March 24, 1936. H. C. EDWARDS 2,035,264

INTERNAL COMBUSTION ENGINE

Filed Sept. 17, 1932 2 Sheets-Sheet 1

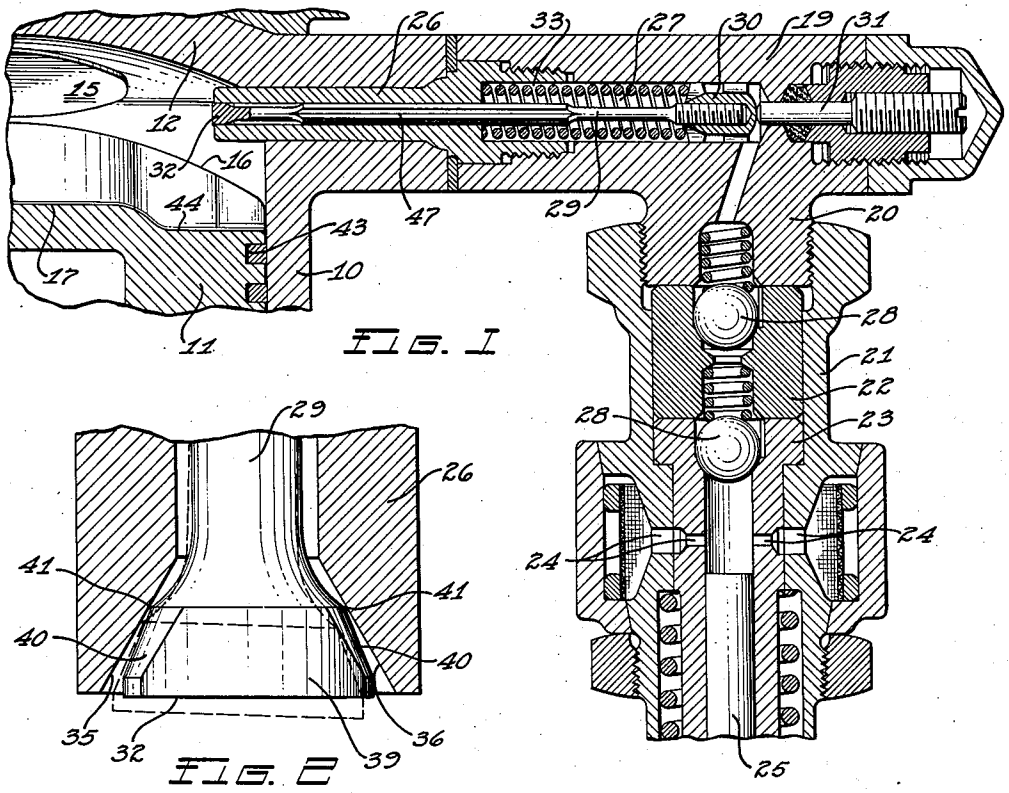


FIG. 1

FIG. 2

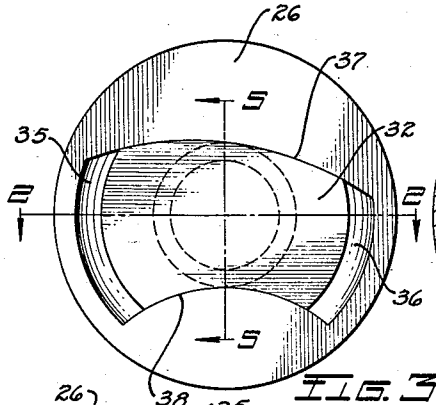


FIG. 3

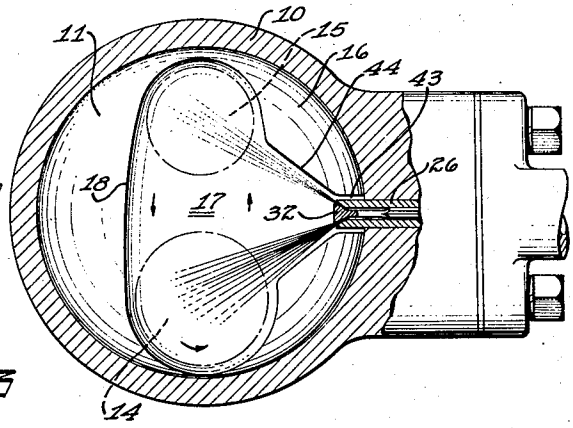


FIG. 4

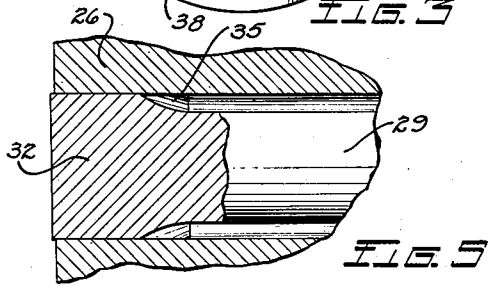


FIG. 5

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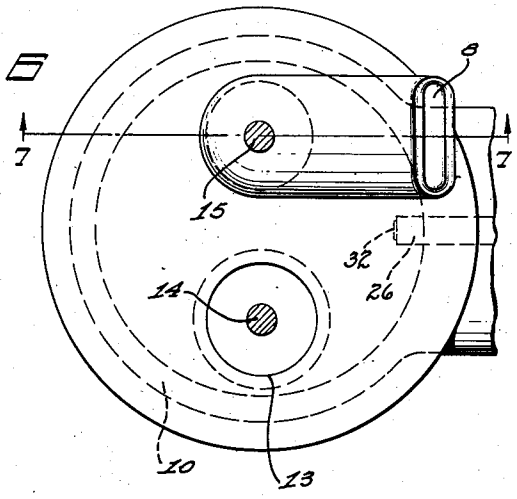
Attorney

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INTERNAL COMBUSTION ENGINE

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FIG. 6



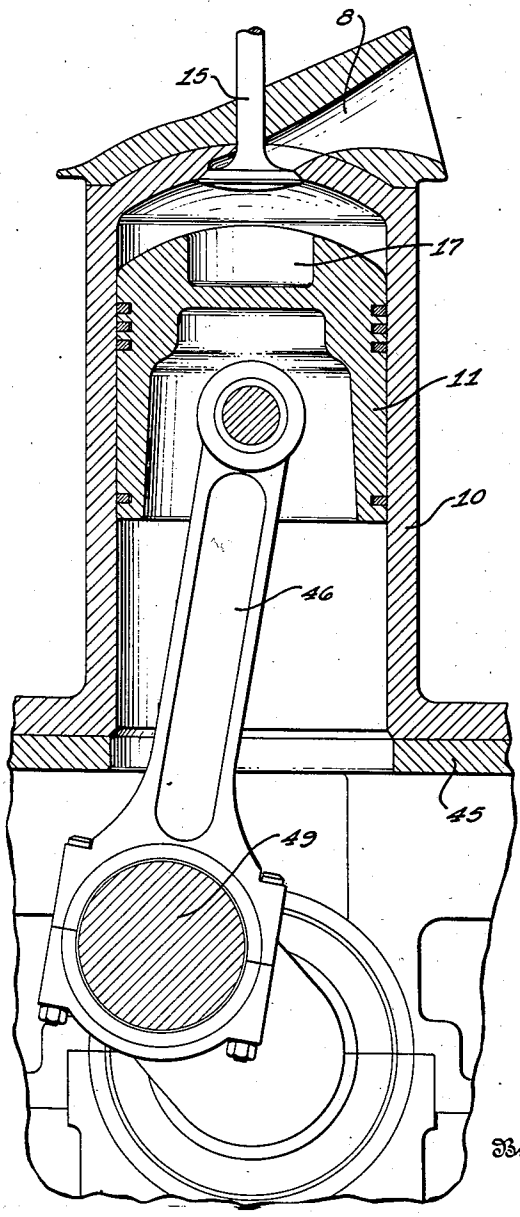


FIG. 7

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Patented Mar. 24, 1936 2,035,264

UNITED STATES PATENT OFFICE

2,035,264

INTERNAL COMBUSTION ENGINE

Herbert C. Edwards, Detroit, Mich., assignor to Packard Motor Car Company, Detroit, Mich., a corporation of Michigan

Application September 17, 1932, Serial No. 633,651

1 Claim. (Cl. 123—32)

This invention relates to internal combustion engines and more particularly to the method of and means for charging an engine with fuel.

In internal combustion engines wherein atomized liquid fuel is injected into rotating compressed air charges in the combustion chambers to form explosion mixtures which will ignite under the heat of compression, the form of the combustion spaces is sometimes of a shape or size such that a single spray of fuel cannot be projected to properly intermingle with the rotating air and, as a consequence, inefficient engine operation results. As an example, chambers in which piston clearance of inlet and outlet valves is allowed for must be of an elongated shape and with a single spray fuel injection, the rotating air will carry the injected spray mainly toward one end of the chamber where it will collect to an extent such that it will not fully ignite and, as a consequence, some of the air is not utilized while some of the collected fuel will carbonize.

An object of this invention is to provide a method of charging an engine, of the character mentioned above, whereby fuel and air are mixed in a manner such that efficient engine operation will result.

Another object of the invention is to inject two sprays of liquid fuel from a single nozzle opening into compressed air rotating in the cylinders so that a greater volume of fuel is directed into the rotating air charge against the current and a smaller volume of fuel is directed into the rotating air charge with the current.

