

April 13, 1954

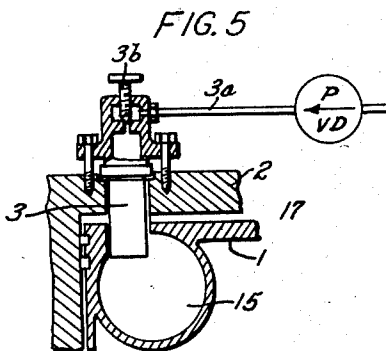
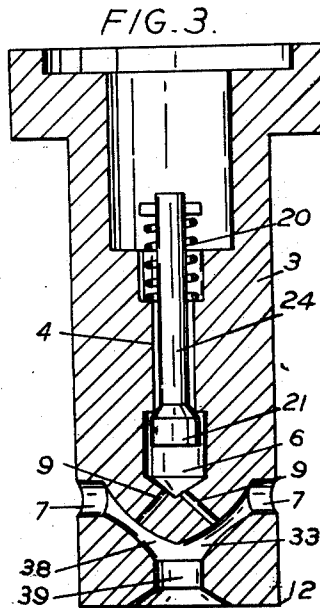
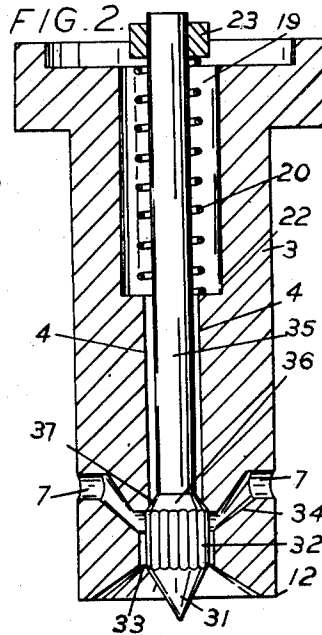
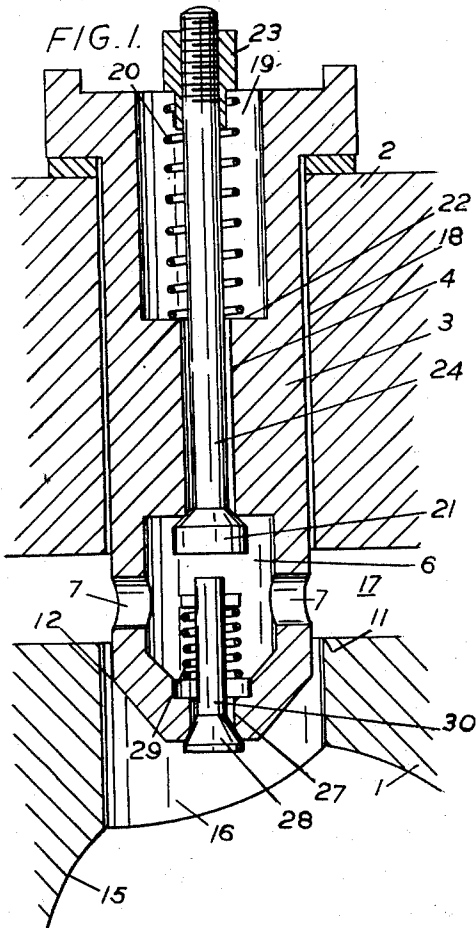
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2,674,984

