Sept. 4, 1923. 1,467,288

A. F. VAN AMSTEL

INTERNAL COMBUSTION ENGINE

Filed Nov. 11, 1920 2 Sheets-Sheet 1

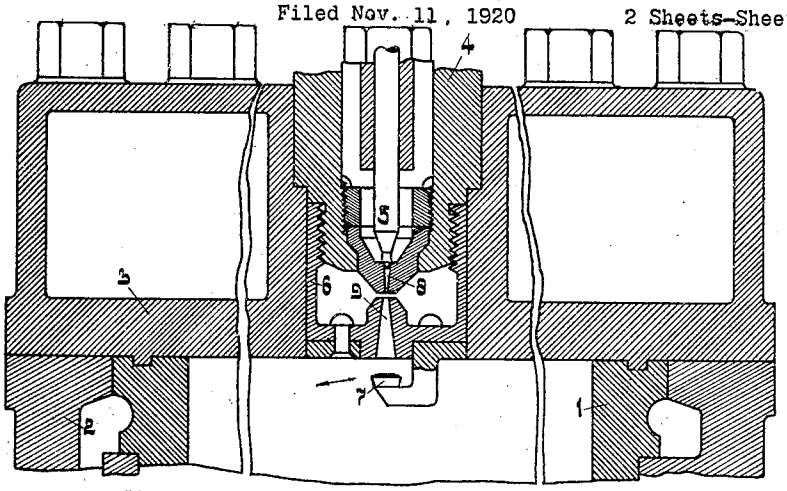
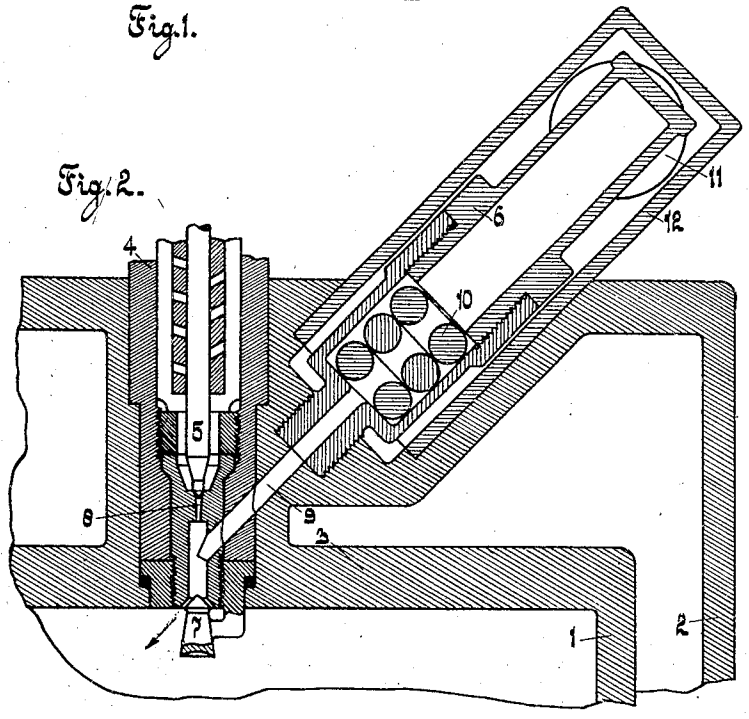


Fig. 1.

Fig. 2.



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Fig. 3.