Other objects of the invention will appear from the following description taken in connection with the drawings, which form a part of this specification, and in which:

Fig. 1 is a fragmentary sectional view of a cylinder and a fuel injection device incorporating my invention;

Fig. 2 is an enlarged sectional view of the outlet end portion of the injection device which is substantially ten times the actual size;

Fig. 3 is an elevational view of the outlet end of the injection device shown in Fig. 2;

Fig. 4 is a sectional view through the engine cylinder showing the relation of the combustion chamber and the injection device, the valves being shown diagrammatically;

Fig. 5 is a fragmentary sectional view of the nozzle taken on line 5—5 of Fig. 3;

Fig. 6 is a top plan view of an engine having my invention associated therewith;

Fig. 7 is a sectional view of the engine taken on line 7—7 of Fig. 6;

Referring now to the drawings by characters of reference, 10 indicates an internal combustion engine cylinder in which a piston 11 is arranged to reciprocate. The cylinder head 12 is formed with a pair of ports 8 and 13 to provide for the intake of air and for the expulsion of exhaust gases. An inlet valve 14 closes the inlet port and another valve 15 closes the outlet port, such valves opening inwardly of the cylinder through means of suitable engine operated mechanism (not shown).

In order to reduce the charge containing space to provide the high compression ratio desirable for compression-ignition engines and to allow for valve clearance, I provide the piston face 16 with a depression or pocket 17 which, with the cylinder head, forms the combustion chamber. Such depression must necessarily encompass the space into which the valves extend when open and one wall 18 thereof curves slightly so as to interfere as little as possible with the rotational movement of air. A crank shaft 49 is mounted in the crank case 45, on which the piston 11 is secured, and a rod 46 connects the piston with the crank shaft.

The air inlet port 8 extends through the cylinder head at an angle to the cylinder axis and tangential to the inner wall of the cylinder so that charges of air drawn into the cylinder by the piston when the valve is opened will be directed so that they rotate therein. Such rotation of the air charge continues all during the compression stroke and as the piston approaches top center, the air is contained more and more within the piston pocket. With the construction shown, the piston closely approaches the cylinder at top center position so that the rotating air charges are contained substantially entirely within the piston pocket at the time the fuel charges are introduced into the cylinder, the direction of the air rotation being shown by arrows in Fig. 4.

Liquid fuel charges are sprayed into the cylinder by injection means having an improved form of nozzle construction which will project two angularly disposed streams of different volume, the larger stream being directed into the air charges against the current at one end of the pocket and the smaller stream being directed into the air charges with the current at the other end of the pocket.

A nozzle casing 19 is formed with a neck 20 which screws into a pump casing 21 and engages the bushing 22 in a manner clamping barrel 23 in the pump casing. The barrel and pump casing

are formed with radial ports 24 which are controlled by the reciprocation of the plunger 25. The nozzle casing has an extension 26 screwed thereon which projects through an aperture in the cylinder wall adjacent the cylinder head, and this entire injection device can be fixed rigidly to the cylinder by suitable fastening means. The passage 27 extends axially through the nozzle casing extension and partially through the nozzle casing and communicates with the interior of the barrel, suitable one-way check valves 28 being provided to prevent the return of fuel oil from the nozzle to the pump. The valve member 29 extends through the extension passage and into the nozzle casing passage. On the interior end thereof is screwed a bearing member 30 having an axially slotted peripheral wall which slidably engages with the nozzle casing. Stop member 31 is arranged in the casing to limit movement of the valve bearing in a direction away from the cylinder and is preferably adjusted so that the valve head 32 can never quite seat. Coil spring 33 is arranged in the nozzle casing passage and normally urges the valve member toward closed position and also limits movement thereof in the opposite or opening direction. The nozzle and pump structure so far described forms the subject matter of Patent No. 1,934,296, issued November 7, 1933, to Hermann I. A. Dorner, and reference can be had thereto for a more complete understanding of the device if desired.

A conical spray is projected from a nozzle shown in the application just mentioned due to the valve head and its seat in the outlet passage being conical. For some forms of combustion chambers, this type of spray is satisfactory to efficiently intermingle the atomized liquid fuel with the air charges, but with a combustion chamber of the character herein described, a conical spray is inefficient as fuel would be carried into the end of the chamber adjacent the exhaust valve and collect therein without properly intermingling with the air and, as a result, there would be a quantity of unused air and carbonizing of the fuel oil in the end of the chamber adjacent the exhaust valve would take place.

