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INTERNAL COMBUSTION ENGINES

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Fig. 1.

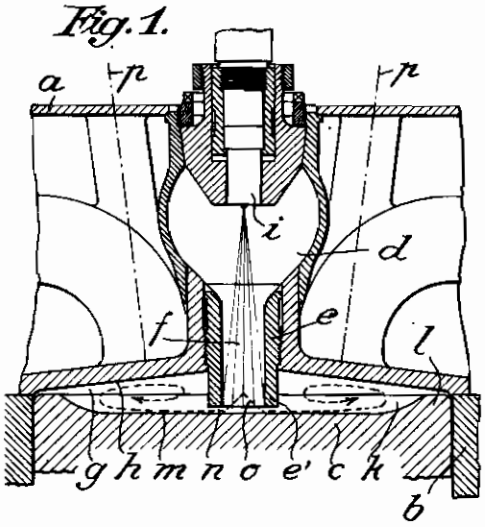


Fig. 2.

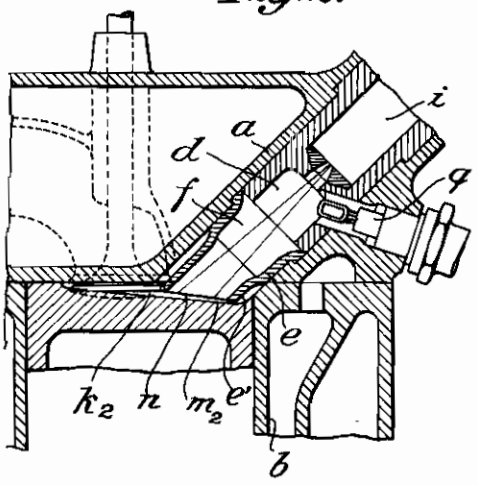


Fig. 3.

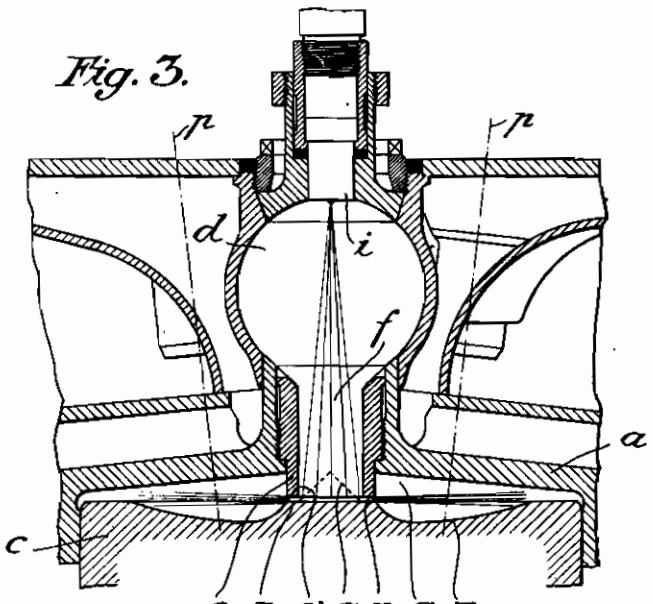
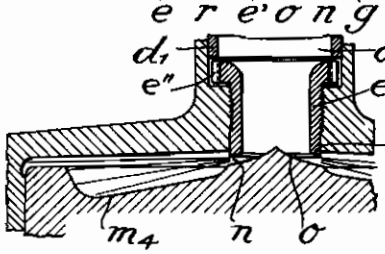


Fig. 4.



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ALIEN PROPERTY CUSTODIAN

INTERNAL COMBUSTION ENGINES

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The invention relates to an improvement of internal combustion engines and an improved method of operation of such engines.

One object of the invention is a decrease of the losses arising from the throttling of the charge within the cylinder and combustion space of engines with divided combustion space, but without giving up the advantages of such engines. Furthermore, the invention aims at a better combustion, a higher medium pressure, a higher output, a lower fuel consumption, and more favorable thermic conditions of the piston and the walls of the combustion space.

