May 4, 1926. 1,583,669

G. K. DAVOL

INTERNAL COMBUSTION ENGINE

Filed August 5, 1921 2 Sheets-Sheet 1

Fig. 1.

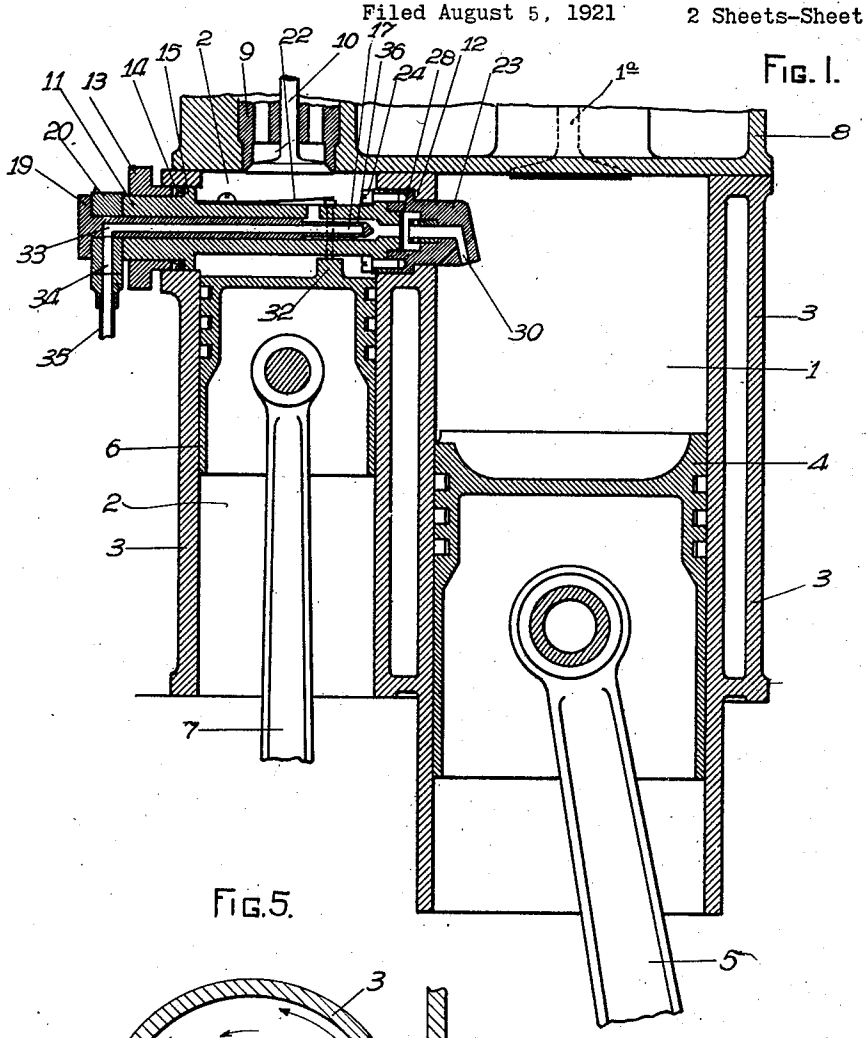
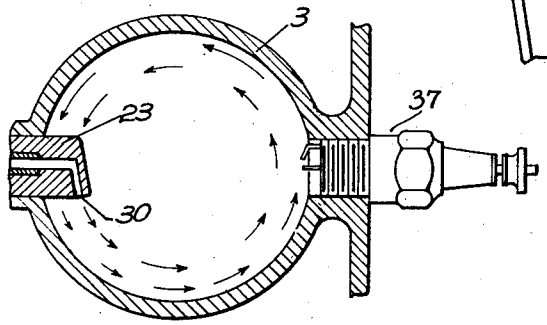


Fig. 5.



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Filed August 5, 1921 2 Sheets-Sheet 2

FIG. 2.

