Feb. 19, 1963 R. E. GEORGES 3,077,868

INTERNAL COMBUSTION ENGINES

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Fig. 1.

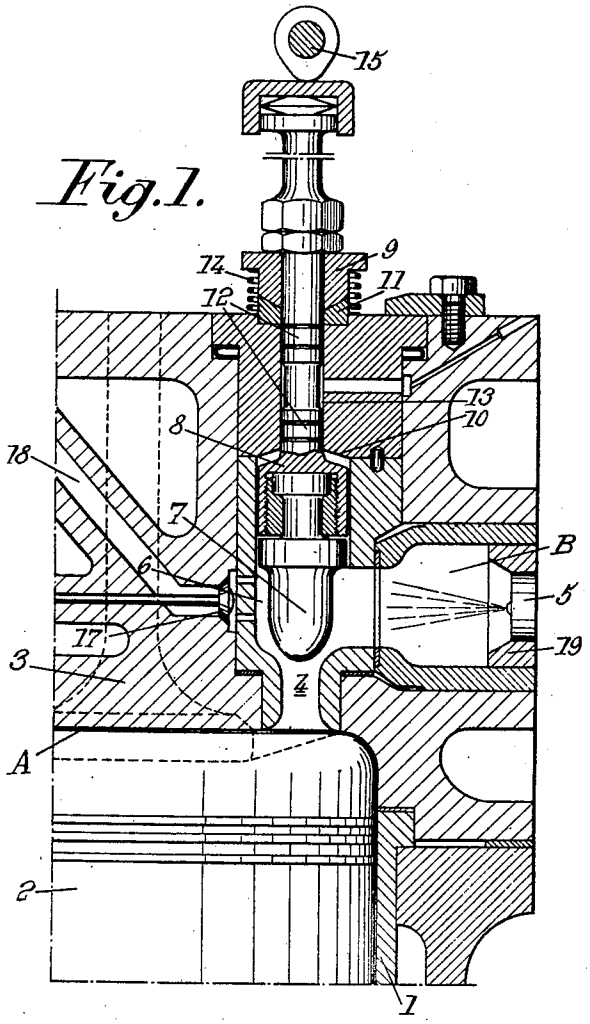
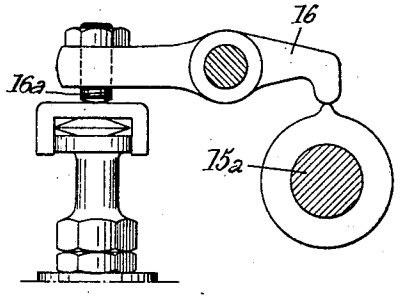


Fig. 2.



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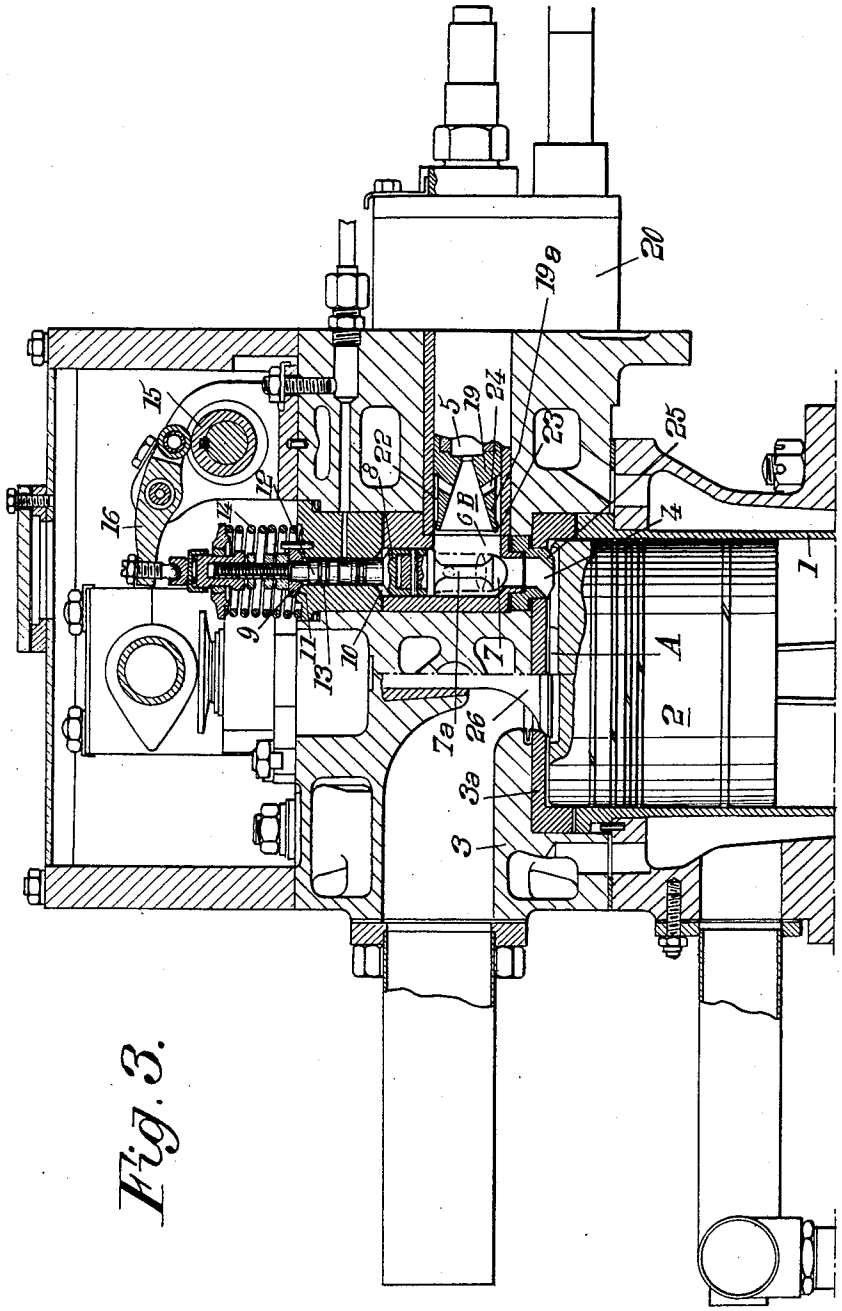