SUPPLY OF FUEL TO INTERNAL-COMBUSTION ENGINES

Filed June 8, 1950

2 Sheets-Sheet 1



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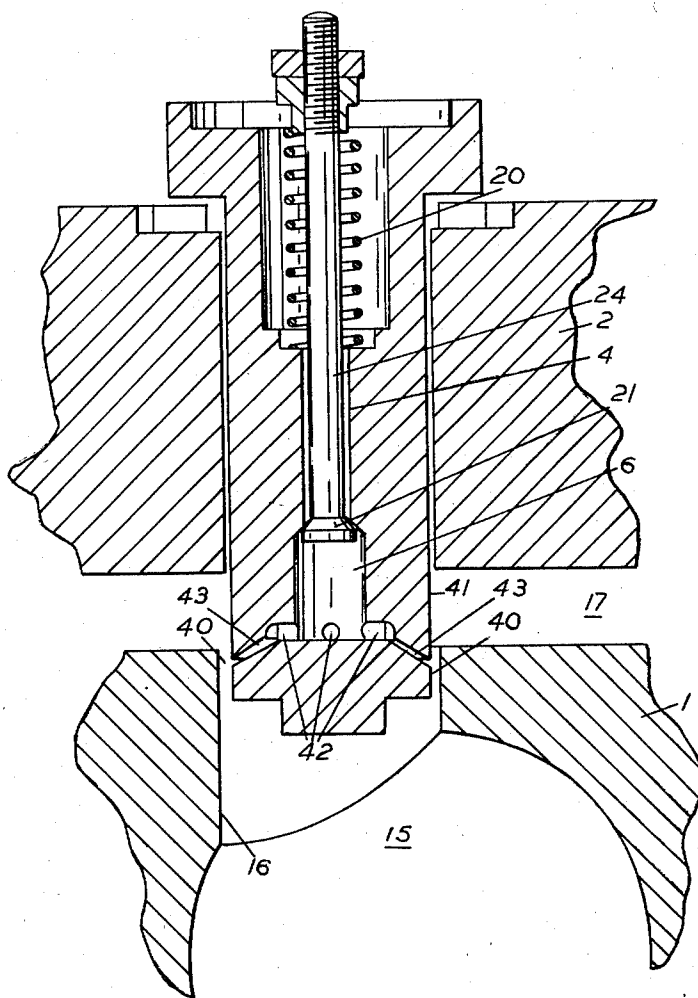
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2 Sheets-Sheet 2

FIG. 4.



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UNITED STATES PATENT OFFICE

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SUPPLY OF FUEL TO INTERNAL-COMBUSTION ENGINES

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1 Claim. (Cl. 123—32)

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This invention relates to compression-ignition internal combustion engines of the kind wherein at least one of the two elements which co-operate to form the combustion chamber, namely the cylinder head and the piston crown, has a recess into which atomised fuel is injected.

Considering the compression, in an engine of this kind, of a charge of air as the piston approaches the cylinder head prior to the injection of fuel, it is convenient to visualise the enclosed space as divided into a number of volumes, which may be termed prismatic volumes, extending parallel to the axis of the cylinder, for example, one such volume having as end surfaces the mouth of said recess and a like transverse area on the opposite element, and one other such volume having as its end surfaces the remainder of the recessed element and the opposite part-surface of the co-operating element. In order to achieve the desired compression ratio, the end surfaces defining said latter volume may be brought very closely together when the piston attains its outer dead centre. It will be appreciated that such end surfaces need not be right transverse planes, but may be oblique and/or curved.

In such a combustion chamber, during the approach of the piston to its outer dead centre, the rate or degree of reduction of volume is not uniform throughout the enclosed space, that is, as between the aforesaid prismatic volumes, which have different axial dimensions; the volume whose end surface includes the said recess has the greater axial dimension, and undergoes a lower rate of reduction than the volume whose end surfaces are constituted by closely approaching surfaces of the piston crown and cylinder head. This difference of rates of volume reduction imparts an internal displacement to the air charge, which is known and will hereinafter be referred to as an air squish effect.

In compression-ignition engines, including those of the kind described, it has hitherto been common practice to inject the fuel into the combustion chamber and to atomise it with the aid of a fuel pump and an atomising injector which apply very high pressure to the fuel.

The present invention has for an object to eliminate the use of high pressure or "jerk" pumps and high pressure injectors which, being usually required to supply and atomise small quantities of fuel at each operation, necessarily comprise small parts that have to be made of very high grade materials and by very accurate machining in order durably to withstand and effectively to operate under the high pressure.

Accordingly, the invention provides, in an engine of the kind described, means for atomising by said air squish effect fuel introduced at a controlled rate with the aid of a metering device.

