

May 7, 1935

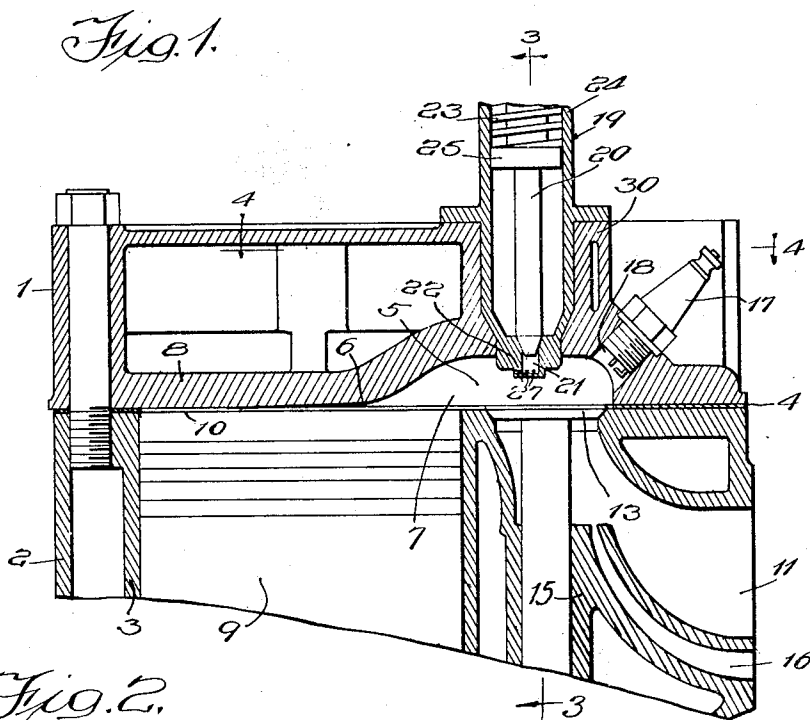
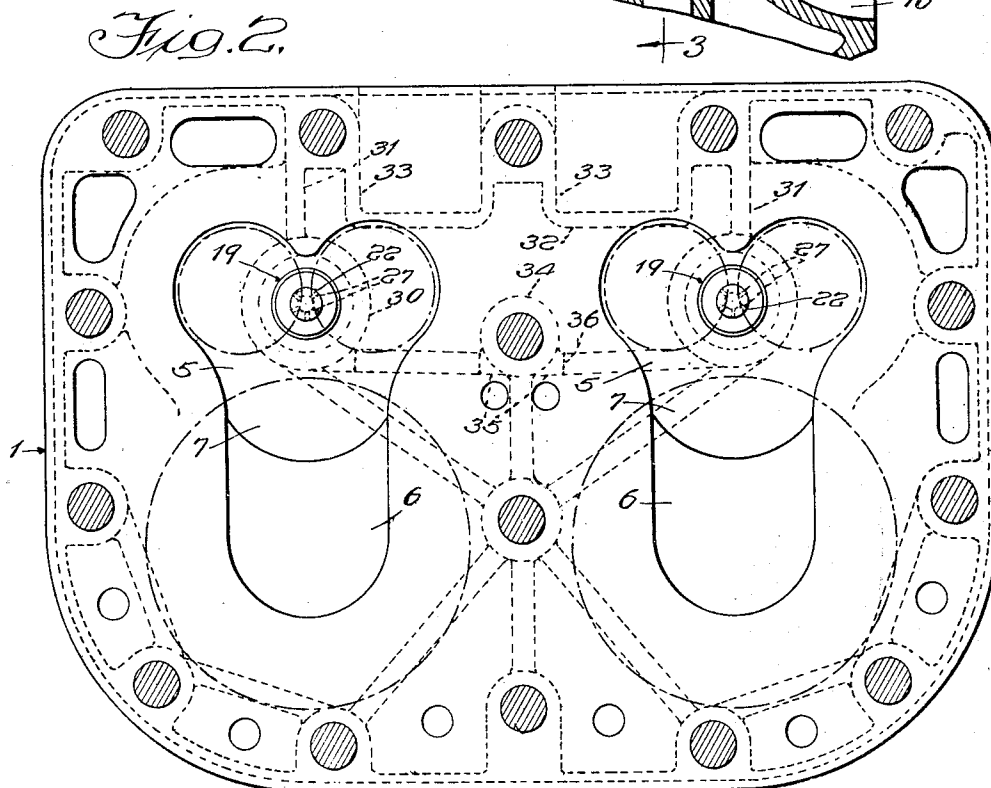
J. B. FISHER ET AL

