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W. O. H. SAUER

INTERNAL COMBUSTION ENGINE

Filed April 8, 1922

FIG. 1

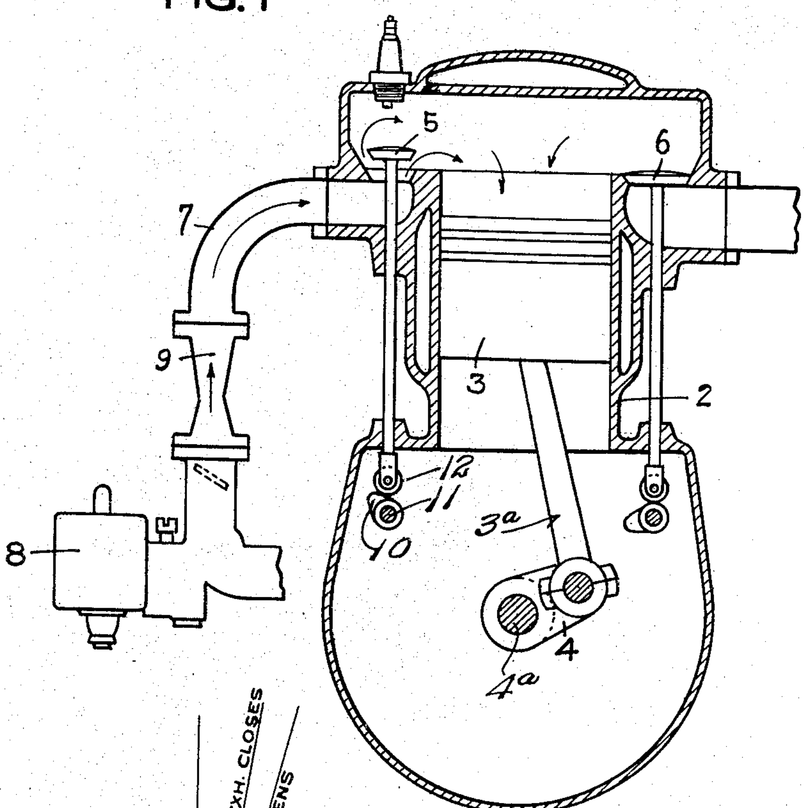


FIG. 2

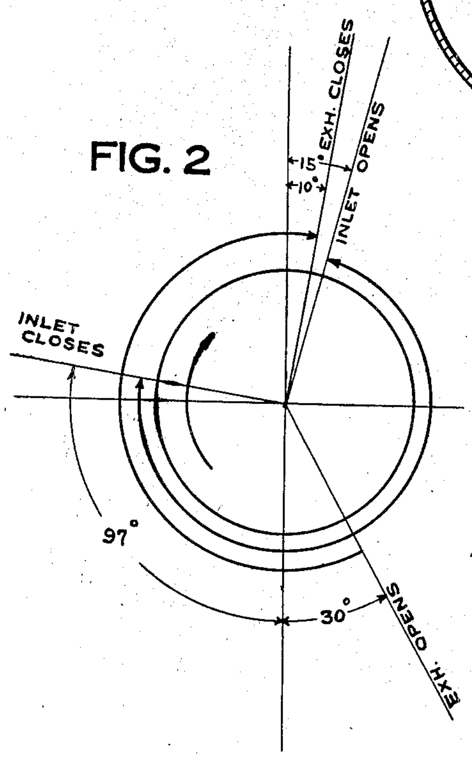
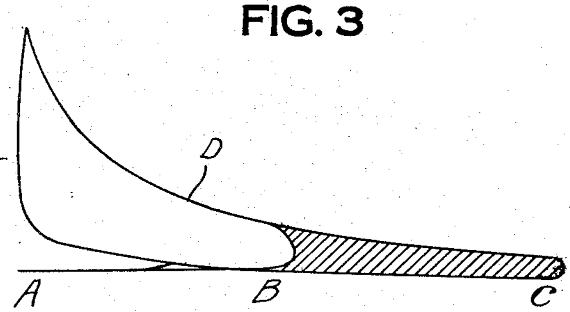


FIG. 3



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

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This invention relates to internal combustion engines, and more specifically to a method and apparatus for effecting greater expansion of the exploded gas charge and thus to prolong and increase the energy applied to the power stroke of the piston, resulting in smoother delivery of power and increased efficiency.

Another object of the invention is to provide means for effecting maximum compression without liability of pre-ignition.

A further object is to provide for a better mixing or atomizing of the gas fuel, whereby the heavier oil fuels are more thoroughly disintegrated and mixed with the air.