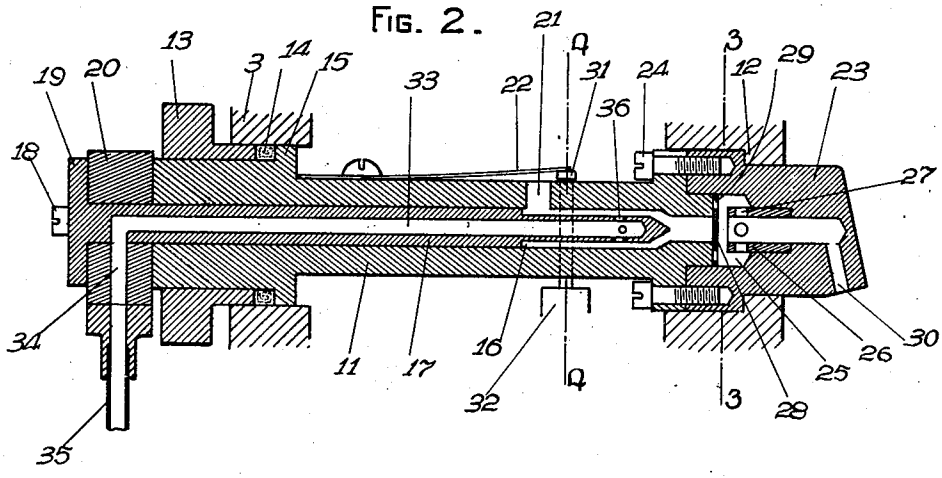


FIG. 3.

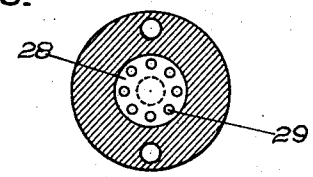
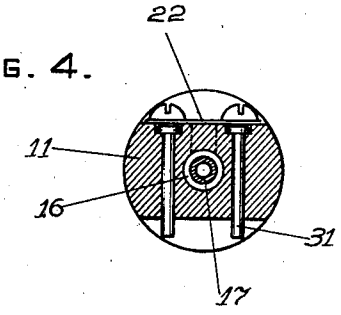


FIG. 4.



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UNITED STATES PATENT OFFICE.

GEORGE K. DAVOL, OF SAN FRANCISCO, CALIFORNIA, ASSIGNOR TO CHARLES A. BROWN, OF HINSDALE, ILLINOIS.

INTERNAL-COMBUSTION ENGINE.

Application filed August 5, 1921. Serial No. 489,980.

To all whom it may concern:

Be it known that I, GEORGE K. DAVOL, a citizen of the United States, residing at San Francisco, in the county of San Francisco and State of California, have invented a certain new and useful Improvement in Internal-Combustion Engines, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention has to do with engines of the fuel injection type. In my co-pending application, Serial No. 490,218, filed Aug. 6, 1921, I have illustrated and described an engine of this type. The present disclosure is directed primarily to a combined and simplified valve holding body and injector.

One of the objects of my invention is the production of an engine, free from the complication of mechanism commonly found in engines of this type.

My invention is applicable to engines operating on either the four-stroke cycle or on the two-stroke cycle, and has particularly to do with engines in which a separate air compressing cylinder for compressing the injection air is supplied for each working cylinder.

In the accompanying drawings:

Figure 1 is a sectional view of a working and a compressing cylinder;

Figure 2 is a sectional view of the fuel atomizing and injecting valve taken through its axial center.

Figures 3 and 4 are cross sections of the fuel atomizing and injecting valve taken on lines 3—3 and 4—4 of Figure 2 respectively.

Figure 5 is a detail section of a modified arrangement, obtainable by a simple readjustment of the parts shown in Fig. 1.

In the embodiment of my invention selected for illustration, two cylinders, a working cylinder 1 and a compressing cylinder 2, are formed in the cylinder casting 3 and are placed close together. The inlet valve 1^a opens, in this instance, directly into the atmosphere, although it could obviously control communication with the usual inlet manifold. The working cylinder has a piston 4 connected to the usual crank shaft by the connecting rod 5. The compressing cylinder is provided with a piston 6 which is connected by the rod 7 to any suitable means of operation, such as a crank on the cam shaft of the engine, if the engine operates on the four-stroke cycle, as in my co-pending application herein above referred to. If the invention be applied to an engine operating on the two-stroke cycle, the compressing piston has the same frequency of reciprocation as the working piston, and it may be operated directly from the main crank shaft. With the means of operating the compressing piston, my invention is not essentially concerned.

Above the cylinder casting 1, a cylinder head 8 is suitably secured, closing the ends of both working and compressing cylinders. An inlet valve 10 is carried in the cage 9 suitably secured in place in the head 8. This inlet valve 10 opens into the atmosphere, although obviously it may be suitably connected to the air supply passages or manifold from which the main piston 4 draws its supply.

