May 21, 1940. A. BOKEMÜLLER ET AL 2,201,220

INTERNAL COMBUSTION ENGINE

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Fig. 1.

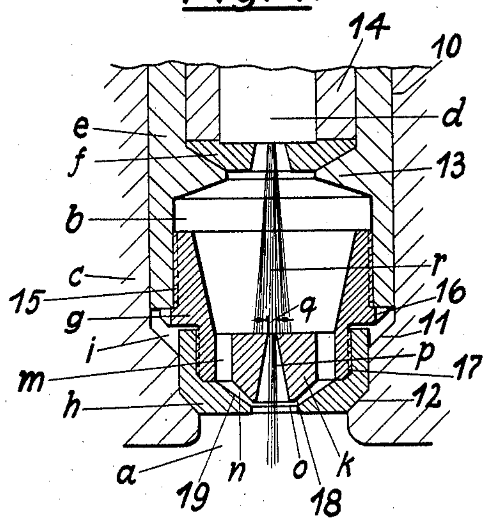


Fig. 2.

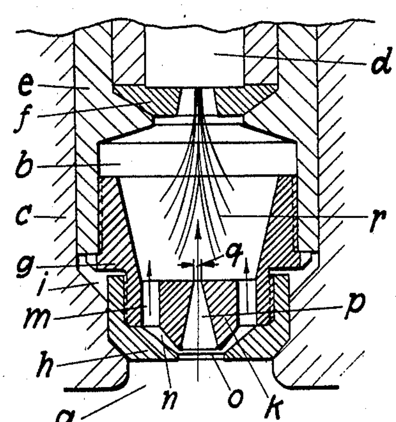


Fig. 4.

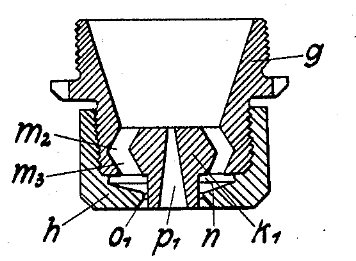


Fig. 3.

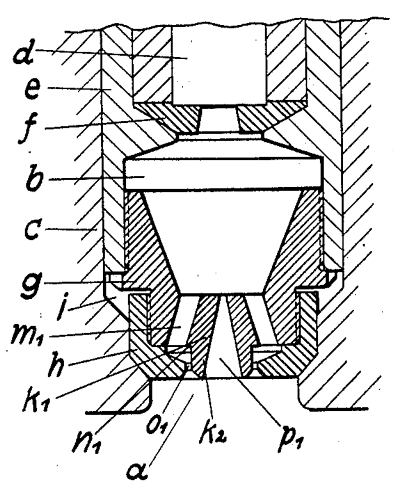
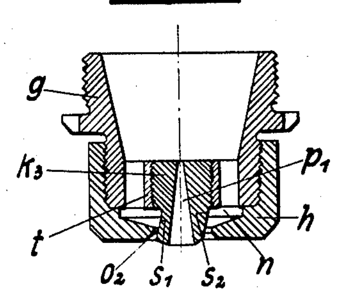


Fig. 5.



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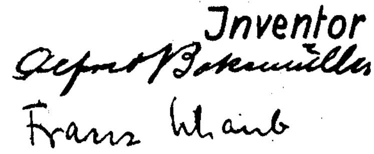

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UNITED STATES PATENT OFFICE

2,201,220

INTERNAL COMBUSTION ENGINE

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8 Claims. (Cl. 123—33)

The present invention relates to internal combustion engines, more particularly to engines of the Diesel type in which the fuel is injected into a precombustion chamber communicating with the main combustion space in the cylinder through a plurality of conduits surrounding a core member.

The object of the invention is an improvement of the fuel injection and pre-combustion means, whereby the engine is better enabled to be reliably and quickly started even at very low temperatures without necessitating the use of incandescent plugs or other auxiliary devices and without sacrificing the advantage which has been obtained prior to this invention by the interposition of a heat accumulating core member between the precombustion chamber and the main combustion space. These advantages are a flexible and smokeless operation of the machine within a very large range of speeds, as desirable for automotive purposes.

Further objects will appear from the description of various preferred embodiments of the invention following hereinafter, and the features of novelty will be pointed out in the claims.

In the drawing,

Figs. 1 and 2 illustrate axial sections through the pre-combustion chamber of an automotive engine, Fig. 1 illustrating the fuel spray during the starting operation and Fig. 2 showing the fuel spray during operation at a higher speed,

Fig. 3 illustrates a modification in a view similar to that of Fig. 1,

Fig. 4 shows an axial section through two modified elements of the combination, and

Fig. 5 is a view similar to that of Fig. 4 of two further modifications, the left-hand section of Fig. 5 and the right-hand section of Fig. 5 illustrating slightly differing embodiments.