2,000,225

INJECTION ENGINE

Filed Dec. 11, 1929

2 Sheets-Sheet 1



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Fig. 3.

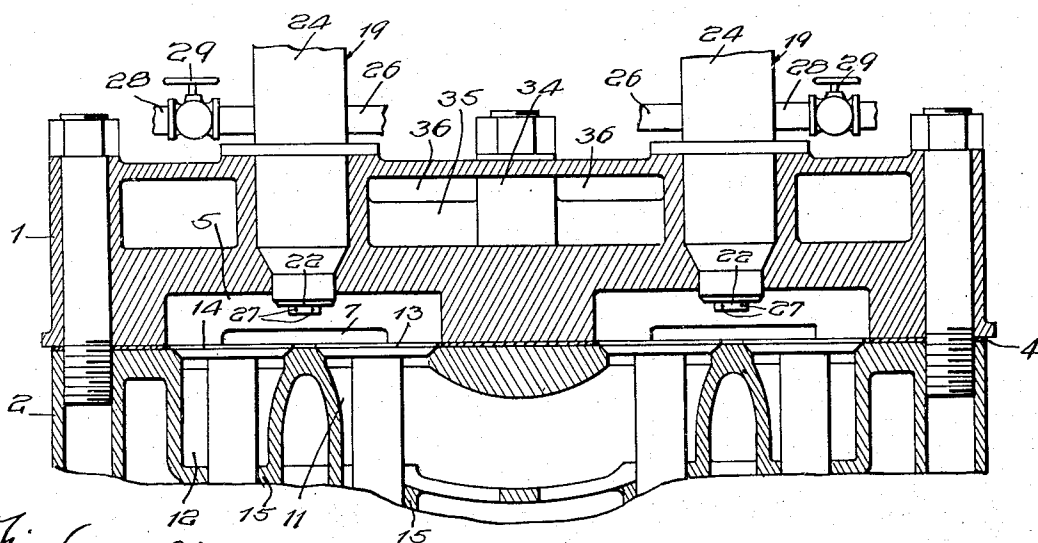


Fig. 6.

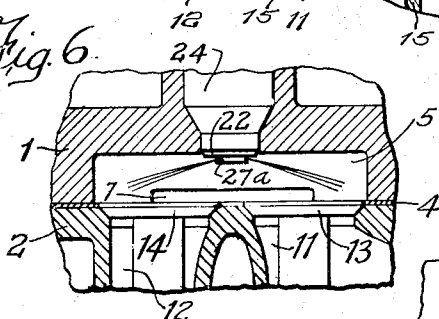


Fig. 4.

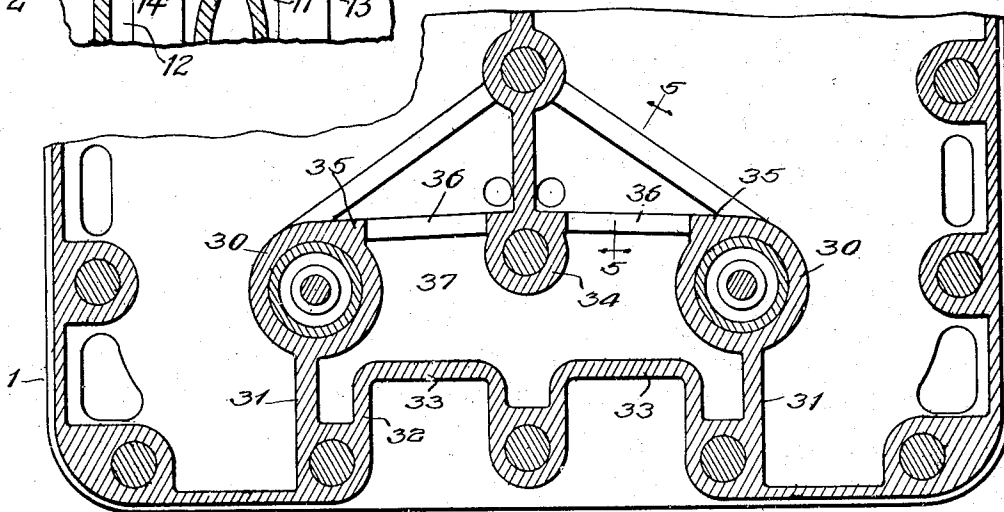
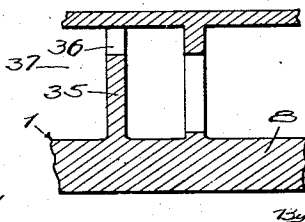