To these ends the invention consists, generally stated, in the provision of means for feeding fuel in which the maximum quantity of the explosive charge will be considerably less than the total piston displacement at atmospheric pressure, preferably a fractional charge having a volume of one-half the total displacement of the piston. The invention herein is described and shown to operate on a maximum charge having a volume of substantially one-half of the total piston displacement, assuming the charge to be at atmospheric pressure, or slightly above, at the beginning of the compression of the charge.

In the accompanying drawings, Fig. 1 is a vertical sectional view, mainly in diagram, showing a typical gas fuel engine having my invention applied thereto; Fig. 2 is a diagram of the timing of the inlet and exhaust valves as used with my invention; and Fig. 3 is a diagram or indicator card showing the power gained.

In Fig. 1 I have illustrated my invention as applied to an engine which is typical as used with auto vehicles, and which comprises such parts as the cylinder body 2, the piston 3, connecting rod 3^a the crank 4, crank shaft 4^a inlet valve 5, exhaust valve 6, inlet manifold 7, and the carburetor 8, the general design of which, in all respects, is the same as commonly used in engines of this type, with the following exceptions:

I have provided an exhaust port considerably larger in area than is the common practice, though it may be of the same size as the intake port, and have modified the fuel passage between the carburetor and the cylinder by inserting between the intake manifold and the carburetor a restricting or retarding device 9. This device is shown as an attachment made in the form of a Venturi tube which may be conveniently bolted to the lower flange of the manifold and to the upper flange of the carburetor. However, I do not confine myself to this particular arrangement, as other means for creating resistance to the flow of the fuel in the intake passage may be employed. For instance, the carburetor itself may be constructed to give resistance to the flow of the fuel in the manner similar to the device 9. Or, the carburetor inlet may be restricted or obstructed in any suitable manner, or a throttle valve may be installed in the passage between the carburetor and the cylinder, and the resistance made adjustable, or, in the case of poppet valves, by making the valve small enough, or by reducing the valve passage, or by increasing the diameter of the valve stem, or decreasing the valve lift. A preferable arrangement, especially for valve-in-the-head engines with poppet valves, corresponds to Fig. 1 of the drawing, in which the inlet valve is made smaller than the exhaust valve in order to gain more space for the latter and reduce the exhaust back pressure, while the main resistance is placed at an equidistant point such as, for instance, the Venturi connection 9 where the inlet manifold branches out to the several cylinders and does not interfere with inter-communication of charge between cylinders, the latter being necessary when the throttle is opened beyond the critical position for any speed, as will hereinafter appear.

In addition to the modifications in the fuel passage, as above mentioned, the timing of the inlet and exhaust valves are arranged differently, as compared with the common practice, to permit the exploded charge to have a greater space in which to expand in respect to the power stroke. That is to say, the advance of the exhaust valve opening with respect to the lower dead center is materially reduced, the angular advance being substantially 30 degrees, as compared with 46 degrees as in the common practice. However, I do not wish to limit my invention to any particular setting of the exhaust valve opening, as the setting may be the same as in the common practice without causing any disadvantages.

The inlet valve 5 may be yieldingly held in closed position by a spring (not shown) and is moved from its seat by a cam 10 which is mounted on a cam shaft 11 and engages the roller 12 of the valve stem. The shaft 11 is rotated at one half the speed of the shaft 4^a, and the cam 10 is of such form and so disposed circumferentially on the shaft 11 that the valve 5 is held open during the intake stroke, as shown in Fig. 1, and is maintained in open position during substantially one half of the compression stroke, as shown in Fig. 2. This arrangement insures that a maximum charge of only about one half the amount of piston displacement at atmospheric pressure is retained in the cylinder, thus avoiding excessive compression and reducing the danger of preignition, as the compression space above the piston, when in the upper dead center position, is only adapted in size to the maximum charge, in order to give the highest possible compression. The angular retardation of the closing of the inlet valve 5 with respect to the lower dead center position of the piston 3 is over 90 degrees, as compared with the usual setting of 30 degrees in present practice. The retardation of the closing of the inlet valve 5 is shown on the drawing as 97 degrees, but it will be understood that the angularity may be either greater or less, as conditions will require. The point is that I insure that the volume of charge to be compressed shall be about one half of the piston displacement.