For sake of simplicity, the central portion or another portion of the cylinder head only enclosing the pre-combustion chamber has been shown in the drawings. It is to be understood, of course, that the cylinder head is mounted on a cylinder in which a reciprocatory piston is guided and that the shape and the length of the piston stroke is so chosen as to provide for a main combustion space *a* in the upper part of the cylinder. The cylinder head is provided with a jacket (not shown) for the circulation of a cooling medium and has a central bore **10** with conical internal shoulders **11** and **12** for the insertion of the fuel injection and pre-combustion means.

These means include a bushing *e* having an internal collar **13** supporting an annular shielding member *f* which constitutes a seat for the fuel injector *d* and for a sleeve **14** surrounding the same. As the fuel injector is known, it is not illustrated in detail, but it may be mentioned that it may comprise a nozzle and a needle valve controlling the same. The pre-combustion chamber *b* is encased by the lower part of the bushing *c* and is confined therein by a cup-shaped member *g*. The upper section of this member is threaded on its periphery to engage an internal thread **15** in the lower section of the bushing *e* and has a collar **16** abutting against the lower end of the bushing. The lower section of the member *g* has a smaller diameter and is threaded on its periphery to engage internal threads **17** of a peripheral flange of an annular member *h* which is firmly seated on the shoulder **12**.

The bottom of the cup-shaped member *g* is provided with a plurality of peripherally distributed bores *m* of circular or other suitable cross-section. These bores form conduits constituting a permanent communication between the pre-combustion chamber *b* and the main combustion chamber *a*. In the embodiment of Fig. 1 they extend parallel to the axis but are so spaced therefrom that they do not afford direct straight-line passage to the globules of the injected fuel traversing the chamber *b*. The central portion *k* of the bottom of the member *g* constitutes a core member which accumulates heat in operation and serves to raise the temperature of the compressed air entering the chamber *b* and thus facilitates the ignition and improves the efficiency of the combustion. Intermediate its ends the member *g* is surrounded by a sealed space *i* acting as heat insulator.

In accordance with an important feature of the present invention the core *k* is provided with a port *p* which is substantially coaxially disposed with regard to the nozzle of the injector *d* and flares towards the main combustion space *a*. As the fuel is sprayed by the injector on to the core member *k*, it is evident that part of the fuel may directly pass straight through the port *p* into the combustion chamber *a*, provided that the fuel globules have sufficient momentum to penetrate the flow of air that takes place at the commencement of the injection period from the cylinder into the pre-combustion chamber *b*.

The core member *k* has a lower conical projection **18** between the conduits *m* forming a protruding lower mouth of the conduit *p*. This mouth projects into a shallow conical recess **19** provided in the upper face of the member *h*. The central opening o of this member is slightly larger than the mouth of the port p.

It will appear from the foregoing description that the annular member h constitutes a partition which is opposed to the bottom face of the core member k and confines therewith an annular duct n. This duct communicates with the conduits m and converges towards the lower mouth of the port p.

Preferably, the smallest cross-section of the port p is smaller than that of the conduits m. Therefore, in the embodiment shown, the diameter indicated at q is smaller than the diameter of the bores m.

The injector d is preferably of the type which issues a spray having a small spray angle and/or a powerful central core jet indicated at r which aims at the port p and is thus adapted to pass clearly through the port p into the main combustion chamber a as indicated in Fig. 1.

The operation is as follows: During the compression stroke of the piston and at the commencement of the fuel injection, compressed air flows from the combustion space a into the pre-combustion chamber b partly through the port p and partly through the duct n and the conduits m. As long as the speed of the piston is low, as is the case when the engine is started by an electric starting motor or by a momentum starting device or when operating at a very reduced speed, the difference of pressure existing prior to the ignition between the main combustion chamber and the pre-combustion chamber is comparatively small and, therefore, produces but a feeble air current flowing through the port p in upward direction. The strength of this current depends upon various factors, particularly on the dimensions of the port p, and these dimensions are so chosen with regard to the momentum of the globules of the injected fuel that the globules are capable of entering port p and of penetrating the feeble air current and directly entering the main combustion space a in which a higher temperature prevails than in the pre-combustion chamber b. Therefore, ignition will readily take place in the main combustion chamber and this ignition spreads into the pre-combustion chamber thus igniting the rest of the fuel. This operation can only take place, however, as long as the speed of the engine does not exceed a certain limit which may be in the neighbourhood of 250 R. P. M.

