July 23, 1935. P. S. TICE 2,008,998

FUEL DISTRIBUTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 2, 1929 4 Sheets-Sheet 1

Fig. 1.

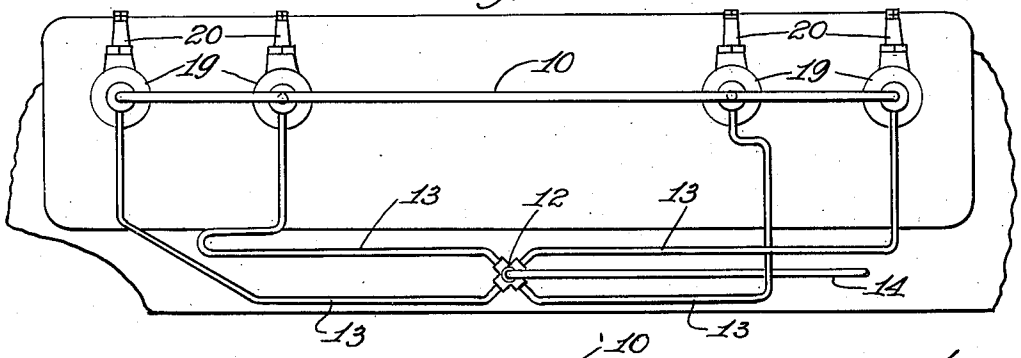


Fig. 2.

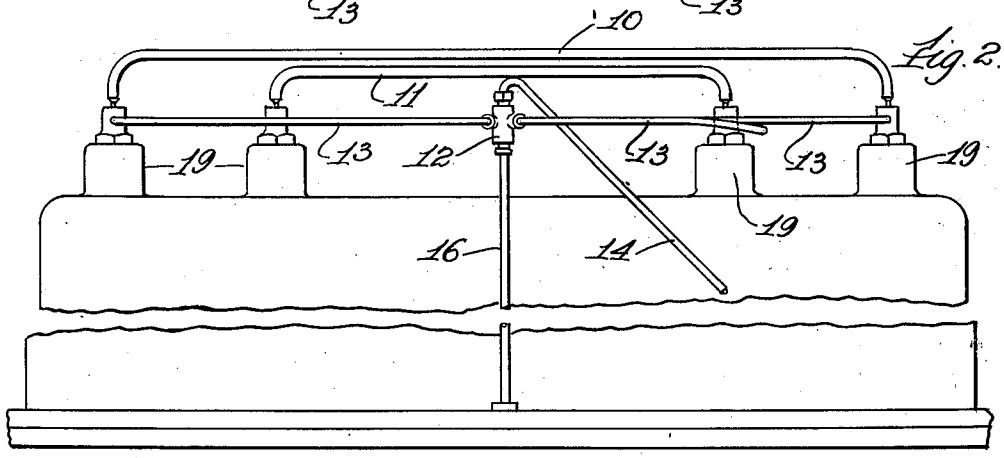


Fig. 3.

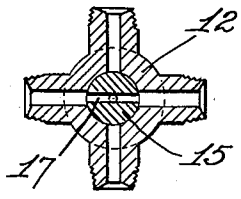


Fig. 5.

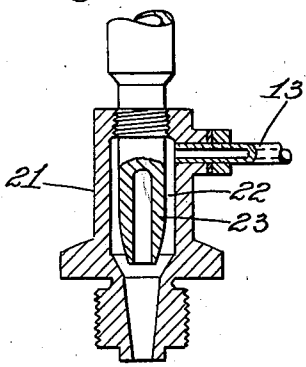
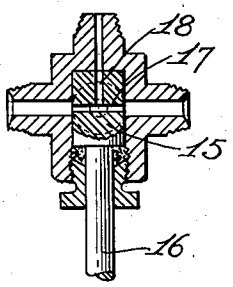


Fig. 4.