Fig. 3.

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INTERNAL COMBUSTION ENGINES

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The present invention relates to reciprocating piston internal combustion engines, and more particularly all such engines irrespective of their cycle of operation.

The invention is more especially but not exclusively concerned with engines of the above type having a constant pressure cycle, that is to say operating by direct injection of fuel, such as in diesel engines.

It is known to provide engines of the above kind with a main combustion chamber in permanent communication, through a transfer passage of adjustable cross section area, with an auxiliary combustion chamber to which fuel is delivered directly by at least one fuel injection device.

The object of the present invention is to provide an engine of the last mentioned kind which is better adapted to meet the requirements of practice than those known, in particular concerning the operation of the means for adjusting the cross section area of the transfer passage.

According to the present invention, the transfer passage communicates with a chamber, hereinafter called "prechamber" interposed between said transfer passage and the auxiliary combustion chamber and a plunger, preferably made of a refractory material, is adapted to cooperate with this prechamber, this plunger being slidable with respect to said prechamber between two positions, a retracted one for which the smallest cross section area of flow of gas through said prechamber is at least equal to the cross section area of said passage, and a projecting one for which the smallest cross section area of flow through said prechamber is smaller than the cross section area of said passage.

Preferred embodiments of the present invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example and in which:

FIG. 1 is an axial sectional view of an internal combustion engine according to a first embodiment of the invention.

FIG. 2 shows a modification of the embodiment of FIG. 1 and particularly of the means for controlling the position of the plunger.

FIG. 3 is an axial sectional view of an internal combustion engine according to a second embodiment of the invention.

In the following description, it will be assumed that the engine is of the constant pressure cycle type.

According to FIG. 1 there is shown a cylinder 1 in which a piston 2 is slidably fitted. Piston 2 defines with the corresponding portions of a cylinder head 3, a main combustion chamber A.

Moreover, an auxiliary chamber B is provided in said cylinder head 3 and in permanent communication with said main chamber A through a transfer passage 4. Fuel is injected into auxiliary chamber B through a conventional injector 5 preferably mounted in such manner that it can be adjustably engaged in said auxiliary chamber, so as to make it possible to vary the volume thereof, for instance if another fuel is to be used in the engine.

The mass and dimensions of the movable parts of this engine are determined in such manner that it is of a light type and capable of working with a high piston velocity and a high number of revolutions per minute, as compared to conventional diesel engines.

It is known that, in order to avoid fatigue failures of

the relatively light weight movable parts of this engine, especially during the expansion stroke, it is necessary to provide means for varying the flow rate of the gaseous streams from the main combustion chamber A toward the auxiliary combustion chamber B or vice versa.

For this purpose, it is known to provide the transfer passage between chambers A and B with a portion of adjustable cross section area adapted to be controlled by a movable closing device including surfaces in frictional contact with each other so as to permit adjusting the cross section of said portion.