One feature of the engine and the method according to the invention consists in the fact, that during the greater part of the piston stroke a part of the combustion space receiving the fuel or at least a part of the fuel is in not-throttled or in relatively little throttled connection with the cylinder space, and that only near the upper dead centre position of the piston, i. e. at the end of the compression stroke, this partial space will be throttled or additionally throttled specially by the piston, in comparison to the rest of the combustion space, so that a substantially ring shaped throttling connection remains between the two part-spaces of the combustion space. This substantially ring shaped throttling connection may be formed either by means of a ring shaped, substantially radially directed throttle slit or by means of substantially radially and circularly arranged separate openings or the like. Furthermore the throttling connection may be preferably formed on the one side immediately by corresponding walls of the cylinder head or of the part-space receiving the fuel, and on the other side by the piston. The piston may preferably serve as impact face for the fuel in order to distribute it after deviating it through the substantially ringshaped throttling connection into the rest of the combustion space. In a particularly advantageous type the latter is formed by a recess in the piston, preventing a striking of the fuel upon the cylinder wall, but allowing simultaneously an effective mixture of air and fuel.

The exceedingly good combustion, the high medium pressure, the high output and the exceedingly small fuel consumption (down to 150 grammes per HP-hour) may be explained by the following circumstances.

In consequence of the short time throttling effect between the injection space and the rest of the combustion space at the approach of the piston to the upper dead centre, and in consequence of the otherwise comparatively unthrottled connection between the two spaces, the generally underrated pumping losses of the piston will be effectively diminished.

The deviation of the fuel mixture makes a uniform distribution of the fuel over the main combustion space possible, so that the entire air contained in the combustion space will be utilized for the combustion, the circular throttling slit guaranteeing a sufficient pressure for an effective spraying into the injection space. By the application of the piston recess the fuel is furthermore prevented on one side to strike the cylinder wall and thereby to cause deposits and a smoky exhaust, and on the other side by these means an advantageous whirling in the main combustion space may be produced by the fact that the air, displaced over the outer piston rim, executes a torus-like whirling motion above the piston recess which may be still increased by the contents of the chamber emerging through the ring shaped slit.

The fuel cone striking in full width the piston bottom without, or without essential preceding throttling, the effect of the burning jet onto the piston bottom is distributed onto a comparatively large surface. The piston will also be stressed thermically only comparatively little by the fact that the flame of the fuel mixture, when striking upon the piston, is still in throttling connection, compared with the main combustion space, and consequently in want of air. Therefore the flame is less hot when striking upon the piston bottom in the upper dead centre than with the well known machines in which the fuel strikes the projections of the piston only after passing through a throttling connection within the main combustion chamber.

When the fuel crosses the injection space without striking upon hot insertion parts, a further danger of burning or scaling of such parts or of a cracking of still liquid fuel parts may be avoided to great extent. The wall of the intake channel eventually protruding into the main combustion space may be made integral with the wall of the cylinder head by means of welding or may be formed by a special insertion piece which may be more or less isolated against the cylinder wall. A protruding of the intake channel until near to the bottom of the piston recess may be of advantage.

Furthermore the starting capacity of the engine may be improved by the fact that on the one hand the throttling of the air entering the injection chamber during the compression stroke is

only small, so that only small losses will occur by the cooling of the air, and that on the other hand the fuel will partly come directly from the injection nozzle into the hotter air prevailing above the piston bottom in the cylinder space, or the main combustion chamber.

Of further importance is under circumstances the arrangement of the injection nozzle in such a way that a sufficient injecting length i. e. a distance of sufficient length between the nozzle and the piston bottom exists. This distance is preferably of such length that the fuel, when striking the piston bottom, is in preparation for the ignition or partly in a state of burning, on the other hand however the aimed at impact effect of the fuel jet at the impact face, for instance the piston bottom, is obtained. As a rule the distance between the mouth of the injection nozzle and the piston bottom will be about the size of half of the cylinder diameter.

In order to have a sufficient quantity of air in the injection chamber for producing a partial ignition and a sufficient rise of pressure in it, the injection chamber may comprise in a way of a pre-combustion chamber, for instance an enlarged space next to the injection nozzle to which joins the intake channel receiving the fuel jet. Eventually however the injection chamber may consist of a space in form of a channel of substantially uniform diameter, specially if this is sufficiently wide for receiving the required quantity of air.

The width of the circular slit for the sizes of aeroplane and automobile engines amounts to about 2–4 mm.

The injection chamber is generally arranged substantially central to the cylinder axis or the main combustion chamber, other arrangements being however possible. So for instance in a special type of the invention the injection chamber in the upper dead center being connected by a narrow ring shaped slit with the remaining combustion space is arranged eccentric and slanting to the axis of the cylinder. This arrangement is specially of advantage for smaller engines of higher speed, having only two valves each in a cylinder head, for instance an inlet and an outlet valve. By the lateral and slanting arrangement of the injection space, this space requires little room so that the valves may obtain a sufficiently large cross section, and the cooling of the valves or the walls of the injection chamber will not be lessened. If the injection chamber is at the same time in the shape of a channel and without an essential enlargement, this chamber will require still less space. Simultaneously the advantage of a diminished surface of the injection chamber will be reached.