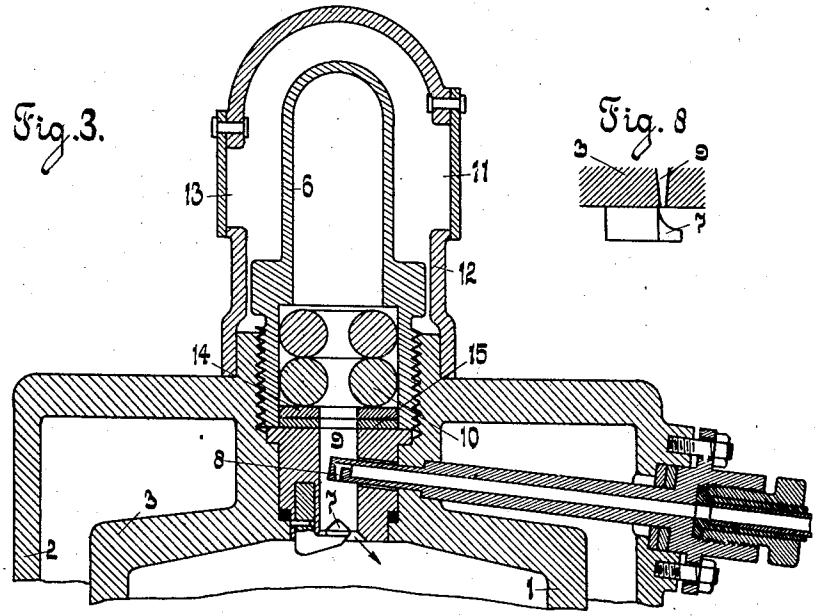


Fig. 8

Fig. 4.

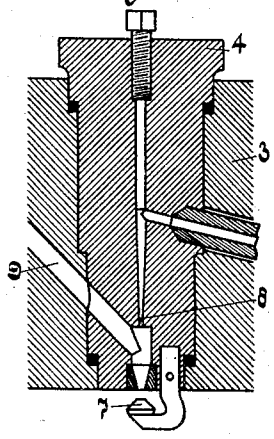


Fig. 5.

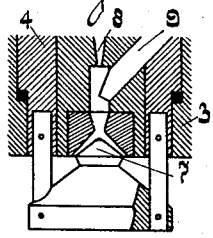


Fig. 6.

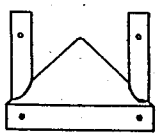


Fig. 7.

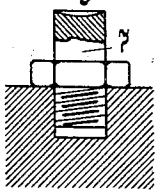
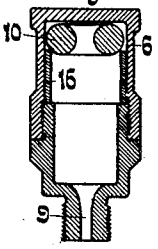


Fig. 9.



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Patented Sept. 4, 1923. 1,467,288

UNITED STATES PATENT OFFICE.

ADRIAAN FREDERIK VAN AMSTEL, OF AMERSFOORT, NETHERLANDS.

INTERNAL-COMBUSTION ENGINE.

Application filed November 11, 1920. Serial No. 423,439.

To all whom it may concern:

Be it known that I, ADRIAAN FREDERIK VAN AMSTEL, a subject of the Queen of the Netherlands, residing at Amersfoort, in the Province of Utrecht, in the Kingdom of the Netherlands, have invented certain new and useful Improvements in Internal-Combustion Engines; and I do hereby declare that the following is a full, clear, and exact description of the same.

My invention relates to internal-combustion engines of the type wherein the cylinder is in constantly open communication with an auxiliary chamber through a permanently restricted passage and wherein the liquid-fuel nozzle opens into the motor in such a way, that the fuel jet issues from the nozzle in a direction through the restricted passage to the cylinder.

In internal-combustion engines of the type referred to, the fuel injection starts before the end of the compression stroke of the motor when, due to the compression, the self-ignition temperature of the fuel has been reached. Through the connecting passage between the cylinder and the auxiliary chamber air then flows from the cylinder into the auxiliary chamber and the first injected particles of fuel, while leaving the fuel inlet opening, are drawn by the stream of air into the auxiliary chamber. This is brought about in order that said particles of fuel be ignited in said auxiliary chamber, so that the pressure in said chamber increases, whereby the flow in the connecting passage is reversed and the remaining fuel is blown into the cylinder in the form of spray. This mode of operation however involves the following drawbacks. The auxiliary chamber is not large and usually has only a volume of about one twentieth of the volume of the compression space of the motor and therefore, even in rather large engines, can only contain a quantity of air sufficient to completely burn some milligrams of fuel. So it may happen that more fuel flows into the auxiliary chamber, in consequence whereof incomplete combustion will take place therein so that the chamber grows foul. Furthermore the efflux of gases from the auxiliary chamber into the cylinder is not always sufficient to pulverize the fuel driven into the cylinder, e. g., when the motor runs slowly and a maximum of fuel is supplied, the pressure in the auxiliary chamber decreases too rapidly with respect to the speed of rotation of the motor to obtain a sufficiently fine spraying during the last part of the fuel injection.