This solution involved relative displacements of parts in frictional contact with one another while they are subjected to the action of gases at high temperatures. In such conditions, there were risks of seizing and of impairing the gastightness of the main closing means.

The chief object of the present invention is to obviate this drawback, that is to say to permit controlling the flow rate of the gas stream circulating between chambers A and B without making use of parts in frictional contact with one another.

According to the present invention, there is provided in cylinder head 3, between transfer passage 4 and auxiliary combustion chamber B, a prechamber 6 serving to connect said passage 4 with said chamber B. In this prechamber 6 there is provided at least one plunger 7 opposite passage 4 and slidable in said chamber, between a retracted and a projecting position. In the retracted position, the minimum cross sectional area for the flow of the gas stream through prechamber 6 is at least equal to the cross sectional area of passage 4. For the projecting position of plunger 7, the minimum cross sectional area for the flow through chamber 6 is smaller than the cross section of passage 4.

It will thus be possible to dimension transfer passage 4 in such manner that its cross sectional area corresponds substantially to an optimum value such that under conditions of operation fatigue failure of the movable parts of the engine is minimized and the flow rate of the gas stream through said passage 4 is reduced by bringing plunger 7 into an at least partly projecting position when the conditions of operation are such that an overload on the movable parts of the engine is to be feared, in particular due to the duration of the time of transfer between chambers A and B.

On the other hand, control of the gas exchange between the two above mentioned chambers takes place without any contact between plunger 7 and the walls of the cylinder head structure directly exposed to the action of the gaseous flux, which eliminates any risks of seizing or of alteration of said walls.

Preferably, plunger 7 is made of a material having a high resistance to heat, for instance a refractory alloy or graphite.

Gastightness is advantageously obtained by providing the movable system to which plunger 7 proper belongs with two closing members 8 and 9 adapted to be applied respectively against bearing surfaces 10 and 11 according as said plunger 7 is in retracted position (member 8 being in contact with bearing surface 10) or in projecting position (member 9 being in contact with bearing surface 11) as shown by FIG. 1.

Thus the means for guiding plunger 7, which may consist for instance of cylindrical bearing means 12 slidable in a bore 13 provided in a portion of cylinder head 3 is isolated in a gastight manner when the plunger is in one of its end positions, either by member 8 when the plunger is retracted or by member 9 when the plunger is projecting.

Advantageously, as shown, transfer passage 4 and plunger 7 are in line with each other and substantially parallel to the axis of cylinder 1, the axis of auxiliary chamber B being perpendicular to said axis.

Advantageously, as shown, the means for controlling plunger 7 is such that this plunger is urged toward its retracted position by a spring 14 whereas control means consisting of a cam 15 is capable of bringing plunger 7 into its projecting position.

Cam 15 may be operated manually by the driver when the working conditions of the engine require a reduction of the transfer flow rate between chambers A and B. Automatic means responsive to variations of a factor of operation of the engine, for instance tachometric governing means, may also be used to move plunger 7 in the retracting direction when the speed of the engine increases above a given value.

Plunger 7 may also be moved into active position on every cycle of the engine. In this case, the plunger must be brought into active position when the force exerted on piston 2 is maximum that is to say when said piston is close to its upper dead center position during every compression stroke thereof, said plunger remaining in retracted position during the remainder of the cycle.

For this purpose, as shown by FIG. 2, plunger 7 is operatively connected with means operating the valves of the engine, for instance through an adjustable threaded rod 16*a* and a lever 16 controlled by a cam 15*a* driven at a speed equal to one half of that of the engine, said cam being adjusted so that the plunger is brought into projecting position during every above mentioned period of the cycle.

The engine above described may further include means for cyclically injecting high pressure compressed air into prechamber 6 to enrich the gaseous streams with oxygen during the expansion stroke, such means consisting, as shown, of an automatic valve 17 disposed in a compressed air conduit 18.

It should be noted that such an engine is well adapted for use with different fuels, especially when auxiliary chamber B is made of variable volume for instance by adjustably engaging piston 19, forming a support for injector 5 into said chamber B. The position of piston 19 is controlled in accordance with the characteristics of the fuel that is used.

FIG. 3 shows another embodiment of the invention including various other features. In FIG. 3 the elements corresponding to those already described with reference to FIG. 1 are designated by the same reference numerals.

In the engine of FIG. 3, plunger 7 is arranged in such manner that its body has a cross sectional area smaller than that of the end thereof located opposite transfer passage 4, the latter said end being for instance in the form of a portion of a sphere.