The injection space may for instance discharge into an eccentric recess in the piston bottom, flatly extending for instance towards the opposite side. In this case the fuel which is injected longitudinally into the injection chamber strikes upon the piston bottom and an angle and is distributed according to this angle, from the striking place substantially towards the side of the cylinder centre, so that also in this case a substantially uniform distribution of the fuel across the main combustion chamber is reached. The flat extending of the piston recess towards the side opposite to the combustion chamber in this case is generally without drawback, as in consequence of the increased distance between the mouth of the injection space and the opposite side of the cylinder wall, a striking of liquid fuel onto this wall is not to be apprehended.

The injection chamber may be enclosed entirely or partially by a lining which may simultaneously contain the mouth of the injection chamber, protruding into the main combustion chamber. This lining may, according to the required heat derivation by means of isolating slits or isolating spaces be entirely or partially separated from the wall of the cylinder head.

The ring shaped slit formed in the upper dead centre may have a uniform width of slit over its circumference. The width of the slit may however be varying specially if the injection chamber is arranged eccentrically, if for instance the end face of the wall of the injection chamber protruding into the piston recess shows a certain incline to the piston bottom, so that a slit is produced having a greater width towards the side of the cylinder axis than towards the side averted from the cylinder axis. By these means the fuel quantity passing through the respective cross section of the ring shaped slit is accounted for. In the accompanying drawing four types of my invention are illustrated in the Figs. 1, 2, 3 and 4.

In Fig. 1, in the cover *a* of a cylinder *b*, centrally above the piston *c* an injection space in the manner of a pre-combustion chamber is provided. In the mouth of this pre-combustion chamber a cylindrical insertion *e* is applied which in the case illustrated is screwed into the cylinder wall and contains a cylindrical discharge channel *f*. This insertion protrudes with its lower end *e'* above the wall *h* of the cylinder cover, limiting the main combustion chamber *g*, into the main combustion chamber and is horizontally cut off at its free end. Axially to the discharging canal *f*, above the pre-combustion-chamber, the injection nozzle *i* is inserted into the cylinder head.

The bottom of the piston *c* shows a recess *k* in the shape of a flat trough extending towards the piston rim *l* in such a manner that in the upper dead centre between the lower end *e'* of the insertion and the bottom of the piston recess a narrow ring shaped slit *n* is formed. For deviating the fuel or fuel mixture a deviating cone o may be provided at the bottom of the recess. The inlet and outlet valves indicated at *p* are preferably arranged above the piston recess. The interior diameter of the insertion *e* is so dimensioned that the fuel jet leaving the nozzle *i* after having crossed the pre-combustion chamber *d*, and here being mixed with air, and eventually being partly ignited, practically passes unthrottled through the discharging channel as indicated by the drawn course of the jet. The throttling required at the beginning of the combustion stroke ensues through the ring shaped slit, the width of which may be controlled by means of an axially adjustable arrangement of the insertion. Through the ring shaped slit the fuel mixture is distributed along the piston bottom into the recess *k* and the main combustion chamber *g*, without coming direct in contact with the cold cylinder walls. By these means and by the displacement of the air above the piston rim *l* when approaching the upper dead centre a torus-like air motion is effected in the main combustion chamber shown in the drawing by a dotted line, which eventually may still be increased by a corresponding shape of the wall *h* of the cylinder head.

For engine sizes in use for aeroplanes and automobile motors a flat recess with a bottom diam-

eter of about 60 to 80% of the cylinder diameter and a depth of about 10 mm. has proven favorable. Preferably the ring shaped slit end has a width of 2–3 mm. and should not be larger than 4 mm. in the upper dead centre of the piston. The distance of the nozzle mouth from the piston bottom corresponds in its size about to half the cylinder diameter, and the diameter of the discharge channel *f* to at least a fifth, and its length to about half this distance.

The insertion *e* may be put into the cylinder head without special isolation. Eventually the bottom of the piston recess may be raised in its centre so that the slit is formed between this raised portion and the lower end of the discharge channel. The main combustion chamber may also be formed mainly by a corresponding cavity made in the cylinder head instead of the recess in the piston bottom.