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FUEL DISTRIBUTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 2, 1929 4 Sheets-Sheet 2

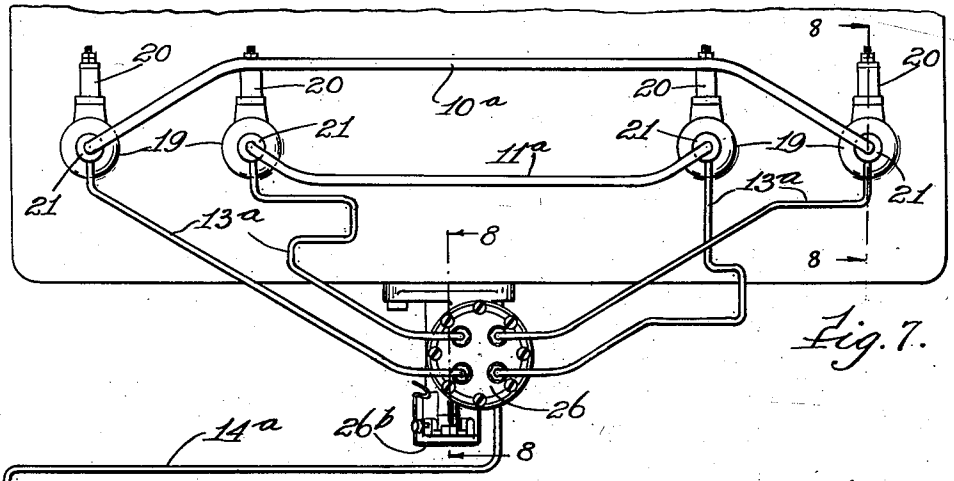

Fig. 7.

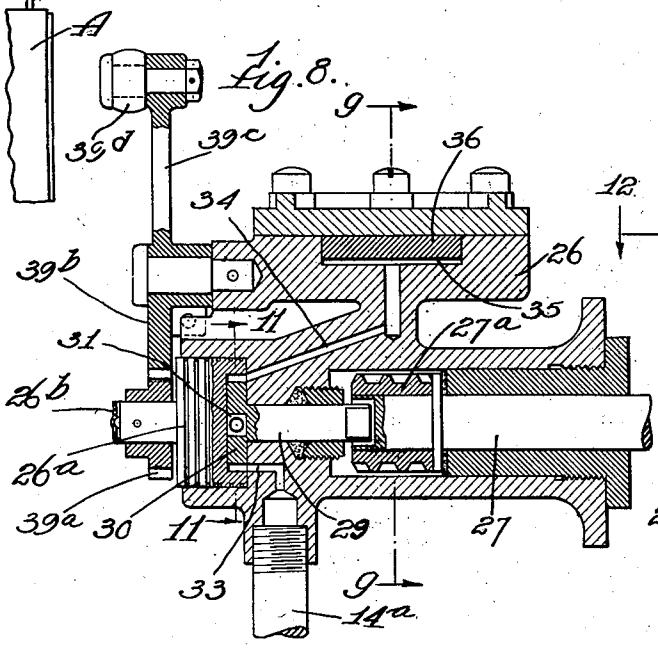

Fig. 8.

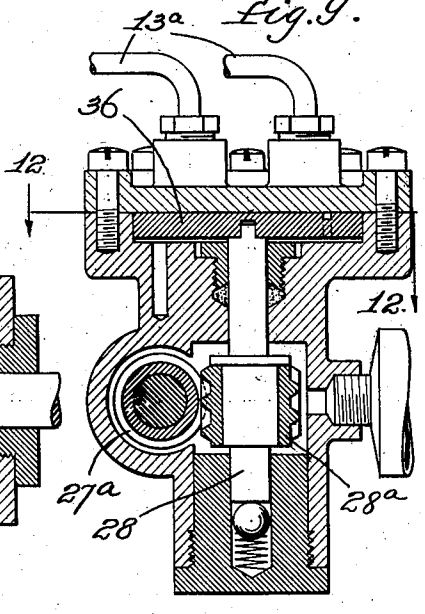

Fig. 9.

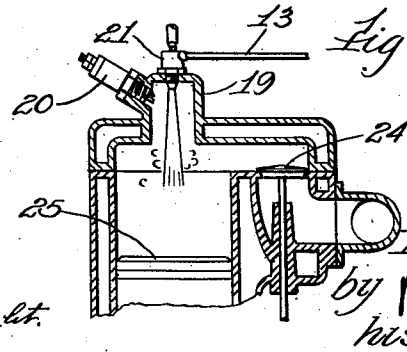

Fig. 6.

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July 23, 1935. P. S. TICE 2,008,998

FUEL DISTRIBUTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 2, 1929 4 Sheets-Sheet 3

Fig 10.

