its orifices selectively into full register or out of full register with the outlet ports, and pipe means leading from the outlet ports towards the cylinders of the engine.

5. In an internal combustion engine including a plurality of cylinders, means to deliver fuel to said cylinders, the means including a stationary casing having a cylindrical bore and provided with a plurality of outlet ports in a spaced relation from each other along the length of said housing, an axially-disposed cylindrical valve in said bore, the valve being adapted to receive fuel under pressure from a source of supply and being provided with a plurality of radial orifices in its wall in a spaced relation to each other along the length thereof, a timing sleeve embracing the valve in a telescopic relation thereto, the timing sleeve being likewise provided with orifices in its wall along its length but in a spacing differing from the spacing between the orifices in the cylindrical valve, said tubular valve and said timing sleeve being adapted for relative movement with respect to each other to bring the orifices of one into register with the orifices of the other, engine-driven means to impart a reciprocal longitudinal movement to the valve to bring its orifices consecutively into register with limited number of orifices in the timing sleeve, and engine-driven means to impart a reciprocal longitudinal movement to the timing sleeve to bring its orifices, one at a time, in register, in a predetermined sequence, with single ports in the housing, and pipe means to convey the fuel from said ports to individual cylinders.

6. In a piston type internal combustion engine including a plurality of cylinders, an oblong housing provided with a cylindrical bore and with a plurality of spaced outlet ports along its length, a cylindrical metering sleeve within said bore, the sleeve being adapted to be rotated about its axis and being provided with an aperture opposite each outlet port in the housing, a cylindrical timing sleeve disposed within the metering sleeve and provided with orifices for register with each aperture, one by one, in the metering sleeve, a hollow cylindrical valve having an inlet for fuel and having orifices in its wall in the number of orifices in the timing sleeve for register therewith but in a different spacing, engine-driven pump means to deliver fuel into the hollow valve through the above-named inlet, engine-driven means to reciprocate longitudinally the valve within the timing sleeve and to bring the orifices of the valve into register, one by one, with the orifices in the timing sleeve, engine-driven means to longitudinally reciprocate the timing sleeve to bring its orifices into register, one by one, with each aperture in the metering sleeve, means responsive to the vacuum pull in the cylinders and operatively connected to the metering sleeve to actuate the same, and pipe means leading from the outlet ports in the housing to deliver fuel to the cylinders.

7. In a piston type internal combustion engine including a riser for each cylinder, means to inject fuel into each riser, the means including a stationary cylindrical housing having a number of outlet ports and a single inlet port in its wall, all the ports being spaced from each other along the length of the housing, a metering sleeve in the form of a cylinder within the housing and in contact with the inner surface thereof, the wall of the metering sleeve containing an aperture opposite each of the ports of the housing, a timing sleeve within the metering sleeve and in a sliding contact with the inner surface thereof, the

timing sleeve being provided with an opening in register with the inlet port in the housing and the inlet aperture in the metering sleeve, and being further provided with a number of orifices in its wall in a longitudinal spacing from each other and adapted to be brought, one by one, in sequence into register with each aperture in the metering sleeve, a sliding valve axially disposed in the timing sleeve and in contact with the inner surface thereof, the valve having the form of a cylinder closed at one end and containing an intake port in register, through intermediate means, with the intake port in the housing and containing an outlet orifice for each outlet orifice in the timing sleeve, pump means to deliver fuel, under pressure, to the sliding valve, pipe means leading from each port of the housing to a separate riser, means driven by the engine to impart a reciprocal sliding movement to the valve within the timing sleeve, similar means to impart a reciprocal sliding movement to the timing sleeve for a consecutive register, one by one, of the orifices of the valve with the orifices in the timing sleeve and of the apertures in the timing sleeve consecutively, one by one, with each aperture in the metering sleeve, and means responsive to the vacuum pull in a riser to turn the metering sleeve about its axis to adjust the passageways from the apertures in the metering sleeve to the outlet ports in the housing.

8. In an internal combustion engine including a plu-

rality of cylinders, means to deliver fuel in a jet spray for combustion in individual cylinders, the means including an oblong housing provided with a plurality of outlet ports along its length, a tubular valve axially disposed in said bore and having orifice means in its wall along its length, a sleeve for said valve, the sleeve including orifices adapted to be brought, one by one, into temporary register with single orifices in the valve, engine-driven means to move the sleeve within the bore for consecutive register of its orifices with single outlet ports when said orifices are in register with the orifices in the valve, means to impart a relative rotary movement between the valve and the sleeve to bring the orifices of one into full register or less than full register with the orifices of the other, means to deliver fuel under pressure to the interior of the valve, and pipe means leading from the outlet ports to deliver fuel in a spray for combustion in the respective cylinders.

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