Fig. 5.



Witness:

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UNITED STATES PATENT OFFICE

2,000,225

INJECTION ENGINE

James B. Fisher and Max Hofmann, Waukesha,
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Waukesha, Wis., a corporation of Wisconsin

Application December 11, 1929, Serial No. 413,303

2 Claims. (Cl. 123—32)

This invention relates to internal combustion engines, and more particularly to injection or Diesel engines.

Our invention has to do more particularly with an injection engine having a comparatively low compression ratio and adapted to be started and warmed up on a light hydro-carbon fuel, such as gasoline, the engine during the warming up period being operated on the Otto cycle and, after it has been warmed up, being operated on the Diesel cycle by injection of a heavier hydro-carbon fuel, in a known manner.

One of the objects of our invention is to provide a novel relation of the combustion chamber and the appurtenances thereof, whereby an L-head engine is adapted to operate efficiently either as an injection engine, or as an aspiration engine. Further objects and advantages of our invention will appear from the detailed description.

In the drawings:

Figure 1 is a vertical sectional view through the head and the upper portion of the cylinder block of an engine in accordance with our invention;

Figure 2 is an underneath view of the head;

Figure 3 is a vertical section through the head and the upper portion of the cylinder block taken substantially in the plane of line 3—3 of Figure 1, parts being shown in elevation;

Figure 4 is a fragmentary horizontal sectional view of the head taken substantially in the plane of line 4—4 of Figure 1;

Figure 5 is a fragmentary sectional view of the head taken substantially on line 5—5 of Figure 4; and

Figure 6 is a fragmentary sectional view, taken on substantially the plane of Figure 3, showing a different arrangement of the injection nozzle.

We have illustrated our invention as applied to a two cylinder engine, by way of example, this engine comprising a head 1 secured, in a known manner, upon the upper end of cylinder block 2, in which the cylinders 3 are suitably supported, a gasket 4 being interposed between the block and the head.

The under face of head 1 is flat or planar and this head is provided, in its under face, with two combustion chambers 5 disposed at one side of the respective cylinders. Referring to Figures 1 and 2, chamber 5 is provided with a narrowed portion 6 which overlies a portion of the cylinder area, the main or body portion of the combustion chamber communicating with the cylinder through a restricted throat 7. Wall 8 of head 1 overlies the remainder of the cylinder area and is disposed closely adjacent thereto. A piston 9 reciprocates in the cylinder and this piston, when in the position of greatest compression, is disposed closely

adjacent the under face of wall 8 forming therewith a shielded area or space 10.

Inlet and exhaust passages 11 and 12, respectively, are formed in the cylinder block 2, these passages being controlled by inlet and exhaust valves 13 and 14, respectively, which are operated in a known manner, the stems of these valves operating in guides 15. The combustion chamber 5 is offset laterally from the cylinder 3 and overlies the passages and the valves therefor. The inlet passages 11 are for the admission of charging air to the cylinders when the engine is operating as a Diesel or injection engine. For starting purposes, a supplemental inlet passage 16 is provided in block 2 adjacent passage 11, for supplying a combustible mixture of a light hydro-carbon, such as gasoline, and air to passage 11 adjacent the inner ends thereof.