The walls of the compressing cylinder 2 are pierced on opposite sides by bored holes having the same axis. On one side, a shouldered hole of two diameters is formed between the compressing cylinder and the adjacent working cylinder, and directly opposite on the same axis a hole is formed in the external wall of the compressing cylinder. Through these holes a delivery valve holding body 11 with a cap 23 passes, the cap abutting against and making a tight joint with the shoulder 12 formed between the two cylinders. The body 11 is held in place and the large hole opening through the external wall of the compressing cylinder is sealed against leakage by the action of the gland 13 forced inward by suitable means, and forcing the packing 14 against flange 15 formed on the body 11. It will be seen that the delivery valve holding body 11 together with cap 23, passes completely through the clearance space of the cylinder 2 with the cap extending into the clearance space of the working cylinder 1 and the outer end projecting external to both cylinder; and that both holes in the walls of the compressing cylinder are sealed against leakage.

Referring particularly to Fig. 2, the valve holding body 11 has an axial hole 16 and a fuel nozzle 17 is fitted within this hole. This fuel nozzle 17 is held in place by two screws, the head of one of which is shown at 18 in Fig. 2. These two screws pass through the flange 19 of the fuel nozzle and

also through the connecting pipe 20 and into the body 11 where they take hold. Connecting with the axial hole 16 is an air port 21. This port is provided with a flexible flat valve 22 secured by screws at one end to the body 11. This valve when seated covers and closes the port 21 against entry of air from the cylinder 2. The inner end of the valve body 11 enters the recessed cap 23 to which it is secured by screws 24. This cap 23 extends into the working cylinder.

A space or recess 25 is formed in the cap 23 and a tubular valve stop 26 projects into this recess. The valve stop has an axial passage and also small radial holes 27 formed in it. The inner end of the body 11 projects into the recess 25 to form a flat valve seat on which check valve 28 seats, said valve being free to move between this seat and the tubular stop 26. This check valve has a number of small holes 29 near its edge, and permits a flow of gas toward the working cylinder, but prevents flow in the opposite direction. The axial hole in the tubular valve stop 26 continues through the cap 23 and connects with the smaller hole 30, which, as shown in Figure 1, is directed down towards the top of the piston 4.

Passing through the body 11 beneath the valve 22 are two holes within which are loosely held two plungers 31, having enlarged upper ends or heads, as clearly shown in Figure 4. In the position of the parts shown in Figure 4, with the valve 22 on its seat, the plungers are dropped down free from contact with the valve with their lower ends extending beneath the body 11. If these plungers be raised from below, their heads will come in contact with the seating face of the valve 22 and raise it off its seat to uncover or open the ports 21, which is the position of the parts shown in Figures 1 and 2. The compressing piston 6 has a projection 32 on its upper face, and its movement is so adjusted that near the upper end of its stroke, the projection 32 comes in contact with the lower end of the plungers 31, pushing them upward and lifting valve 22 off its seat.

The fuel nozzle 17 has an axial passage 33 within it, which passage communicates with the passage 34 in the connector 20, by means of which connection is made with the fuel pipe 35. The reduced inner end of the fuel nozzle has small radial holes or orifices 36 opening from its axial passage 33 into the annular space surrounding it. If fuel be forced by suitable means through the fuel pipe 35, it will pass through the passages just described and be deposited in the annular space surrounding the inner end of the fuel nozzle.

On the upward or compressing stroke of the piston 6, the air previously drawn through the valve 10 and entrapped within the cylinder 2 is compressed. Near the top or end of the stroke of the piston, the projection 32 comes in contact with plungers 31 and the valve 22 is raised off its seat, uncovering port 21. The air compressed within the cylinder 2 then rushes through the port 21 and passage 16, picking up the fuel previously deposited there, which fuel is carried with the air through the passage 16, holes 29 in the valve 28, holes 27, and finally through the passage 30 into the working cylinder 1, where with the direction given to the final passageway or orifice 30, shown in the drawings, it would impinge on the face of the piston 4. The fuel, in being carried through these broken passages and orifices by the rush of air, is finely atomized.

The cap 23 forming the inner end of the valve holding body 11 and extending into the working cylinder, can be made of any length and form desired within limits. It can for example be lengthened so that it projects to the axial center of the working cylinder, and the final passage or orifice 30 may be pointed directly in line with the cylinder axis, or any number of other modifications of this cap and its orifice 30 may be carried out.

In using the word "cylinder" in this description and the claims which follow I intend to designate the chamber which, together with a piston fitting a portion of it, sustains the pressure of air or gases held, compressed, or expanded within it, whether such chamber be actually of cylindrical form or other form. The portion of the chamber not entered by the piston I therefore refer to as a part of the cylinder or as the clearance space or compression chamber thereof, as the case may be, although its form need not be cylindrical.