For this purpose, as shown in solid lines, the body 7*a* of plunger 7 is in the form of a rod having a circular cross section of a radius much smaller than that of the end portion of the plunger.

Additionally, as shown in dot and dash lines (with indication of the cross section), said body 7*a* may be provided with a streamlined cross sectional shape to limit the resistance to flow of the gas streams. The shape may be of an elongated airfoil contour.

In both cases the reduced portion 7*a* of the plunger is connected through rounded lines wth the end of said plunger. This construction makes it possible to obtain an increased power due to the corresponding increase in volume of prechamber 6 and to the increase of temperature of the whole of the plunger, this increase of temperature reducing the condensation of fuel on the plunger and accelerating vaporization.

According to another feature, cylinder head 3, which is made of aluminium or a light alloy, is provided with an inner lining 3*a* of a material capable of maintaining its mechanical resistance qualities at high temperature, for instance a refractory metal or an austenitic steel.

The valve seats and the orifice intended to receive transfer passage conduit 4 are directly machined in this lining.

Advantageously also, prechamber 6 is provided with a similar metal lining.

The lining 3*a* of cylinder head 3 and the lining 6*a* of prechamber 6 may be threadably fixed in said cylinder head.

According to still another feature, the means 20 for controlling the depth of engagement of the support 21 of injector 5 to determine the compression ratio of the engine is located on the outside of cylinder head 3 to avoid dangerous heating thereof.

According to still another feature, the end of the support 21 of injector 5 is in the shape of a flaring nozzle or diffuser 21*a* extending from the outlet of the injector. Preferably the outer wall of nozzle 21*a* is recessed so as to form a space 22 where air can accumulate and which space communicates through a calibrated passage 23 with prechamber 6 and through channels 24, extending radially and preferably inclined in the direction of the jet, with the inside of diffuser 21*a*.

This arrangement produces a sweeping of the burnt gases which would otherwise tend to remain in the vicinity of the injector.

According to a still further feature of the invention, transfer passage 4 has its outlet into main chamber A directed toward the reserves of air (dead spaces) existing in said chamber, especially in the portion thereof where the valves are located, the transfer passage being preferably formed, as shown, in a piece 25 made of a refractory material and adapted to be rotatably adjustable when mounted in its housing.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

What I claim is:

1. An internal combustion engine which comprises, in combination, a cylinder, a piston slidably supported in said cylinder for reciprocating movement therein, a cylinder head defining with said piston, at the end of every inward stroke thereof in said cylinder, a main combustion chamber, means defining an auxiliary combustion chamber fixed with respect to said cylinder, means for injecting fuel into said auxiliary combustion chamber, means fixed with respect to said auxiliary combustion chamber forming a prechamber in permanent communication with said auxiliary combustion chamber, means fixed with respect to said prechamber and said cylinder forming a permanently open transfer passage between said prechamber and said main combustion chamber, a plunger supported in said prechamber forming means and movable with respect thereto between limit positions, one of said positions being a retracted position, the other being a projecting position, said plunger in said positions defining a path in said prechamber for the flow of fuel therethrough, said path having a minimum cross sectional area with the plunger in the retracted position which is at least equal to the cross sectional area of the passage, said path having a minimum cross sectional area with the plunger in the projecting position which is less than the cross sectional area of said passage, and means operative from outside said cylinder for controlling the active position of said plunger with respect to said prechamber.

2. An internal combustion engine according to claim 1, further comprising means operatively connected with said piston for actuating said plunger to move the same to said projecting position at the end of every compression stroke of the engine.

3. An internal combustion engine which comprises, in combination, a cylinder, a piston slidably supported in said cylinder for reciprocating movement therein, a cylinder head defining with said piston, at the end of every

inward stroke thereof in said cylinder, a main combustion chamber, means forming an auxiliary combustion chamber fixed with respect to said cylinder, means for injecting fuel into said auxiliary combustion chamber, means forming a prechamber fixed with respect to said auxiliary combustion chamber and in permanent communication therewith, means fixed with respect to said prechamber and said cylinder and providing a permanently open transfer passage between said prechamber and said main combustion chamber, and a plunger slidable in said prechamber between two positions, one of said positions being a retracted one for which the smallest cross sectional area for the flow of fuel through said prechamber is at least equal to the cross sectional area of said passage, the other of said positions being a projecting one for which the smallest cross sectional area for the flow of fuel through said prechamber is smaller than the cross sectional area of said passage, said plunger including a body located in said prechamber and including an end located opposite said transfer passage and of a cross section greater than that of said transfer passage, said body including a remaining portion of a cross section smaller than that of said end.