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More particularly, fuel atomising means in an engine of the kind described may comprise an obturator body disposed within the combustion chamber so as to enter and substantially enclose said recess on the approach of the piston crown element to the cylinder head element, and thereby to divide the combustion chamber into two volumes one of which comprises the recess and is subject to a lower rate of volume reduction than the other volume, at least one passage for air under displacement to said one volume from said other volume, a receiving chamber for fuel in the cylinder head, a feed duct to the receiving chamber, a non-return valve associated with the feed duct and at least one atomising duct extending from the receiving chamber to convey fuel from said chamber to the recess under the air displacement.

The invention may further provide, for mounting in the cylinder head of an engine having a piston with a recess in its crown, an obturator body in which are formed the aforesaid receiving chamber, feed duct, atomising duct and air passage.

Alternatively an obturator body may be integral with or mounted on the piston, and the recess may then be located in the cylinder head.

An obturator body mounted in the cylinder head may have extending through an aperture in its inner end a jet member, the peripheral wall of which has a plurality of grooves or flutes to constitute with the surrounding wall of the aperture a plurality of atomising ducts. Such a jet member may have a stem displaceable axially in the obturator body and incorporating the non-return valve.

The or each passage for air under displacement may extend from the combustion chamber into the fuel receiving chamber for ejecting the fuel in the latter chamber by pressure.

In an alternative arrangement, the or each passage for air under displacement may extend transversely across that end of an atomising bore which is remote from the receiving chamber, for inducing fuel from the latter chamber. Such passage may extend through the obturator body or alternatively may be constituted by annular clearance between the peripheral walls of the obturator body and the recess. The or each of such passages may have a Venturi section, the atomising bore opening into its narrowest portion.

In any of the aforesaid variants of the obturator body, said body may be adjustable axially with respect to the element in which it is secured.

The fuel metering means for controlling the rate of fuel supply to atomising means as aforesaid may consist in a low pressure pump with

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positive displacement and capable of speed variation for controlling the quantity delivered.

Alternatively, in atomising means wherein the air under displacement acts on the fuel by induction, the fuel metering device may comprise a valve, for example a screw down needle valve, in combination with the feed duct, which valve serves to throttle and thereby control the amount of fuel injected, since such fuel extends as an unbroken body or column through the obturator and induction of a quantity of fuel from the receiving chamber into the aforesaid recess results under the automatic operation of the non-return valve in its replacement by further fuel at a rate controlled by the setting of the metering valve.

Some embodiments of the invention will be described by way of example with reference to the accompanying diagrammatic drawings wherein, on an enlarged scale,

Figure 1 shows in axial section one embodiment of obturator body mounted in a cylinder head for co-operation with a recess in the piston crown,

Figure 2 shows in axial section an alternative obturator body,

Figure 3 shows in axial section yet another obturator body,

Figure 4 shows in axial section a still further embodiment of an obturator body mounted in a cylinder head for co-operation with a recess in the piston crown, and

Fig. 5 is a fragmentary sectional view showing the arrangement of the invention including a fuel pump.

Referring now to Fig. 5, a piston 1 is movable in a cylinder 2. The piston crown is formed with a recess 15 into which an obturator body 3 projects. These elements will be described in detail hereinafter. A fuel pump P supplies fuel to a fuel passage in the obturator body through a conduit which ends in a conduit member 3a in which a threaded needle valve 3b is mounted for throttling the fuel injected by the fuel pump P.

Referring to Figure 1, the piston 1 is shown with a bulbous recess 15 having an offset cylindrical opening 16 into the combustion chamber 17. The cylinder head 2 has an obturator body 3 secured in an opening 18 in co-axial relationship to the opening 16 in the piston crown. The body 3 has an axial bore constituting the feed duct 4 which at its outer end, has an enlarged portion 19 to accommodate a compression coil spring 20 for a non-return valve 21, the stem 24 of which extends through the feed duct 4 and is surrounded at its outer end by the spring 20 which is compressed between a shoulder 22 at the inner end of the opening 19 and a nut 23 screwed on the outer end of the stem 24.