Figure 5 shows a modified manner of injecting the mixture of fuel and air into the cylinder to produce a stratification of the cylinder contents, or a degree of separation between the ignitible mixture and an excess of air within the cylinder. As there shown, the final orifice 30 is directed tangentially relative to the cylinder, and the issuing atomized fuel and air creates a whirling vortex, in this instance about the axis of the cylinder. Under such conditions centrifugal action causes a degree of separation or stratification of the cylinder contents, throwing the heavier fuel vapor and unvaporized particles of fuel toward the cylinder wall, while keeping the pure air in the center.

Under certain conditions this stratification of the charge is importantly desirable, as, in an engine operating with electric ignition, it renders possible the drawing of a full, unthrottled, charge of air into the cylinder with the injection for light load of a rela-

tively small quantity of fuel, the fuel forming a relatively small quantity of rich ignitible mixture, which under the centrifugal stratifying action described, is thrown close to the cylinder walls, where a spark plug 37 can be conveniently located for its ignition.

Without further elaboration, the foregoing will so fully explain the gist of my invention, that others may, by applying current knowledge readily adapt the same for use under various conditions of service.

It is, for instance, not essential that the valve 22 be of the construction shown, as any form of valve may be used.

It should also be noted that while as described and shown, the valve carrying body 11 passes directly through the upper end of the compressing cylinder, it could as well be placed at one side and pass through a side pocket or chamber, connected with the main cylinder space by a suitable open passage.

These and many other modifications may obviously be made without eliminating certain features which may be properly said to constitute the essential items of novelty involved in my invention, which items are intended to be defined and secured to me by the following claims.

I claim:

1. In an internal combustion engine, a working cylinder, a cylinder for compressing air to inject fuel, a piston moving in said compressing cylinder, a body passing through the clearance space of said compressing cylinder and extending into the clearance space of said working cylinder, a mechanically operated delivery valve on said body, and means for operating the said delivery valve from movement of said piston.

2. In an internal combustion engine, a working cylinder, a cylinder for compressing air to inject fuel, a piston moving in said compressing cylinder, a fuel atomizing device passing through the clearance space of said compressing cylinder, and extending into the clearance space of said working cylinder, a mechanically operated delivery valve on said device, means for operating said valve from movement of said piston, and means for supplying fuel to said device.

3. In an internal combustion engine, a working cylinder, a cylinder for compressing air to inject fuel, a piston moving in said compressing cylinder, a body passing through the clearance space of said compressing cylinder and having one end freely open to the interior of said working cylinder and its opposite end exterior to both cylinder, a mechanically operated valve on said body, said body having passages within it communicating with said valve, and means for operating said valve by contact with said piston.

4. In an internal combustion engine, a working cylinder, a cylinder for compressing air to inject fuel, a piston moving in said compressing cylinder, a passageway connecting the clearance spaces of said cylinders, a body fitting into and closing said passageway, a mechanically operated valve on said body, means for operating said valve to contact with said piston, and means for supplying fuel to said body.

5. In an internal combustion engine, a working cylinder, a cylinder for compressing air to inject fuel, a piston moving in said compressing cylinder, said compressing cylinder having two openings in its walls, one of said openings connecting with the clearance space of said working cylinder and the other of said openings connecting with the external atmosphere, a fuel atomizing device passing through and closing said openings, a mechanically operated delivery valve on said device, and means for operating said valve from movement of said piston.

6. In an internal combustion engine, a working cylinder, a cylinder and piston for compressing air to inject fuel, said compressing cylinder having two cylindrical holes in its walls, one of said holes opening into said working cylinder and the other opening into atmosphere, a fuel atomizing device having cylindrical portions fitting into and closing said holes, a mechanically operated valve on said device, and means for operating said valve by contact with said piston within said compressing cylinder.

7. In an internal combustion engine, two adjacent cylinders, one of said cylinders having aligned holes in its walls, one of said holes opening into the other cylinder, and an injector passing through both holes.

8. In an internal combustion engine, a cylinder casting, defining two adjacent cylinders, and means defining a passageway entering the clearance space of one cylinder and passing through the clearance space of the other, and a fuel injection device filling said passageway.

9. In combination, two adjacent cylinders, a body passing through the clearance space of one cylinder and entering the other, and means in and on said body for mixing fuel with air compressed in one of the cylinders and injecting the mixture into the other cylinder.

In witness whereof, I hereunto subscribe my name this second day of August, 1921.

GEORGE K. DAVOL.