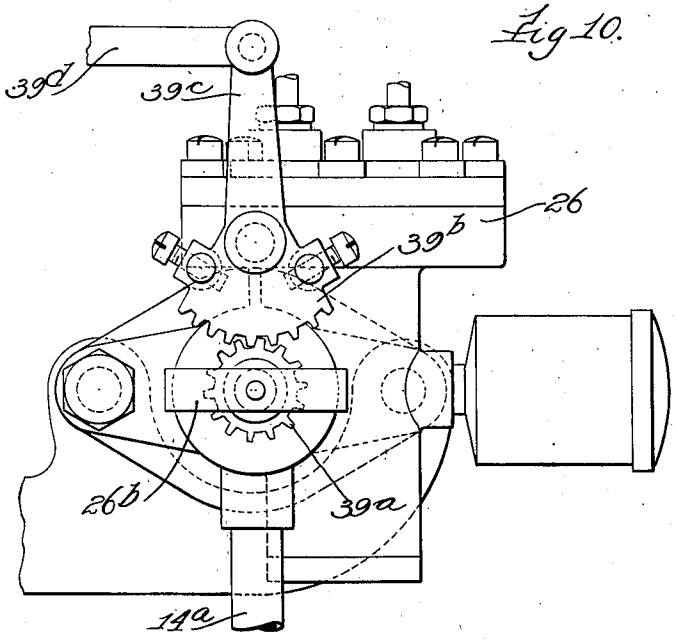


Fig 11.

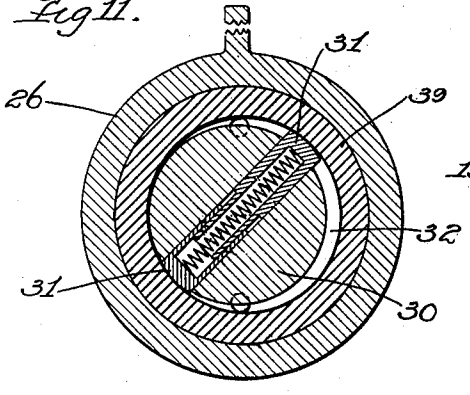


Fig 12.

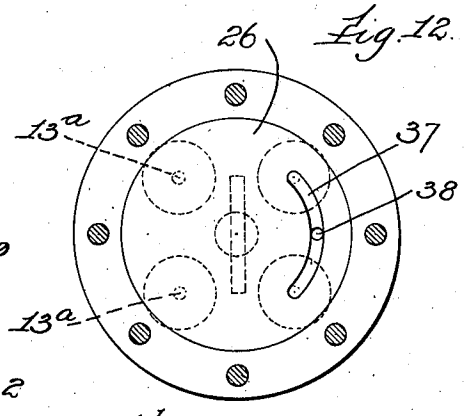


Fig 13.

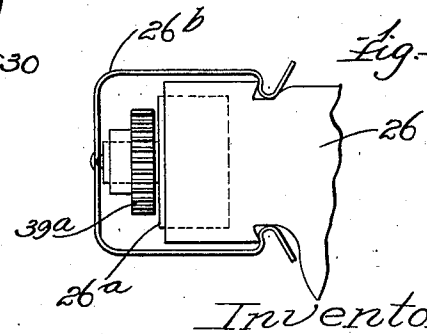
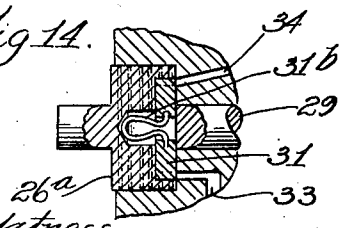


Fig 14.



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July 23, 1935. P. S. TICE 2,008,998

FUEL DISTRIBUTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 2, 1929 4 Sheets-Sheet 4

Fig. 15.