In order to properly introduce the atomized liquid fuel into air charges in a cylinder having an elongated chamber of the character described, I have provided an improved form of nozzle discharge end whereby two streams of fuel will be projected in a particular manner more fully described hereinafter. The interior wall surface of the outlet end of the nozzle extension is formed with two diametrically disposed conical portions 35 and 36 and with two other diametrically disposed curved surfaces 37 and 38. The surfaces 35 and 36 are formed so that they are segments of a similar cone whereas the curved surfaces 37 and 38 are formed with different radii so that the distance between the curved surfaces is different adjacent the two conical surfaces. These curved surfaces extend axially of the casing extension as segments of cylinders and provide a bearing for the head of the valve and the conical surfaces 35 and 36 provide the passage wall portions past which liquid fuel is projected from the injection device.

The head portion of the valve member is formed with two surfaces 39 which are formed complementary to the surfaces 37 and 38 of the extension casing respectively so that they will have a close sliding fit therewith axially of the nozzle. Joining these two curved surfaces of the valve head are segmental conical surfaces 40, the angle of which is different from the angle of the adjacent conical surfaces of the nozzle extension casing. The valve is reduced in diameter at the inner end of the conical surfaces 40 so that a knife edge portion, as indicated at 41, is formed at the inner termination of said surfaces. Such knife edge portions cooperate with the conical surfaces of the nozzle extension casing to form two arcuate spaces through which fuel passes from the nozzle, the curved surfaces 39 of the valve fitting closely against the curved surfaces 37 and 38 of the casing to prevent escape of oil therebetween. The valve stem portion 47 which extends into the passage in the nozzle extension has a small amount of clearance to permit a small lateral movement thereof and it is grooved axially to allow fuel to flow freely through the extension.

With the form of nozzle outlet just described, it will be observed that the outlet space between the valve head and the surface 36 is of less length circularly than the space between the valve head and the surface 35 so that a more compact spray will issue from the shorter space than will issue from the longer space. When pressure is applied to the fluid in the nozzle, the valve member is moved axially toward the interior of the cylinder and laterally toward the surface 35 as indicated by dotted lines in Fig. 2. This lateral movement takes place because of the impossibility of movement in the other direction due to the decreasing width between the walls 37 and 38 when the fuel pressure builds up against the head. As a result of this lateral movement of the valve, a greater volume of fuel oil will pass from the nozzle extension casing by the surface 36 than will pass by the surface 35. The nozzle is associated with the cylinder so that the surface 35 points toward the end of the piston pocket adjacent the exhaust valve while the surface 36 points toward the end of the piston pocket adjacent the air intake valve and, as a result, a greater volume of oil will be projected into the rotating air charge in the pocket in a direction opposing the air currrent.

The piston head is formed with a depression 43 so that it can telescope the outlet end of the nozzle and its valve, and it is also formed with a pocket portion 44 having angularly disposed walls formed to permit the introduction of the two fuel sprays into the far ends of the piston pocket without interference when the piston is substantially at top center position. This pocket portion 44 forms a continuation and part of the pocket 17.

The engine illustrated is of the four-stroke cycle type and air charges entering the cylinder will rotate during the compression strokes of the piston. As the piston approaches top center, the injection mechanism is actuated to project charges of fuel into the compressed rotating air and ignition occurs, through the heat developed, while the compression stroke is completed. With the nozzle herein described, two angularly disposed sprays are introduced into the compressed rotating air charges, the larger spray penetrating the rotating air charge in a direction opposed to its direction of travel and the smaller spray penetrating the air charge in the same direction in which it is traveling. The larger spray is directed toward the inlet valve and the smaller spray is directed toward the exhaust valve, and therefore the main portion of the fuel charge will be well intermingled with the rotating air charge during its travel from the inlet valve end of the pocket to the exhaust valve end of the pocket. The smaller spray is of such a volume

that there will be no excess fuel directed into the air at the exhaust end of the pocket and that which is injected will thoroughly mix with the rotating air. By this arrangement of sprays, the liquid fuel will become thoroughly intermingled with the air charges and will not be carried by the air current to the end of pocket adjacent the exhaust valve in a volume or condition such that the liquid fuel will collect therein, and thus the intermingling of the fuel charges will be of such a nature that efficient operation of the engine will result.

Although the invention has been described in connection with a specific embodiment, the principles involved are susceptible of numerous other applications which will readily occur to persons skilled in the art. The invention is therefore to be limited only as indicated by the scope of the appended claim.

What I claim is:

The method of charging an internal combustion engine comprising introducing air charges into the engine to form rotating cylindrical masses, compressing the rotating cylindrical air masses into flat elongated form, the ends of which are of different radii, and introducing two streams of atomized liquid fuel from a common point into the elongated air masses in a direction to intersect the end portions thereof, the stream of fuel directed toward the elongated end having the larger radius being of greater volume than the other stream of injected fuel.

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