This supplemental passage 16 is connected in any suitable manner to a carburetor and associated means for supplying the desired mixture of air and hydro-carbon to passage 16. The particular manner of supplying air to passage 11 and a fuel mixture to supplemental passage 16 is disclosed in detail in the copending application of James B. Fisher and Max Hofmann for Starting system, filed December 11, 1929, Serial No. 413,235, and need not be illustrated nor described here in detail, it being sufficient to note that a suitable fuel mixture may be supplied to passage 11 by means of the supplemental passage 16 when the engine is operating as an aspiration engine, and the supply of this mixture to passage 16 is cut off when the engine is operating as an injection engine, at which time air is admitted through the passage 11.

A spark plug 17 is secured in head 1 and the electrodes of this spark plug are disposed in a recess or pocket 18 which opens into combustion chamber 5 adjacent and above inlet valve 13. This spark plug may be otherwise disposed, but is preferably located as shown, and operates in a known manner for igniting the fuel charge when the engine is operating as an aspiration engine on the Otto cycle.

An injection nozzle 19 extends downwardly through head 1 into the upper portion of chamber 5. This injection nozzle is of known type and operates in a known manner. A needle valve 20 controls fuel passage 21 in the nozzle tip 22.

This valve is normally held seated by an expansion coil spring 23 confined between a member at the upper end of body 24 of the nozzle and a piston 25 carried by valve 20 and having a working fit with body 24 of the nozzle. Fuel oil is supplied, under pressure, to the space beneath piston 25, by means of the tube 26. The fuel oil is supplied in measured quantity to the nozzle and in synchronism with the operation of the engine so as to raise the valve 20 from its seat against

the action of spring 23, at which time a charge of fuel is injected into combustion chamber 5 through the fuel passage 21, and spray openings 27 of the nozzle tip 22. A second tube 28 communicates with each of the nozzles 19, beneath the piston 25, and is provided with a valve 29 which is normally closed. When starting the engine on a light hydro-carbon mixture, the valve 29 in the tube 28 is opened so as to permit escape from body 24 of the nozzle 19 of the fuel oil or other heavy hydro-carbon supplied thereto under pressure. This prevents opening of the needle valves 20 with consequent injection of fuel into the combustion chambers 5 so that, with the valves 29 open the engine may be operated on the Otto cycle. After the engine has been properly warmed up, the supply of fuel mixture to supplemental passage 16 is cut off and the valves 29 are closed, after which fuel is injected into the combustion chambers and the engine is operated on the Diesel cycle.

The means for operating the valves 29, and associated parts, are disclosed in detail in the copending application of James B. Fisher and Max Hofmann, above identified, and need not be further illustrated or described here, it being sufficient to note that suitable means is provided for throwing the injection nozzles into and out of operation in accordance with the cutting off of the supply of fuel mixture to the inlet passage and the supplying of fuel mixture to such passage. As will be understood by those skilled in the art, the compression of the fuel charge, when operating as an aspiration engine and using a highly volatile fuel, such as gasoline, should be materially lower than when operating as an injection engine. Any suitable means may be provided for accomplishing this result. Conveniently, a pet-cock may open into the cylinder at a proper point for regulating the volume of air and fuel retained therein, as disclosed in said copending application of James B. Fisher and Max Hofmann.

It is desirable that the combustion chamber have appreciable height to provide a body of air of such volume that the fuel from the nozzle can be injected into such air body without striking the walls of the combustion chamber. This means that the combustion chamber should be as high as possible consistent with its horizontal area to accommodate the inlet and exhaust valves. With this object in view, the valves are made of the smallest area possible which will give the proper volume of air and fuel mixture, and these valves are disposed closely adjacent the outer and side walls of the combustion chamber, the space between the valves and the adjacent walls of this chamber being only that required for mechanical clearance. By disposing the valves in the manner illustrated and described, and using as small valves as possible for satisfactory operation of the engine, we are enabled to provide a combustion chamber of small volume relative to the displacement volume of the piston, and this chamber is of appreciable height so as to provide an air body of suitable depth and volume for injection therinto of fuel from the nozzle.