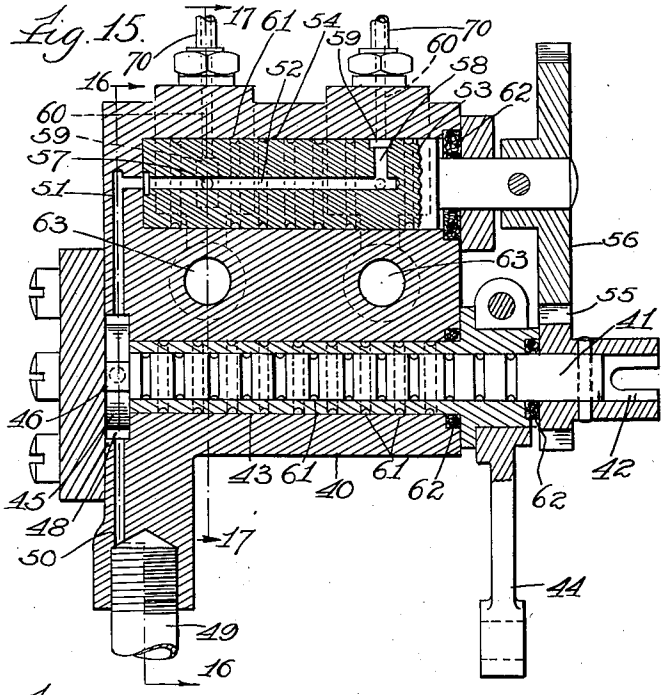


Fig. 16.

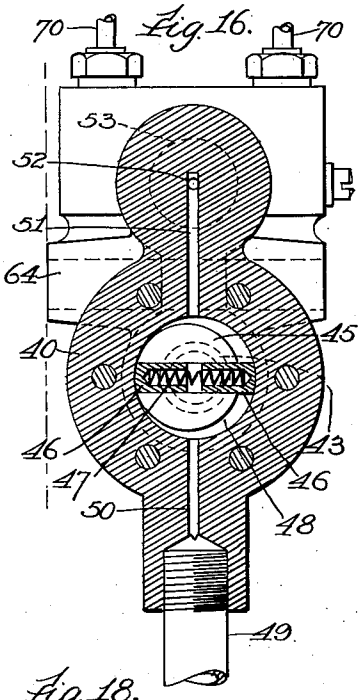


Fig. 19.

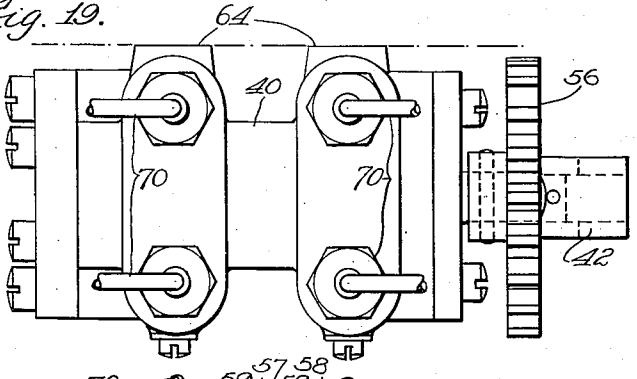
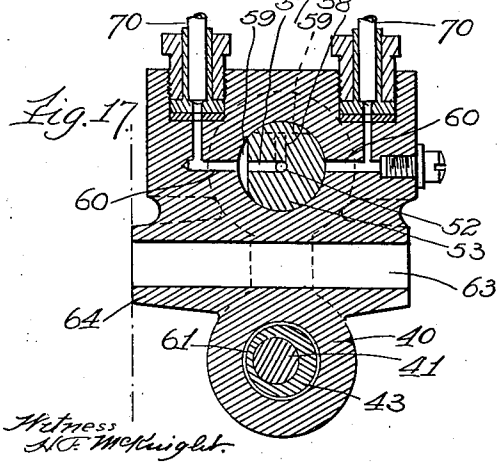


Fig. 17.



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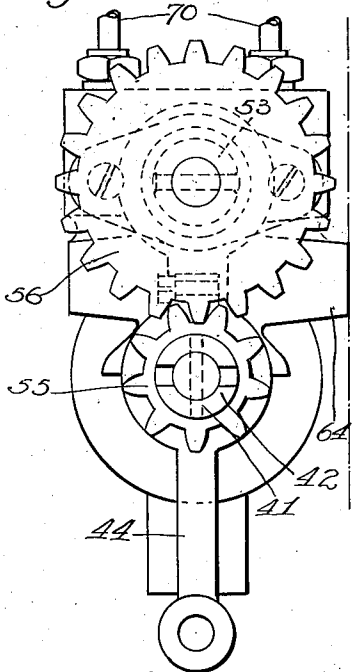
H. C. McKnight.

Fig. 18.



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Patented July 23, 1935 2,008,998

UNITED STATES PATENT OFFICE

2,008,998

FUEL DISTRIBUTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

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Application December 2, 1929, Serial No. 411,186

4 Claims. (Cl. 123—33)

This application is a continuation in part of my application Serial No. 418,543 filed October 21, 1920, relating to a carbureting system for internal combustion engines. The purpose of the invention is to provide an improved method of distributing liquid fuel to the explosion chambers of an internal combustion engine, and also to provide apparatus for operating the engine in accordance with such method. It consists of the scheme of operation, together with certain elements and features of construction hereinafter shown and described in the drawings, as indicated by the claims.