In order to get a clearer understanding of the action of the restricting device 9 in the performance of this engine it must be borne in mind that the resistance for any fixed opening in the venturi with the throttle wide open increases about as the square of the quantity of gas flow, and is therefore directly a function of the speed of the engine. In starting and at low speed with the throttle fully open the cylinder will take up a full charge of explosive mixture equal to the piston displacement at atmospheric pressure, expelling half of it again on the compression stroke on account of the definite and fixed timing of the inlet valve which always stays open for one half of the compression stroke, as shown in Fig. 2. As the engine speeds up with the throttle fully open and the gas flow increases, the flow resistance (as I call it) will increase also until at some high speed the cylinder charge will be one half of the total piston displacement at atmospheric pressure at which speed no surplus charge will be expelled back again through the inlet valve, as the total charge drawn in is only one half. The same result can now be accomplished for any lower speed by a certain setting of the throttle, called critical setting, thereby inserting additional resistance, which added to the lower flow resistance at said lower speed with the throttle wide open, will give a cylinder charge of one half of the piston displacement at atmospheric pressure without any surplus charge being expelled back again through the inlet valve. As there is a different critical setting for every speed below high speed, or inversely a different critical speed for every setting of the throttle, it will be evident that for any particular constant speed under consideration a further opening of the throttle beyond this critical setting will cause a surplus charge to be expelled back again through the inlet valve, while a further closing of the throttle will decrease the charge below one half of the piston displacement at atmospheric pressure.

In operation the engine is controlled for speed by the throttle as in present practice, except that it contains in addition a self governing feature, whereby any variation in load is automatically regulated without changing the throttle setting. Assuming the throttle to be set and the engine running at a certain load and speed, the latter being above critical speed. As the load decreases the speed will increase, but owing to the flow resistance increasing with the speed, the cylinder charge will be less and in proportion to the load. In a similar manner when the load increases the speed will decrease, but owing to the flow resistance decreasing with the speed the cylinder charge will be greater than at first and in proportion to the load. With further increase in load the speed will drop until the critical speed is reached, at which the cylinder charge is one half of the piston displacement at atmospheric pressure and below which the charge will not increase, as any surplus charge is expelled back again through the inlet valve. It must be pointed out however that in the normal operation of this engine no surplus charge will be present, except possibly in starting and at low speeds when overloaded, as the throttle opening is usually kept below the critical setting, which latter corresponds to full throttle opening in present practice.

Referring to Fig. 3 the line A B represents the normal length of piston stroke, and the line D represents the power derived from expansion of a full cylinder charge in an ordinary present day engine. If piston and exhaust valves were so arranged that the expansion could be continued for the distance B C equal to A B, about 33⅓% additional power would be secured from a given explosion, which is shown by the shaded portion above lines B C. In my invention this additional power is secured from a given amount of explosive charge equal to one half of the piston displacement at atmospheric pressure, but expanded to twice the volume, which is equivalent to twice the power stroke in the ordinary engine or the distance A C in Fig. 3, and a diagram of the power produced is therefore substantially identical to Fig. 3.

If the valve 5 and the operating mechanism therefor were employed independently of a restricted inlet passage, the fuel charge in the cylinder with the throttle wide open would be the same at all speeds and substantially equal to one half of the piston displacement at atmospheric pressure. With the arrangement above described and the throttle wide open, the cylinder charge will also be constant and equal to the same quantity, but the amount of discharge expelled back through the inlet valve will decrease as the speed increases, until at some high speed it will be zero and above which speed the cylinder charge will diminish until the speed limit is reached.

As a result of the greater expansion of the gas in the power stroke, more heat is converted into mechanical energy, leaving less for dissipation through the water jacket and exhaust manifold, so that air cooling with this engine may be used to advantage.

On account of the much smaller amount of burnt gases to be expelled through the exhaust valve, as compared with the piston displacement, there will be considerably less back pressure to the piston, thus permitting the opening of the exhaust valve to be delayed for a longer period than is possible at present.

By reason of the action of the restricting device 9 in alternately contracting and expanding the fuel mixture when passing through it, the heavier and the less volatile oil fuels will be more thoroughly disintegrated due to the expansion.

From the above description it will be seen that I have provided an engine in which the maximum exploded charge has greater expansion, as compared with the common practice, and greater duration of expansive energy applied to the piston on the power stroke, thus making for more efficient performance and smoother delivery of power.

What I claim is:

The combination with an internal combustion engine, of a fuel inlet passage, means for retarding the flow of fuel through said passage, comprising a fixed restriction therein of such size that charges of fuel equal, at atmospheric pressure, to only substantially one-half of the piston displacement will be drawn into the engine cylinder when the engine is running at a predetermined speed, and means for expelling fuel in excess of said quantity when the engine is running at slower speeds.

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