The flaring conical shape of the port p has the dual function of reducing the resistance met by the air current flowing from the space a to the chamber b and of preventing the fuel globules from condensing on the walls of the port or from being swept back by the air current after having passed the smallest cross-section q. It is evident that the speed of the air flow reaches a maximum at the smallest cross-section q and is a minimum at the wider lower mouth. Therefore, the fuel globules will meet with reduced resistance after having passed the cross-section q and in continuing their straight-line flight will get at the same time farther away from the walls of the port owing to the flaring shape thereof. Therefore, this flaring shape facilitates the penetration of the fuel globules into the highly heated air prevailing in the main combustion chamber a near the end of the compression stroke without striking the walls of the port p, whereby the ignition is secured even at such low temperatures at 5° F. or even less.

The operation of the machine at higher speeds is not adversely affected by the provision of the central port p. As soon as the speed exceeds a certain limit, the upward current flowing through the port p at the commencement of the injection period becomes so strong as to effectively block the port p to the entrance of fuel globules and as to sweep back any globules that might enter. In Fig. 2 the effect of this strong air current is illustrated. It is shown there that the current deflects the path of the fuel globules laterally thus broadening the core of the fuel jet. Therefore, at higher speeds, for instance at a speed of 400 or 500 R. P. M., the pre-combustion chamber operates substantially in the same manner as though the port p did not exist. Since the conduits m, the duct n and the opening o have a much larger cross-section than the port p, the pressure which is produced in the pre-combustion chamber by the combustion and is operative to blow the mixture of fuel, air and gas into the main combustion space a through the conduits m, the duct n and the opening o is not materially reduced by the provision of the port p.

The only effect which the provision of the port p may have in normal operation is the beneficial function of producing an air blast at the commencement of the injection period which enters the pre-combustion chamber spreads the fuel jet and improves the atomization and distribution of the fuel, whereby the efficiency of the combustion is improved and the fuel consumption reduced.

In the embodiment of Fig. 3 the elements g, k and h have been slightly modified. The conduits surrounding the core member k_1 are formed by bores of the member g which are so inclined that their axes intersect in a point located on the axis of the pre-combustion chamber near the injector d. Owing to this arrangement, the compressed air entering the chamber b through the conduits m_1 is directed towards the core of the fuel spray in a similar manner as the air current entering through the port p_1. Owing to this direction of the air currents, the atomization of the fuel at higher speeds is further improved and heat is more quickly imparted to the fuel.

A further improvement of this embodiment is the shape of the projection k_2 of the core member k_1. This projection extends through the opening o_1 into direct proximity to the main combustion chamber. Otherwise the structure and function of this embodiment is the same as that shown in Fig. 1.

In the embodiment shown in Fig. 4, the elements g and h differ from those shown in Fig. 1 in that the conduits surrounding the core member do not extend parallel to the axis of the pre-combustion chamber but are comprised of two sections m_2 and m_3 extending at an angle to each other.

In the embodiment of Fig. 5, the core member surrounded by the conduits is not integral with the member g but is formed by a separate cylindrical element k_3 provided with external threads and screwed in a tapped central bore provided in the bottom of the cup-shaped member g. The thread constitutes a means for axial relative adjustment of the core member g and the partition member h.

The lower projection of the core member extending through the opening o_2 may have different contours as shown at the right or at the left of Fig. 5. At the left, the lower projection of the core has a conical face s_1 which so cooperates with the rim of the opening o_2 of the partition member that downward displacement of the core member increases the cross-section of the annular passage therebetween. At the right of Fig. 5, the projection has an oppositely inclined conical face s_2, whereby downward adjustment of the core will reduce the cross-section of this passage. Owing to this structure, the elements may be so relatively adjusted as to meet the particular requirements of any case regarding the nature of the fuel, the speed of operation and so forth. More particularly, the axial relative adjustment of the projection k_2 and the partition member h affords a possibility of relatively varying the cross-section and the position of the mouth of the port p and of the mouth of the duct n_1 and of relatively proportioning the amount of fuel issuing from these mouths.

If desired, the conduits h and/or the port p may be provided with internal helical grooves and ribs adapted to impart rotation to the air or gas currents passing therethrough.

Experience has shown that, with an engine of approximately 30–75 cubic inches piston displacement per cylinder as used for automotive purposes, the best results are obtained with a central port of conical shape having a smallest diameter q of .04 to .08 inch and having a largest diameter of .16 to .24 inch, i. e., where the area of the central passage at its smallest part expressed in square inches is 1/6,000 to 1/60,000 of the piston displacement volume expressed in cubic inches. The injection pressure must be selected to meet the particular requirements of any case, particularly the requirements resulting from the distance from the mouth of the injection nozzle to the mouth of the central port p. The pressure may amount, for instance, to 1,400 to 2,000 pounds per square inch.

As a rule, the volume of the pre-combustion chamber b amounts to 25 to 40 per cent of the entire compression space comprised of the chamber b and the space a. The smaller the piston displacement and the larger the speed of operation, the larger will be this percentage.