Preferably the ring shaped slit is directed horizontally outward. Eventually it may however be directed slantingly downward or slantingly upward if the piston bottom is formed correspondingly. Furthermore the ring shaped slit may under circumstances be divided into single apertures, by means of ribs arranged in the piston bottom, or it may have different widths on its circumference. The indication of a substantially ring shaped throttling connection should comprise all these forms.

With the type of the invention according to Fig. 2 the injection space *f* in the cylinder head *a* is arranged slantingly and eccentric to the cylinder axis. Near the injection nozzle *i* it has an enlargement *d* in the way of a pre-combustion chamber which eventually may be omitted by the fact that the injection space from the nozzle onto the discharge into the main combustion chamber has a uniform cross section. The narrow part of the injection space is surrounded by a lining *e* which is inserted tight fitting or with play, into the corresponding bore of the cylinder head, the lower end *e'* of which protrudes into a recess k_2 of the piston *c* and is slanting in such manner, corresponding to the bottom of the piston recess, extending flat towards the opposite side, that in the upper dead centre of the piston a narrow ring shaped slit end is produced between the end face of the lining *e* and the bottom m_2 of the recess. As shown, the slit *n* may be wider on the side adjacent the cylinder axis than on the opposite side.

The fuel is injected through the injecting nozzle in axial direction of the channel shaped injection space under an angle onto the bottom m_2 of the piston recess, after which the fuel being partly in burning state distributes through the narrow ring shaped slit *n* into the main combustion chamber, and that substantially towards the side of the cylinder axis. As for the rest, the manner of operation for this type, which is given by way of example, is substantially the same as explained for the arrangement according to Fig. 1.

An incandescent ignition plug *q*, serving for the start may be omitted under circumstances, as the starting of engines according to the invention is substantially facilitated, also when the engine is in cold condition.

The arrangement with eccentric and slantingly arranged injection space is specially meant for such engines which have only a single inlet- and outlet- valve *p*. The eccentric and slanting position has, as mentioned above, in this case the advantage that there is enough space for the arrangement of sufficiently large valves.

Specially such an arrangement is of advantage for engines of smaller dimensions, if eventually it may be applied to engines of larger dimensions.

The type of the invention according to Fig. 3 is distinguished from the one according to Fig. 1 substantially by the fact that the piston has a ring shaped recess m_3, so that within same an elevation *r* is formed serving as impact face for the fuel injected from the nozzle *e* through the pre-combustion chamber *d* and the channel *f*. The impact face may again be provided with a deviating cone o.

The slit *n* is formed by the endwall *e'* of the insertion *e* and by the elevation *r* of the piston. While with a shape m_2 of the recess the main combustion chamber is crossed by the fuel deviated at the impact faces *r* or o substantially in radial direction, the recess form may also be adapted to great extent to the fuel jet deviated in outward direction.

As for the rest, corresponding parts are designated with corresponding reference characters like in the Figs. 1 or 2.

The type of the invention given in Fig. 4 is distinguished from the one according to Fig. 3 substantially by the fact that the ring shaped slit *n* is directed not exactly radially in outward direction but somewhat slanting towards below. For this purpose the end edge of the extension *e'* of the insertion *e* is beveled a little conically and the deviating cone o is shaped correspondingly. The piston recess m_4 is deepened by and by from the cylinder axis towards the circumference and is adapted substantially to the fuel jet leaving the ring shaped slit *n*. The insertion *e* is provided with teeth *e''* engaging corresponding teeth of an insertion d_1 forming the chamber *d*. By changing the screwed position *e* or d_1 the width of the slit *n* may be changed. The insertion d_1 may be locked against turning in the cylinder head by any suitable way and may at the same time surround the injecting nozzle as shown in the type according to Fig. 2.

The features of the type according to Fig. 4 may be for example applied onto the types or embodiments of the invention according to Figs. 1, 2 or 3, such as, on the whole the features of the single types may be interchanged each other.

Furthermore, for instance, the channel *f* may be of smaller diameter as shown so as to form a first throttling connection between the partial combustion space *d* and the partial combustion space *g* or the cylinder space. The split *n* may be, in this case, a second or additional throttling connection. However, in other cases, it may be the only throttling connection between the two partial combustion spaces, for instance a pre-combustion or injection space and the main combustion or cylinder space.

Furthermore, the partial combustion space receiving fuel may be formed by a chamber arranged in the piston, in which for example the fuel may be injected from the cylinder head. Also, the invention is not restricted to such engines, in which the whole fuel is injected or otherwise introduced into one partial combustion space throttled from the remaining combustion space in the upper dead center position of the piston. Under circumstances, fuel may be also injected or introduced into another partial combustion space.

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