In the drawings:—

Figure 1 is a fragmentary top plan view of an internal combustion engine fitted with apparatus embodying this invention for distributing fuel to the explosion chambers.

Figure 2 is a somewhat fragmentary side elevation of the same.

Figure 3 is a detail plan section of a fuel distributing fitting employed in the combination shown in Figure 1, section being taken as indicated at line, 3—3, on Figure 2.

Figure 4 is a detail vertical section through the distributing fitting, being taken as indicated at line, 4—4, on Figure 1.

Figure 5 is an axial section of a fuel feed nozzle, being taken as indicated at line, 5—5, on Fig. 1.

Figure 6 is a transverse vertical section of the explosion chamber of an engine of the type shown in Figure 1.

Figure 7 is a partial top plan view similar to Figure 1, showing a modified form of fuel distributing device.

Figure 8 is a vertical detail section taken as indicated at line 8—8 on Figure 7.

Figure 9 is a transverse vertical section taken as indicated at line 9—9 on Figure 8.

Figure 10 is a side elevation of the fuel distributing device shown in Figure 7.

Figure 11 is a detail section taken as indicated at line 11—11 on Figure 8.

Figure 12 is a detail section taken as indicated at line 12—12 on Figure 9.

Figure 13 is a detail plan view showing a spring retainer for the pump shaft.

Figure 14 is a detail section showing a modified form of spring for the pump vanes.

Figure 15 is an axial sectional view of another modified form of fuel distributing device including a mechanically driven fuel feeding pump.

Figure 16 is a transverse section taken as indicated at line 16—16 on Figure 15.

Figure 17 is a transverse section taken as indicated at line 17—17 on Figure 15.

Figure 18 is an end elevation of the device shown in Figure 15 showing the geared connection between the pump and distributor.

Figure 19 is a top plan view showing individual delivery pipes leading from the distributor to the several engine cylinders.

In the form of the invention illustrated in my application Serial No. 418,543, the distribution of liquid fuel to the several cylinders of the engine is effected wholly by interconnecting the cylinders in pairs in such a way that the difference in pressures between the respective cylinders will serve to carry the fuel from a branched fitting to the explosion chambers in the proper order. The forms of the invention herein shown and described include a controlling valve in the branched fitting which cuts off communication through the fuel carrying passages between all the cylinders except the two whose relative pressures are thus to be employed at any given portion of the engine cycle, and in some of the forms the fuel feed is rendered more positive by the employment of a pumping device interposed between the source of liquid fuel supply and the distributing fitting.

For purposes of illustration I have employed a four-cylinder engine. As it is commonly designed, the cycle of operation for this type is subdivided into half strokes of the pistons and may be represented in tabulated form as follows:

Cylinder			
No. 1	No. 2	No. 3	No. 4
Working.	Exhaust.	Compression.	Intake.
Exhaust.	Intake.	Working.	Compression.
Intake.	Compression.	Exhaust.	Working.
Compression.	Working.	Intake.	Exhaust.

Thus during the working stroke,—that is, the explosion stroke,—of cylinder No. 1, the valves of cylinder No. 4 are arranged for intake. In other words, when cylinder No. 1 is under its maximum pressure, cylinder No. 4 is subject to suction,—that is, negative pressure. In Figures 1 and 2 I have shown cylinder No. 1 connected to cylinder No. 4 by a pipe, 10, while cylinder No. 2 is connected to cylinder No. 3 by a similar pipe, 11. This permits interchange of cylinder pressures at all times. The fuel distributing fitting, 12, is formed with four branches, each connected to one of the cylinders by a pipe, 13, while at the center of the fitting a feed pipe, 14, leads from

a source of fuel supply, not shown. A rotary valve member, 15, is journaled in the fitting and arranged to be driven by a shaft, 16, leading from any suitable source of motion such as the engine cam shaft, so that the valve shall rotate in phase with the engine cycle. The valve 15, is provided with a single transverse port, 17, arranged diametrically so as to connect the pipes, 13, in pairs while an axial bore, 18, connects the supply passage, 14, with the port, 17.