As will be noted more clearly from Figure 2, the area of the portion of the combustion chamber 5 which extends beyond the cylinder area is quite small, relative to the cylinder area, and this portion of the combustion chamber constitutes the main portion of the combustion space when the piston is in the position of greater compression. The maximum width of the combustion

chamber, taken in a plane parallel to the plane of the cylinder axes, i. e., lengthwise of the engine, is materially less than the diameter of the cylinder bore. Also, the maximum horizontal dimension of the effective combustion space or body portion of this chamber, taken in any direction, is materially less than the diameter of the cylinder bore. This renders it possible to obtain, in an L-head engine, sufficiently high pressure to operate the engine on the Diesel cycle. This engine preferably has a compression ratio of from ten or fifteen to one. We find that a compression ratio of twelve and one-half to one is satisfactory. To provide this ratio, the combustion chamber must be so designed as to have a ratio to the effective cylinder volume of approximately one to eleven and one-half. By relating the valves and the combustion chamber in the manner illustrated and above described, it is possible to obtain this ratio in an L-head engine, whereas, in L-head engines of ordinary type the ratio of the combustion chamber to the cylinder volume is considerably greater than one to eleven and one-half and is so great that the engine cannot be operated on the Diesel cycle.

Referring more particularly to Figures 1 and 2, it will be noted that the injection nozzle is disposed midway between the inlet and exhaust valves and the spray openings 27 are disposed radially of the tip 22 and in such manner as to spray the fuel toward the sides of the chamber, that is, above the valves and in the direction thereof, as well as toward the restricted throat 7.

This disposition of the injection nozzle and the spray openings is highly advantageous. When the engine is operating on the Diesel cycle, during downward movement of the piston 9 on the suction stroke, the inlet valve 13 being open, a charge of air is drawn into the cylinder and the combustion chamber. In this connection, the relatively small volume of the combustion chamber is advantageous as rendering it possible to produce a comparatively high degree of vacuum during the downward stroke of the piston so that, upon opening of the inlet valve, a comparatively large volume of air is drawn into the cylinder in the short time available for charging the cylinder with air. During the compression stroke of the piston, the air and whatever burnt gases may remain in the cylinder are forced through the restricted throat 7 into the main portion of the combustion chamber 5. These gases flow from the inner end or portion 6 of the combustion chamber toward the outer wall thereof. The fuel which is sprayed toward the sides of the combustion chamber is injected into the air across the direction of flow thereof. This is advantageous as assuring thorough penetration of the air by the fuel and intimate mixing of the fuel with the air thus providing a mixture such as to assure proper and substantially complete combustion. This results in smooth operation and high efficiency. When operating on the Diesel cycle, the fuel charge is ignited by the heat incident to compression, as is known to those skilled in the art, the spark ignition means being disabled in the manner set forth in the above identified copending application of James B. Fisher and Max Hofmann.

A further advantage of disposing the injection nozzle in the manner illustrated and described resides in the fact that the space above the valves is heated to a somewhat higher temperature than the space beyond the valve area, with the result that the fuel which is injected towards

the sides of the combustion chamber is sprayed into a relatively warm body of air, which facilitates proper mixing of the fuel and air.

When the engine is operated on the Otto cycle, in warming up, the exhaust valve 14 becomes heated to a higher temperature than the inlet valve, due to the effect of the hot exhaust gases, as is known in the art. This causes an unequal distribution of heat in the combustion chamber 5 which is objectionable as reducing to a certain extent the efficiency of the engine. To avoid this objection we provide means whereby the portion of the combustion chamber 5 above the inlet valve is not cooled to the same extent as the portion of this chamber above the exhaust valve, so that this chamber is kept at approximately the same temperature above both of the valves. The head 1, as well as the block 2, is suitably cored out to provide passages therethrough for a cooling liquid, such as water, in a known manner. The top and bottom walls of the head are connected by sleeves 30 formed integrally therewith, these sleeves receiving the injection nozzles.