The number of conduits m will be preferably 6 to 8 each of which may have a cross-section which is two to four times that of q, so that the cross-sectional area of the outer conduits will be from 12 to 32 times that of the port p at the point q.

The term "flaring shape" applied to the port p is intended to include a step-shaped profile of the port p, the diameter of the different steps becoming larger towards the main combustion space a. Moreover, the mouths of the port p may have rounded edges.

While various specific embodiments of the invention have been described hereinabove, it is to be understood that the invention is not limited to the details thereof but is capable of numerous modifications within the scope of the appended claims.

What we claim is:

1. In an internal combustion engine, a cylinder including a main combustion space, a precombustion chamber, a fuel-injecting nozzle opening into said pre-combustion chamber, and a heat accumulating core member interposed between said pre-combustion chamber and said space and at least one conduit establishing communication between said main combustion space and that portion of said pre-combustion chamber which is nearest the main combustion space, said core being provided with a port which is substantially coaxially disposed with regard to said nozzle offering to the injected fuel a direct straight-line passage from said nozzle into said space, said port being of such cross-section relative to the dimensions of the engine that when the engine operates substantially above starting speed the passage of the fluid jet through said port is prevented by the air flowing from said main combustion space to said precombustion chamber.

2. In an internal combustion engine, a cylinder including a main combustion space, a precombustion chamber, a fuel-injecting nozzle opening into said pre-combustion chamber, and a heat accumulating core member interposed between said pre-combustion chamber and said space and at least one conduit establishing communication between said main combustion space and that portion of said precombustion chamber which is nearest the main combustion space, said core being provided with a port which is substantially coaxially disposed with regard to said nozzle offering to the injected fuel a direct straight-line passage from said nozzle into said space, said port having a cross-sectional area of 1/6,000 to 1/60,000 of the piston displacement of said cylinder whereby when the engine operates substantially above starting speeds, passage of the fluid jet through said port is prevented by the air flowing from said main combustion space to said precombustion chamber.

3. In an internal combustion engine, a cylinder including a main combustion space, a precombustion chamber, a fuel injecting nozzle opening into said precombustion chamber, and a heat accumulating core member interposed between said precombustion chamber and said space, said core member being surrounded by a plurality of conduits which establish communication between the main combustion space and that portion of said precombustion chamber which is nearest the main combustion space, said conduits being so constructed and arranged that fuel injected by said nozzle cannot pass directly through said conduits and into the main combustion space, said core being provided with a port which is substantially co-axially disposed with regard to said nozzle and offering to the injected fuel a direct straight-line passage from said nozzle into said main combustion space, said port being of such cross-section relative to the dimensions of the engine that when the engine operates substantially above starting speed the passage of the fluid jet through said port is prevented by the air flowing from said main combustion space to said precombustion chamber.

4. In a fuel injection internal combustion engine, a main combustion space, a precombustion chamber in communication therewith, a fuel injecting nozzle opening into said precombustion chamber, a plurality of channels communicating between the main combustion space and the precombustion chamber, one of which channels comprises a port which is substantially co-axial with the fuel jet and is made of sufficiently small cross-sectional area relative to the dimensions of the engine so that while at starting speed a part of the fuel is injected directly through said port into the main combustion space at higher speeds the fuel is prevented from being sprayed directly into the main combustion space due to the velocity of the counterflowing air, the other communicating channels being located outwardly of the fuel jet and being so constructed and positioned that a direct spraying of the fuel there-

through into the main combustion space is substantially prevented, the latter channels each having a larger cross-sectional area than the said co-axial port and serving during normal operation for the delivery of most of the fuel into the main combustion space.

5. In a fuel injection internal combustion engine the combination according to claim 4 in which the injection nozzle is so constructed as to deliver a narrow fuel jet toward the said port and whereby the second mentioned communicating channels so surround the said port that their points of entry into the precombustion chamber lie substantially outside of the fuel jet, however so near thereto that upon the occurrence of higher speeds they lie within the cone of the fuel jet which has been broadened due to the counter current of air through the said port.

6. In a fuel injection internal combustion engine the combination according to claim 4 wherein the narrowest cross-section of the said port is not more than one-tenth of the total cross-section of all the communicating passages.

7. In a fuel injection internal combustion engine the combination according to claim 4 wherein the said port is narrowest at the point of connection with the precombustion chamber and expands conically from the said point toward the main combustion space.

8. In a fuel injection internal combustion engine the combination according to claim 3 in which the port co-axial with the fuel nozzle is so formed that its smallest cross-section occurs only at the point where it connects with the precombustion chamber and that its cross-section increases from said point toward the main combustion space.

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