Each of the cylinders is formed as shown with a small sub-combustion chamber, 19, preferably, though not necessarily, disposed in coaxial relation to the cylinder itself and fitted with a spark plug, 20. The fuel feed pipes and the pipes, 10 and 11, for interchange of pressures are connected into these chambers, 19, by feed nozzle fittings, 21. The small fuel feed pipe, 13, discharges into an annular chamber, 22, which is formed between the inner wall of the fitting and the axially disposed terminal, 23, of the gas pressure pipe. The flow of gas caused by the interchange of pressures between the cylinders thus entrains the fuel discharge from the pipe, 13, so that it is spread somewhat forcibly into the sub-combustion chamber, 19, so as to mix readily with the air in the chamber upon its arrival. The somewhat rich mixture thus formed is ignited by the spark plug and as additional air is furnished in the main explosion chamber of the cylinder the combustion attains explosive force.

Figure 6 indicates a typical formation of the explosion chamber employing this system of fuel distribution, and shows the usual inlet valve, 24, and piston, 25. It will be understood that the inlet valve, 24, will be employed to admit only air to the cylinder, though operating with substantially the same timing as in present constructions in which such a valve admits the entire explosive charge.

The foregoing tabulation of the engine cycle indicates that during the working stroke of cylinder No. 4 the intake stroke of cylinder No. 1 occurs while cylinders No. 2 and No. 3 are similarly related in that the working stroke of each occurs during the intake stroke of the other. During the working stroke of cylinder No. 1, cylinder No. 2 is exhausting and cylinder No. 3 is compressing. There is much less difference of pressure, therefore, between cylinders No. 2 and No. 3 than between cylinders No. 1 and No. 4. It will be noted that the fuel feed pipes, 13, are so connected into the distributing fitting, 12, that the pipes from cylinder No. 1 and No. 4 are diametrically disposed with respect to each other, as are the pipes from cylinders No. 2 and No. 3. Thus the transverse port, 17, provides communication between cylinders No. 1 and No. 4, or between cylinders No. 2 and No. 3, and the rotation of the valve, 15, by its shaft, 16, may be so timed that these connections are effected in suitable relation to the pressure conditions in the respective cylinders, thus placing each cylinder in communication with the fuel supply at the instant when the pressure condition in the cylinder is such as to move the fuel into it.

It may be understood that the air admitted through the inlet valves, 24, during the intake stroke of each cylinder may, if desired, be drawn through an air cleaner, not shown, but the system does not necessarily contemplate any throttling means upon the air supply. Preferably the cylinders are permitted to secure their maximum possible air charge under all conditions since with the possibility of certain and regular ignition of the fuel charge, this will result in the greatest economy of fuel. The control of the power output of the engine under this system may be accomplished through the regulation of a quantity of liquid fuel admitted into the distributing fitting, 12, either by means of any suitable form of valve, not shown, or by varying the rate of feed of a fuel supply pump, not shown, by which the liquid fuel is carried from the supply receptacle into the feed pipe, 14. A reduction in the fuel supply will reduce the power output and an increase in the supply will increase the output. Steady and dependable firing of the charge in each cylinder throughout the entire range from light to full load is secured by locating the igniting means, such as the spark plug, 20, rather near the point of entry of the liquid fuel so that in the event of admission of only a small quantity of fuel, it will be ignited before it has diffused it far through the air content of the cylinder; otherwise, such diffusion might render the mixture so lean that it would not be inflammable. This is the purpose of the design indicated in Figure 6 in which the spark plug, 20, is disposed in one side of the sub-combustion chamber, 19, while the fuel supply nozzle protrudes through the top of the chamber.