My invention consists in that a spreader is disposed before or in (or partly before and partly in) the cylinder end of the restricted passage between the cylinder and the auxiliary chamber so that the fuel jet which is injected through this passage, into the cylinder, on meeting the spreader, is broken up into spray, or vaporized, or partly pulverized and partly evaporated.

The fuel is preferably injected in a solid or almost solid, rod-like and thin jet against the spreader and by giving said fuel a high pressure it is pulverized into extremely small particles which guided by the deflecting surface or deflecting surfaces of the spreader diverge in favorable directions. The shape, the dimensions and the location of the spreader may be chosen in such a manner, that the injected fuel is totally or partly vaporized or even ignited by the heat of the spreader. The fine subdivision of the fuel therefore does not depend on unreliable fuel spraying by a current of gases and in combination with the working of the auxiliary chamber a device is obtained, which can be applied to high-compression and low-compression engines, as well as to motors with constant pressure and such engines in which the pressure increases or decreases during the combustion.

The advantages obtained by the invention can be explained more clearly by describing a few examples. The invention therefore will now be more fully explained with reference to the annexed drawings, in which a few embodiments of the invention in the form of motor parts are shown, somewhat diagrammatically and not drawn to scale, for as much as is necessary for a thorough understanding of the invention.

Fig. 1 shows, partly in section, a part of a high-compression engine, provided with an arrangement according to the invention.

Figs 2 and 3 show, also partly in section, parts of engines in which an auxiliary chamber provided with an arrangement according to the invention, extends beyond the cylinder head of the engine.

Figs. 4 and 5 each show, partly in section, a part of an engine, to which another embodiment of the invention is applied.

In Fig. 6 a spreader with a large, cone-like deflecting surface is shown.

Fig. 7 shows a spreader, partly in section, the deflecting surface of which is concave, said spreader being secured to the piston of the engine.

Fig. 8 is a view of a spreader which causes the fuel jet emerging from the connecting passage to spread sideways.

Fig. 9 shows a section of an auxiliary chamber with a heat accumulator in the top part.

Referring to Fig. 1, 1 indicates the engine cylinder, 2 the water jacket, 3 the cylinder cover, 4 the fuel inlet plug, 5 the fuel inlet valve, 6 the auxiliary chamber and 7 the spreader. The engine is started by rotating the crank shaft by hand or in any other well known manner. The motor is a two-stroke or a four-stroke cycle engine. The air is drawn or induced in a known manner into the cylinder 1 and is compressed therein by the piston (not shown) to such a volume, that its temperature rises beyond the self-ignition temperature of the fuel, before the fuel injection starts. The latter starts before the end of the compression stroke. The fuel inlet opens into the auxiliary chamber 6 and the fuel is shot in a thin, solid jet from the nozzle 8 through the connecting passage 9 upon the centre of the spreader 7. The fuel spreads in the cylinder, in which it is rapidly burnt. The burnt gases are driven in a well known manner from the cylinder and the up and down movement of the piston is effected and utilized in the usual way. In this embodiment the auxiliary chamber 6 serves to promote the turbulence in the cylinder and to blow clean the passage 9, the spreader 7 and the edge of the nozzle 8 after the fuel injection has been completed so that such parts cannot become foul or unclean by a crust being formed. Whether at the moment in which the fuel injection is completed a current of gases flows from the cylinder 1 through the connecting passage 9 to the auxiliary chamber 6, or whether this movement takes place in opposite direction, depends on certain circumstances, but no matter in what direction the gases may travel, the object in view is attained. If gases pass from the cylinder into the auxiliary chamber 6, so that a small quantity of fuel, which, e. g., has stuck to the edge of the nozzle 8, is driven into the auxiliary chamber, then this fuel immediately takes fire due to the heat of the stream of gases, in consequence whereof the movement in the passage 9 is reversed by the increase of pressure arising in said auxiliary chamber, or such reversal takes place due to the decrease of pressure in the cylinder caused by the expansion of its contents during the working stroke. The nozzle 8 is preferably so shaped, that the fuel jet is shot through the passage 9 without touching the walls thereof and the injection preferably takes place in such a manner, that the fuel, before it passes along the valve 5 into the nozzle 8, during the total injection, i. e., also at the beginning as well as at the end thereof, stands under a higher pressure than the pressure prevailing in the cylinder 1. The arrow shown in the drawing indicates one of the radial directions which the particles of fuel after leaving the deflecting surface take around the spreader through the combustion space, provided that such particles are not driven from their course by the flow of gases. Such fuel, as is already vaporized while leaving the spreader 7, easily passes into and mixes with the flowing gases in the cylinder, and in order to cause part of the fuel to penetrate as far into the cylinder as possible, it is desirable to make the spreader 7 as small as possible, so that it accumulates a minimum of heat from the combustions in the cylinder, and the convex deflecting or spreading surface shortly after the starting of the fuel injection, is cooled by the first particles of fuel to such an extent, that the subsequent particles of fuel leave the spreader in a liquid state, i. e., in the form of extremely small globules. Whether the engine works with constant combustion pressure or with increasing combustion pressure depends on the fuel injection. If the fuel be injected in a short time, then the pressure in the cylinder increases during the combustion, and if it be injected in such a manner, that the injection continues during a certain part of the power stroke of the piston it may be arranged in such a way, that the combustion takes place with a constant or decreasing pressure.