The forward portions of sleeves 30 are connected by webs 31 to front wall 32 of head 1, this front wall being provided with offset portions providing pockets 33 which accommodate the spark plugs 17. The webs 31 are continuous from the top wall to the bottom wall of the head. A sleeve 34, for reception of a securing stud, is disposed midway between the sleeves 30 and is connected thereto by baffles 35. These two baffles terminate short of the top wall of the head so as to provide restricted openings 36 by means of which the cooling water can enter the space 37 and can flow therefrom. It is to be noted, however, that the water cannot circulate freely through space 37 but is, in effect, trapped therein, the flow of water through the openings 36 being due to a thermo-siphon effect. As a result, the water trapped in the space 37 will be raised to a higher temperature than the surrounding body of water which circulates freely through the head. In this connection, it will be noted that the space, at each side of the head, between the sleeve 30 and the adjacent side wall of the head, is free and unobstructed so that the cooling water flows freely above the portion of the combustion chamber which extends over the exhaust valve. The portion of the combustion chamber wall above the inlet valve is, therefore, not cooled to the same extent as the portion of this wall above the exhaust valve.

In this manner, we compensate for the higher temperature of the exhaust valve and equalize the temperature of the two portions of the combustion chamber corresponding to the two valves. In operating the engine without this provision for equalizing the temperature in these two portions of the combustion chamber, it was quite noticeable that there was a tendency to deposit carbon upon the wall of the combustion chamber above the inlet valve to a much greater extent than above the exhaust valve. There was also a tendency to deposit carbon upon the cylinder wall over an area diagonally opposite to the area of the combustion chamber corresponding to the inlet valve. This we attribute to the cooling effect of the relatively cool area contiguous to the inlet valve. By equalizing the temperature of the two portions of the combustion chamber corresponding to the two valves, as above described, this tendency to deposit carbon was

eliminated and smoother operation and increased efficiency of the engine was obtained. While the greater benefit was noticeable when operating the engine on the Diesel cycle, as assuring more uniform combustion of the fuel which is injected into the combustion chamber, this equalizing of the temperature is also advantageous when changing from the Diesel cycle to the Otto cycle.

In the form illustrated in Figure 6, the tip 22 of nozzle 24 is disposed adjacent the top of combustion chamber 5, and the spray openings 21a are drilled so as to direct the jets of oil slightly downwardly, as indicated. This form is, in some respects, preferable to that of Figures 1 and 3; though both forms have been found to be highly efficient.

What we claim is:

1. In an L-head compression ignition engine of the Diesel type, a cylinder, a piston operating in the cylinder, inlet and exhaust passages, valves for said passages, a head having a combustion chamber with a flat roof and overlying the valves and also overlying a portion of the cylinder area and communicating therewith through a restricted throat, the head having a wall overlying and closely adjacent the remainder of the cylinder area and forming with the piston a shielded area, when said piston is in the position of greatest compression, the valves being disposed in close proximity to each other and the clearance space between the respective valves and the surrounding wall of the chamber at the outer side and end portions thereof being only that required for mechanical reasons, the chamber constituting substantially all of the effective combustion space when the piston is in said position of greatest compression and the volume of the chamber being so related to the volume of the cylinder that the heat due to compression as the piston approaches its position of greatest compression is sufficient to ignite fuel injected into the chamber, and means for injecting fuel into said chamber.

2. In an L-head compression ignition engine of the Diesel type, comprising a cylinder and a piston operating therein and two passages disposed side by side outward beyond the cylinder bore, two valves disposed side by side and controlling said passages, a head having a combustion chamber overlying the valves and a portion of the cylinder area, the roof of said chamber being flat and the clearance space between the respective valves and the surrounding wall of the chamber at the outer side and end portions thereof being only that required for mechanical reasons, the head having a wall overlying and closely adjacent the remainder of the cylinder area and forming with the piston a shielded area when said piston is in its position of greatest compression, the height of the combustion chamber being slight relative to its width and said chamber constituting substantially all of the effective combustion space when said piston is in said position of greatest compression, and an injection nozzle opening through the roof of the combustion chamber above and between said valves, said nozzle being provided with spray openings disposed to inject fuel into said chamber adjacent the roof and substantially radially thereof.

JAMES B. FISHER.
MAX HOFMANN.