The non-return valve 21 is located in a fuel receiving chamber 6 at the inner end of the body 3. Radial passages 7 extend from the chamber 6 so that their outer ends open into the combustion chamber 17 adjacent the inner surface of the cylinder head 2. The inner end of the chamber 6 has an aperture 27 which is closed by a valve 28 under the action of a spring 29 surrounding the valve stem 30 within the chamber 6.

In the operation of this embodiment of fuel atomising means, during upward movement of the piston 1, the upper edge 11 of the aperture 16 in the piston crown passes the lower edge 12 of the obturator 3. A pressure difference is then set up, due to the lower rate of volume reduction at the zone of the opening 16 in the piston

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relative to the rate of volume reduction between the piston crown and the surface of the cylinder head surrounding the body 3. This pressure difference creates an air squish effect which forces air through the passages 7 into the chamber 6 and thereby causes the valve 28 to open to an extent sufficient to afford a conical atomising duct between the face of the valve 28 and its seat, through which fuel in the chamber 6 is expelled in atomised form into the recess 15. Combustion of the fuel is therefore initiated within the recess 15 and extends over the entire volume of the combustion chamber 17 as soon as downward movement of the piston causes the edge 11 of aperture 16 to be withdrawn beyond the edge 12 of the body 3.

On the attainment of suitably reduced pressure within the chamber 6, at a subsequent stage of the engine cycle, the said chamber is refilled with fuel by means of a low pressure metering pump (not shown), the non-return valve 21 opening to permit the ingress of further fuel and then closing under the action of the spring 29.

In an alternative embodiment of obturator body 3 shown in Figure 2, there is provided a co-axial jet member 31 the peripheral surface of which is formed with a plurality of grooves or flutes 32. This jet member is located centrally in an aperture 23 at the inner end of the body 3, said aperture extending from an annular fuel receiving chamber 34 with which radial passages 7 communicate. The jet member 31 is mounted on a stem 35 and an inner frusto-conical surface 36 on said member serves in co-operation with a seat 37 as the non-return valve. The jet member is urged upwardly for the closing of the valve 36 by spring 20, housed in an enlarged part 19 at the outer end of the feed duct 4 and abutting a shoulder 22 at the lower end of said enlarged part and a collar or nut 23 secured to the outer end of the stem 35.

The operation of this embodiment is similar in principle to that of the preceding embodiments. Air under displacement from the volume between the piston crown and the inner surface of the cylinder head is forced radially inwards through the passages 7 and expels fuel from the receiving chamber 34 through the grooves or flutes 32 of the jet member 31 into the recess such as 15 (Figure 1), these grooves or flutes co-operating with the surrounding wall of the aperture 23 to constitute atomising ducts. Again, at a suitable stage in the engine cycle, reduction of pressure in chamber 34 permits a low pressure metering pump to displace the jet member 31 and open the non-return valve 36 against the action of spring 29 to convey a fresh fuel charge to the chamber 34.

In the embodiment shown in Figure 3 the modified obturator body has a receiving chamber 6 in which is located a non-return valve 21 normally maintained in closed position by a spring 20. From the chamber 6 atomising ducts 9 extend downwardly and outwardly each to open into the narrowest portion of one of a plurality of downwardly and inwardly directed, Venturi-shaped passages 38 which extend each from one of the radial openings 7 in the body 3 to a central aperture 39 at the inner end of said body.

In the operation of this embodiment, air under displacement from between the piston crown and the inner surface of the cylinder head is forced radially inwards through the openings 7 and the passages 38. By reason of the form of these passages, the air therein acquires where it traverses

the ends of the bores 9 a high velocity sufficient to induce fuel through these bores from the receiving chamber 6. Such induced fuel is then expelled in atomised form with the air through the aperture 39 into a recess such as 15 (Figure 1) within the piston.

Further, in this arrangement since fuel is displaced from the chamber 6 by the inductive effect of air traversing the passages 38, the non-return valve 21 opens automatically on such withdrawal to replenish the chamber 6. The rate of supply of fuel to the feed duct 4 can therefore be controlled by a simple needle valve serving as the fuel metering device, since at all times an unbroken body or column of fuel must extend from the bores 9 through chamber 6 and feed duct 4 to the valve which is located in a fuel supply line connected to the duct 4.