In the case of the engine according to Fig. 2 the cylinder 1, the water jacket 2 and the head 3 are formed in one piece, whilst the auxiliary chamber is formed partly outside the head 3 and the spreader 7 partly projects into the connecting passage 9. In the case of this construction the dimensions of the spreader are such, that it takes up more heat by the combustions, in order to promote the vaporization of the fuel. The uppermost part of the spreader has the shape of a cone, the apex of which is somewhat rounded and the fuel jet is directed against the centre of the rounded apex. The compression of the motor does not suffice to reach the ignition temperature of the fuel in the cylinder, but a temperature beyond the self-ignition temperature of the fuel prevails in the auxiliary chamber 6 or is brought about therein by the compression since the auxiliary chamber and the three

rings 10 located therein are hot. Though in using difficultly vaporizing fuel, the temperature of the air in the cylinder, before combustion starts therein, remains below the boiling point of the heaviest parts of the fuel, the fuel still vaporizes totally or partly, before, after leaving the spreader, it reaches the piston. The liquid vaporizes, even if the temperature is below the boiling point as long as the air is not saturated with vaporized fuel. As the fuel drops are very small and move with a high speed, so that a large fuel surface each time comes into contact with other particles of air, such fuel drops vaporize easily. After the beginning of the compression stroke a stream of air passes from the cylinder into the auxiliary chamber 6 through the gap between the spreader 7 and the wall of the cylinder end of the passage 9. Along with this stream of air vaporized fuel passes into the auxiliary chamber, in which it takes fire. Such influx of fuel is promoted by the fact that a portion of the fuel leaving the cone-mantle-shaped spreading surface of the member 7 collides against the bracket of the spreader and consequently is deflected in such a way, that it is guided into the stream of air to the auxiliary chamber. Near or at the beginning of the power stroke of the piston, the pressure in the auxiliary chamber begins to surpass the pressure in the cylinder, so that burning gases from the auxiliary chamber pass into the cylinder and ignite the contents thereof, whilst at the same time the mixture of the contents of the cylinder is strongly promoted. In the case of this embodiment the combustion in the cylinder or main combustion space only starts when all the fuel or part thereof has already mixed with the air in the cylinder. If the self-ignition temperature of the fuel permanently prevails in the auxiliary chamber 6, i. e., also at the beginning of the compression stroke, such fuel may be injected early. In using very volatile fuel such as petrol the injection may even start before the beginning of the compression stroke. Since fuel entering the auxiliary chamber immediately takes fire therein, no sudden increase of pressure is effected, but rather a gradual one and the pressure in the auxiliary chamber only begins to surpass the pressure in the cylinder when the compression and therefore the increase of pressure in the cylinder draws near the end. The combustion therefore spreads from the auxiliary chamber into the cylinder not long before the end of the compression stroke. If however the ignition temperature in the auxiliary chamber is not reached but by the compression, then the fuel injection must start late, during the compression stroke, since otherwise combustible mixture might get into the auxiliary chamber, such mixture exploding therein not before the ignition temperature is reached. By this explosion a sudden increase of pressure would be effected and an immediate ignition of the contents of the cylinder might take place. As it is not certain at what point of the revolution of the engine the ignitnon temperature in the auxiliary chamber is reached by the compression, in the case mentioned, a premature ignition of the cylinder contents might take place if the fuel is injected too early.