Figures 7 to 14 inclusive illustrate a mechanism designed to be driven by positive connection of the engine which it serves and combining in one assembly a pump for feeding the liquid fuel from a source of supply and a timed distributing valve through which it passes from the pump to the several cylinders, as required by the engine cycle. The cylinders are shown connected in pairs by pipes, 10[a] and 11[a], and individual fuel pipes, 13[a], are shown leading out of the top of the distributing device. Within the cast housing, 26, are journaled a drive shaft, 27, with its spiral gears, 27[a], and a transverse shaft, 28, with its spiral gear, 28[a], meshing with the gear 27[a]. The shaft 27, is aligned with and coupled to the shaft, 29, of a pump rotor, 30, carrying spring-pressed vanes, 31, which sweep through the eccentric chamber, 32, into which the fuel inlet port, 33, leads from the supply pipe 14[a]. The outlet port, 34, communicates with the space, 35, under the distributing valve disk, 36, which is mounted for rotation by the shaft, 28, and has formed in its upper surface an arcuate channel, 37, connected with the space, 35, by a port, 38, and adapted to register successively with the outlets to the feed pipes, 13[a], upon rotation of the valve disk, 36, as will be evident from consideration of Figure 12. The eccentric relation of the chamber, 32, to the vanes, 31, may be varied by rotative adjustment of the bushing, 39, in which it is formed, such adjustment being effected by means of a gear, 39[a], and a segment, 39[b], whose arm, 39[c], is provided with any suitable operating link, such as that shown at 39[d]. A closure plug, 26[a], seals the cavity of the casing, 26, in which the pump rotor, 30, operates, this plug being peripherally grooved for oil packing, and being held in place by a spring yoke, 26[b], as shown in Figure 13.

By this arrangement the fuel from the supply tank, indicated at A, in Figure 7, is drawn through the pipe, 14[a], and passed by the rotary pump, 30, to the space, 35, under the distributing valve disk, 36, which releases the liquid fuel to the pipes, 13[a], in timed relation to the engine cycle. The channel, 37, being of just sufficient length to span the distance between successive outlets to the pipes, 13[a], provides that as soon as the supply

to one cylinder is cut off, the fuel is shunted to another cylinder in the order corresponding to that of the engine cycle. The flow of fuel through the pipes, 13a, is produced partly by the pressure of the pump, 30, supplemented by the suction in the cylinder itself, and by the pressure supply from one of the other cylinders through the pipe, 13a or 11a, producing an entrainment effect in the nozzle fitting, 21. It will be understood that the casing, 26, may be mounted on the side of the engine base, as indicated in Figure 7, so that the shaft, 27, may extend into the crank case of the engine or into the housing which encloses the usual timing shaft, where suitable gear connections may be provided for operating the pump whenever the engine is in motion.

Figures 15 to 19 illustrate a slightly different mechanism, which also includes in one assembly a pump for feeding the liquid fuel from a source of supply and a timed distributing valve through which the fuel passes to the several cylinders, as required by the engine cycle. The device comprises the casing, 40, in which there is journaled a shaft, 41, having a coupling member, 42, secured at one end for engaging any suitable drive connection, as for example, a flexible shaft driven from the crank shaft of the engine. An eccentrically bored bushing, 43, serves as a journal bearing for the shaft, 41, and is itself rotatably mounted in the casing, 40, and is provided with a lever arm, 44, for rotatively adjusting it.

The inner end of the shaft, 41, carries a flange or head, 45, in whose diametral slot are carried a pair of pumping vanes or blades, 46, yieldingly pressed apart by a spring, 47, pocketed in them. Rotation of the shaft, 41, causes these vanes, 46, to traverse a circular pump chamber, 48, formed in the casing, 40, with some eccentricity with respect to the bore which carries the bushing, 43. It will be evident that by suitable adjustment of said bushing in the casing the eccentricity of the bore of the bushing will be added to that of the chamber, 48, thus giving the shaft, 41, and its head, 45, a markedly eccentric position. From a fuel supply tank (not shown), a pipe, 49, connects with the inlet duct, 50, leading to the chamber, 48, and from the opposite side of the chamber an outlet duct, 51, leads to the axial bore, 52, of the distributing valve, 53. Thus as the shaft, 41, is rotated, the pump blades, 46, sweeping through the crescent-shaped part of the chamber, 48, defined by its wall and the head, 45, of the shaft, will transfer the liquid entering through the duct, 50, to the outlet duct, 51, for distribution to the engine cylinders.

As shown in Figure 16 the bushing, 43, is adjusted to give the shaft, 41, its maximum eccentricity but by rotative adjustment of said bushing, 43, this eccentricity may be decreased at will and as a result the pumping capacity of the device will be diminished without altering the speed of rotation of the shaft, 41.