4. An internal combustion engine according to claim 3, in which said remaining portion of said body is of circular cross section of a radius substantially smaller than that of the cross section of said plunger end.

5. An internal combustion engine according to claim 3, wherein said fuel injecting means is adapted to direct fuel along an axis into said prechamber, said remaining portion of said body having a cross section in planes parallel to said axis which is smooth and elongated in the direction of said axis to minimize resistance to flow of said fuel.

6. An internal combustion engine which comprises, in combination, a cylinder, a piston slidably supported in said cylinder for reciprocating movement therein, a cylinder head defining with said piston, at the end of every inward stroke thereof in said cylinder, a main combustion chamber, means forming an auxiliary combustion chamber fixed with respect to said cylinder, means for injecting fuel into said auxiliary combustion chamber, means fixed with respect to said auxiliary combustion chamber forming a prechamber in permanent communication with said auxiliary combustion chamber, means fixed with respect to said prechamber and said cylinder forming a permanently open transfer passage between said prechamber and said main combustion chamber, a plunger supported by said prechamber forming means and movable with respect thereto between limit positions, one of said positions being a retracted position, the other being a projecting position, said plunger in said positions defining a path in said prechamber for the flow of fuel therethrough, said path having a minimum cross sectional area with the plunger in the retracted position which is at least equal to the cross sectional area of the passage, said path having a minimum cross sectional area with the plunger in the projecting position which is less than the cross sectional area of said passage, said prechamber forming means being provided with a cylindrical bore in line with the opening of said transfer passage in said prechamber, a rod slidably supported in said bore and coupled to said plunger to control the position thereof, said prechamber forming means including two fixed annular bearing surfaces locataed respectively at the opposite ends of said bore, and annular parts on said rod and constituting two annular bearing surfaces for cooperating in gastight fashion with one of said two fixed annular bearing surfaces, respectively with said plunger in said retracted and projecting positions.

7. An internal combustion engine which comprises in combination, a cylinder, a piston slidably supported in said cylinder for reciprocating movement therein, a cylinder head defining with said piston, at the end of every inward stroke thereof in said cylinder, a main combustion chamber, means forming an auxiliary combustion chamber fixed with respect to said cylinder, means for injecting fuel into said auxiliary combustion chamber, means fixed with respect to said auxiliary combustion chamber forming a prechamber in permanent communication with said auxiliary combustion chamber, means fixed with respect to said prechamber and said cylinder forming a permanently open transfer passage between said prechamber and said main combustion chamber, a plunger supported by said prechamber forming means and movable with respect thereto in between limit positions, one of said positions being a retracted position, the other being a projecting position, said plunger in said positions defining a path in said prechamber for the flow of fuel therethrough, said path having a minimum cross sectional area with the plunger in the retracted position which is at least equal to the cross sectional area of the passage, said path having a minimum cross sectional area with the plunger in the projecting position which is less than the cross sectional area of said passage, and means operative from outside of said cylinder for controlling the position of said plunger with respect to said prechamber, the axis of said transfer passage and the line along which said plunger is slidable being coincident and being parallel to the cylinder axis, said auxiliary combustion chamber having its axis at right angles to the cylinder axis.

8. An internal combustion engine which comprises, in combination, a cylinder, a piston slidably supported in said cylinder for reciprocating movement therein, a cylinder head defining with said piston, at the end of every inward stroke thereof in said cylinder, a main combustion chamber, means forming an auxiliary combustion chamber fixed with respect to said cylinder, means for injecting fuel into said auxiliary combustion chamber, means fixed with respect to said auxiliary combustion chamber forming a prechamber in permanent communication with said auxiliary combustion chamber, means fixed with respect to said prechamber and said cylinder forming a permanently open transfer passage between said prechamber and said main combustion chamber, a plunger supported by said prechamber forming means and movable with respect thereto between limit positions, one of said positions being a retracted position, the other being a projecting position, said plunger in said positions defining a path in said prechamber for the flow of fuel therethrough, said path having a minimum cross sectional area with the plunger in the retracted position which is at least equal to the cross sectional area of the passage, said path having a minimum cross sectional area with the plunger in the projecting position which is less than the cross sectional area of said passage, means operative from outside of said cylinder for controlling the position of said plunger with respect to said prechamber, a support for said fuel injecting means and a flaring nozzle on said support and constituting a diffuser, said nozzle being coupled to said fuel injecting means and opening into said prechamber, said nozzle including an outer wall defining an annular space therearound, said outer wall defining a calibrated passage separating said space and said prechamber, said wall being provided with radial passages to permit said space to communicate interiorly of said wall.

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