At the termination of the fuel injection in the case of this embodiment, the spreader 7, the passage 9 and the edge of the nozzle 8 are also blown clean by the current of gases flowing through the passage 9. A current from the auxiliary chamber effects at the opening of the nozzle 8 a strong whirlstream, which rapidly leads all particles of fuel, sticking to the edge or emerging from the aperture, into the cylinder.

In starting the cold engine the auxiliary chamber 6 is heated by means of a lamp, through the opening 11 in the cap 12 of the auxiliary chamber 6 and an opening 13 provided in the opposite side of said cap (the opening 13 is not shown in Figure 2, but it is shown in Figure 3). As soon as the chamber 6 is sufficiently hot the engine may be started in the manner stated hereinbefore. The spreader 7 is then cold, but it may also be preheated by rotating the engine a few times, without fuel being injected. Thereby, after the compression stroke, hot air from the auxiliary chamber 6 is blown against the spreader so that it becomes hot. It is however not necessary to heat the spreader beforehand, since even if it is cold, sufficient fuel is driven into the auxiliary chamber 6 to obtain the initial combustion therein. Notwithstanding the low temperature of the spreader and the walls of the main combustion space the fuel jet totally or partly vaporizes in the cylinder, even if heavy fuel is used, since the liquid also vaporizes below the boiling point, as long as the air which comes into contact with it is not saturated with fuel vapour and since the temperature of the air is increased by the compression. If during the first revolutions of the engine or even later when it is hot, fuel in a liquid state reaches the piston, the proper working is not influenced thereby, because such fuel vaporizes shortly after the beginning of the combustion in the cylinder and burns completely. As soon as the rings 10, due to the heating of the auxiliary chamber from without and the combustions in said chamber have become sufficiently hot, said auxiliary chamber no longer requires to be heated from without. The arrow in Fig. 2 indicates one of the radial directions followed by the fuel drops around the member 7 after their leaving the deflecting surface.

It is not necessary that the fuel inlet be closed by a valve 5. Said inlet in that case may also lead from above through the cylinder head or it may be applied laterally, as e. g., shown in Fig. 3. In this case it is however desirable to design the fuel pump or accumulator, or in general the supply-means, in such a way that after the injection is completed, the fuel does not remain in the fore part of the outlet opening of the nozzle 8, but is somewhat withdrawn in order to prevent the fuel, due to the decrease of pressure in the cylinder, from afterwards flowing from the nozzle 8 by reason of contraction of the walls of the inlet pipe and expansion of the fuel therein. The arrow in Fig. 3 also indicates the course taken by a particle of fuel after it has left the spreading surface, inasmuch as it is not influenced by the flow of gases from or into the passage 9. In the case of this construction the spreader 7 projects into the passage 9 and is smaller than in the case of the embodiment shown in Fig. 2. The dimensions of the spreader may be chosen more or less large in proportion to the fuel used. In using volatile fuel a smaller spreader may do than in using more difficultly vaporizing fuel, in order to obtain that sufficient fuel be vaporized and be mixed in that state with the air in the cylinder, before the combustion in the cylinder starts. In the case of the embodiment according to Fig. 3 only two rings 10 are provided and the lower one of them is placed upon a ring 14, resting upon a ring 15, the latter being made of non-conducting material.