The timing valve, 53, is simply a cylindrical member fitted to run in a cylindrical bore, 54, in the casing, 40, and connected with the shaft, 41, by a pinion, 55, and gear, 56, proportioned to drive the valve, 53, at half the speed of the shaft, 41. Leading radially from the bore, 52, are two ducts, 57 and 58, respectively, disposed at right angles to each other and each opening into a groove or notch, 59, formed in the cylindrical surface of the valve member, 53. As the valve, 53, rotates, each notch, 59, registers first with an outlet duct, 60, at one side of the valve axis and then with another such outlet, 60, at the opposite side of said axis. Each of said outlets, 60, leads to a pipe, 70, connected to one of the engine cylinders and corresponding in function to the pipes shown at 13 in Figure 2. With the design shown it will be seen that each of the notches, 59, will register with the same duct, 60, once for each revolution of the distributing valve, 53, and once for every two revolutions of the pump shaft, 41, so that if said shaft is driven at the speed of the engine crank shaft the fuel will be furnished to each cylinder at the proper intervals for "four cycle" operation. By cutting the notch or groove, 59, to such a depth that it extends over substantially 90 degrees of the cylindrical valve surface, communication will be maintained between the fuel supply pump and the engine cylinder through practically the entire intake stroke of the piston; but the quantity of fuel transferred to the cylinder in this period may be varied through wide limits by altering the eccentricity of the pumping element in the chamber, 48, as above described, thus varying the effective cross-section of the pump chamber and limiting the quantity of liquid moved by each revolution.

It may be understood that preferably the mechanism shown in Figures 15 to 19 will be used in connection with an arrangement similar to that shown in Figures 1 and 2, the casing, 40, replacing the fitting, 12, and the pipes, 70, replacing the pipes, 13. With such arrangement the fuel delivered through the pipes, 70, will be atomized by the interchange of gases between the cylinders of each pair which are connected together by pipes such as those shown at 10 and 11. With a pump of variable capacity no by-pass connection such as shown in Figure 1 of my Patent No. 1,737,813 will be necessary, since the quantity of liquid fuel delivered may be limited to the requirements by adjusting the eccentricity of the pump rotor as above described.

For lubricating the moving parts the drawings show grooves, 61, formed in the cylindrical surfaces of the shaft, 41, the bushing, 43, and the valve member, 53. These cylindrical surfaces are made relatively long in proportion to the normal strain or wear upon them so that if when the device is assembled, these grooves, 61, are packed with the lubricant the parts should run for a long time without requiring further attention. At the driving end the bearing surface may be sealed by means of packing washers, 62, to insure retention of the lubricant originally provided. For mounting the device at any convenient position on the engine, the body casing, 40, is formed with two bolt-receiving apertures, 63, both located between the pump shaft and timing valve and within elongated bosses, 64, extending at one side beyond all other surfaces of the body, 40, to insure bearing against the supporting element at these points.

I claim:—

1. In combination with an internal combustion engine having a plurality of cylinders, passages connecting in pairs those cylinders whose working and suction strokes are respectively coincident, to permit interchange of gas between the cylinders of each pair at all times in response to their relative pressures; pumping means connected with a supply of liquid fuel and individual feed passages communicating with said connecting passages and leading to the several cylinders for delivering the liquid fuel thereto under pressure, together with a timing valve geared to operate in phase with the engine and constructed to connect successively the fuel supply with the

feed passage to each cylinder substantially only during the suction stroke of the latter.

2. In the combination defined in claim 1, said timing valve being constructed to connect the fuel supply successively with the individual feed passages during the suction strokes of the respective cylinders to which they lead.

3. In combination with an internal combustion engine having a plurality of cylinders, passages connecting in pairs at all times those cylinders whose working and suction strokes are respectively coincident, to permit interchange of gas between the cylinders of each pair in response to their relative pressures, a source of supply of liquid fuel and individual feed passages communicating with said connecting passages and leading to the several cylinders for delivering the liquid fuel thereto, together with a timing valve geared to operate in phase with the engine and constructed to connect successively the fuel supply with the feed passage to each cylinder substantially only during the suction stroke of the latter and when the fuel supply is subjected to the gas from the other cylinder to which it is connected during its working stroke.

4. In combination with an internal combustion engine having a plurality of cylinders, passages connecting in pairs those cylinders whose working and suction strokes are respectively coincident, to permit interchange of gas between the cylinders of each pair at all times in response to their relative pressures, variably adjustable pumping means connected with a supply of liquid fuel and individual feed passages communicating with said connecting passages and leading to the several cylinders for delivering the liquid fuel thereto under pressure, in an amount adjusted to the variable characteristics of the interchanged gas, together with a timing valve geared to operate in phase with the engine and constructed to connect successively the fuel supply with the feed passage to each cylinder substantially only during the suction stroke of the latter.

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