In the embodiment shown in Figure 4, air under displacement from the combustion chamber 17 to the recess 15 in the piston 1 is confined to an annular passage 40 between the peripheral surface 41 of obturator body 3 and the surrounding wall of the aperture 16 from the recess 15 to the piston crown surface. In this embodiment the receiving chamber 6 communicates by way of radial passages 42 with a plurality of atomising bores 43 downwardly and outwardly directed to the peripheral surface 41 of the body 3 so that on the approach of the piston crown to the inner surface of the cylinder head they are masked as shown by the wall of the aperture 16 in the piston crown. Thus air under displacement from the combustion chamber 17 to the recess 15 is forced at high velocity through the annular passage 40 and exercises an inductive effect through the bores 42 and passages 43 upon fuel in the receiving chamber 6. This fuel is thus conveyed by the air in atomised form into the recess 15 for combustion therein. Furthermore, since the fuel is withdrawn by induction from chamber 6 the non-return valve 21 is enabled to open against the action of its return spring 20 for replenishment of the chamber 6 by way of feed ducts 4 from a fuel supply line connected to said duct, under the control of a needle valve serving in the manner above described as a fuel metering device.

If desired, the peripheral surface of the body 3 may be made convex at the zone of the bores 43, and/or the upper part of the wall of aperture 16 may be made convex to impart to the annular passage 40 a Venturi form in radial section.

The embodiments above described with reference to the drawings are merely examples of various modes in which the invention may be practiced and it will be appreciated that variations may be made in the fuel atomising means in relation to cylinder heads and pistons having other forms, without exceeding the scope of the invention.

For example, the cylinder head may have a recess and include or support adjacent thereto atomising means comprising a fuel receiving chamber, for example a toric chamber, at least one atomising bore extending for example upwardly and inwardly to the recess, and the obturator body may be provided on the piston crown to enter the recess in the cylinder head so as to divide the combustion chamber into two volumes, one enclosed in the recess by said body, and the other enclosed between the remaining surfaces of the cylinder head and the piston crown and having a higher rate of volume reduction so as to create the aforesaid air squish

effect. In such an arrangement, various dispositions of atomising ducts and air passages may be embodied. One such disposition may correspond, for example, to the means illustrated in Figures 1 and 2 of the drawings, wherein fuel is expelled from the receiving chamber into the recess by the air squish effect. Another such disposition may correspond, for example, to the means illustrated wherein fuel is withdrawn from the receiving chamber by inductive action of the air under displacement, either in a manner similar to that described with reference to Figure 3 by the provision of passages through the material of the cylinder head across the ends of atomising bores, or in a manner similar to that described with reference to Figure 4 by the disposition of the atomising bores to open into the peripheral wall of an aperture in the cylinder head from the recess therein, so that fuel in said bores is disposed for induction by air under displacement in the annular passage between the periphery of the obturator on the piston and the wall of said aperture.

I claim:

1. In a compression ignition internal combustion engine having a cylindrical head element and a piston crown element which cooperate to form a combustion chamber, and wherein the piston crown element is formed with a recess adapted to receive injected atomized fuel, fuel atomizing means comprising, in combination, an obturator body secured to the cylinder head and projecting into the combustion chamber so as to enter and substantially enclose said recess on the approach of the piston crown element to the cylinder head element whereby the combustion chamber is divided into two volumes, one of said volumes comprising said recess and being subject to a lower rate of volume reduction than the other of said volumes, said obturator body being formed with a receiving chamber for fuel, with a feed duct to said receiving chamber, and with an axial passage communicating with said receiving chamber and ending in a frusto-conical valve seat located at the inner end of said obturator body, said obturator body being also formed with a transverse passage connecting said receiving chamber with the other of said volumes of said combustion chamber for the passing of displaced air from said other volume through said receiving chamber to said one volume; a non-return valve located in said feed duct of said obturator body; a frusto-conical valve cooperating with said frusto-conical valve seat; and resilient means urging said frusto-conical valve into engagement with said valve seat, said frusto-conical valve being adapted to be raised from said valve seat by displaced air passing through said axial passage to said one volume.

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