In the embodiment shown in Fig. 4 the spreader is so disposed and the cylinder end of the passage 9 is so narrow, that no fuel can flow into the auxiliary chamber before the fuel injection is completed or nearly completed, provided that the injection takes place under high pressure. If the injection takes place with sufficient force, an ejector action may be created so that air from the auxiliary chamber is drawn thereby into the cylinder notwithstanding that a higher pressure prevails in the cylinder than in the auxiliary chamber. In the case of this arrangement the combustion in the cylinder cannot start, before the fuel injection is completed and under certain circumstances this may be preferable, e. g., if using a small auxiliary chamber, in order to obtain by making the passage 9 narrower a thin flame of sufficient length shooting into the cylinder after the ignition in the auxiliary chamber. The spreading surfaces of the member 7 have the shape of a circle and a cone mantle.

In Fig. 5 an arrangement is shown in which the fuel jet also passes through a narrow portion of the passage 9, whereby fuel is drawn into the auxiliary chamber and the ignition takes place not before the fuel injection has been completed. In the case of this embodiment the spreader is substantially larger so that also heavy fuel is rapidly totally or partly vaporized by the heat of the spreader, as soon as the latter, after a few combustions have taken place, is sufficiently heated. The dimensions of the spreader may also be such, that it becomes sufficiently hot to ignite the fuel, in which case the ignition immediately takes place, or shortly after the commencement of the injection. The fuel is first spread by the upper conical face of the spreader and then the drops pass immediately along the lower conical face thereof. The said two conical faces may also be united into a single one, according to Fig. 6, so that the fuel comes into contact with this large surface, which may be useful when using very difficultly vaporizing fuel.

It is obvious, that the above described examples only show a few of the embodiments of the invention, which might be increased by a large number. The engines according to Figs. 2, 3, 4 and 5, e. g., might serve as high-compression motors, if the compression space be made sufficiently small and then it is not necessary to heat the auxiliary chamber beforehand, since the ignition temperature, even when the engine is cold, is reached in the air of combustion by the compression. In the embodiments shown in Figs. 2 and 5, in this case, the spreader need not be large and in all the engines to which the said four figures relate the fuel injection is preferably started near the end of the compression stroke when the self-ignition temperature in the air in the cylinder has been attained.

The shape imparted to the spreader is such that the fuel is spread thereby in the most advantageous directions. If the shape of the combustion space is disc-like and the location of the spreader is suitably chosen, it may also be flat. In Fig. 7 a cylindrical spreader is shown, partly in section, said spreader being secured to the piston, so that no fastening means in the way of the fuel are necessary and the deflecting surface is concave, so that a fuel jet, being directed upon it in the direction of the axis, is spread upward. In Fig. 8 a spreader is shown in elevation, by which the fuel jet directed thereupon through the passage 9 is not spread around and which may be used if the passage 9 is not in the centre of the cylinder head, but at the side thereof.

It is not necessary that the hot rings 10 always lie on the bottom of the auxiliary chamber. Under certain circumstances they may also be placed higher or even in the top. According as the rings lie higher in the auxiliary chamber, a higher increase of

pressure is effected therein by the combustion in the auxiliary chamber, because then more combustible mixture flows into said auxiliary chamber before this takes fire in the heat zone (at the rings 10), unless in the space of the chamber under the rings the self-ignition temperature of the fuel already prevails, in which case the arrangement of the rings makes no or little difference. In Fig. 9 an auxiliary chamber is shown in section, in the upper part of which a hot ring 10 is arranged. By omitting the ring 16 or placing it above the ring 10 the latter is about in the middle of the chamber 6.

It is understood that the invention may be applied to one-cylinder as well as to multi-cylinder engines and also to horizontal as well as to vertical machines, whilst per cylinder more than one auxiliary chamber provided with the arrangement according to the invention may be arranged.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

In an internal-combustion engine, the combination of a combustion chamber, an auxiliary chamber in constantly open communication with said combustion chamber through a permanently restricted passage, a spreading-member, and a nozzle adapted to inject fuel into said combustion chamber in such a way that said fuel before entering said combustion chamber moves through said restricted passage, and on that wise that said fuel after issuing from said nozzle hits against said spreading-member, and substantially coheres together until it has struck said spreading-member.

In testimony whereof I have affixed my signature in the presence of two witnesses.

ADRIAAN FREDERIK van AMSTEL.

Witnesses:
ANTON DER NAYTEGARD,
ANTONIO ELBERTO DOYER.