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INJECTION INTERNAL COMBUSTION ENGINE ESPECIALLY FOR LIGHT FUELS WITH TIMED SPARK IGNITION
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Fig. 1.

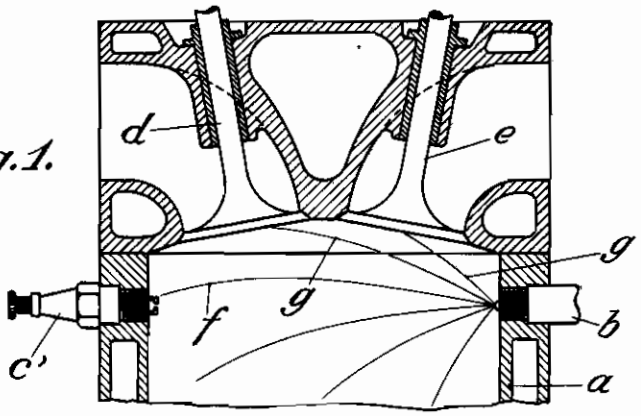


Fig. 2.

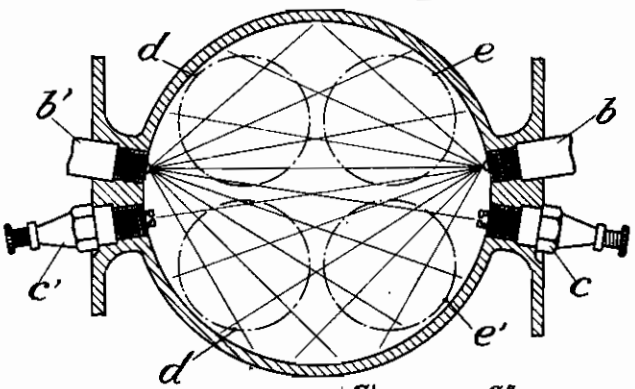
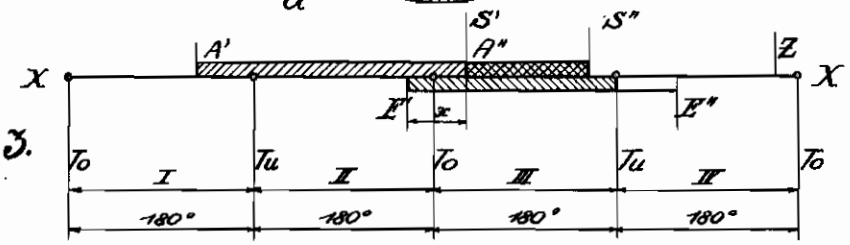


Fig. 3.



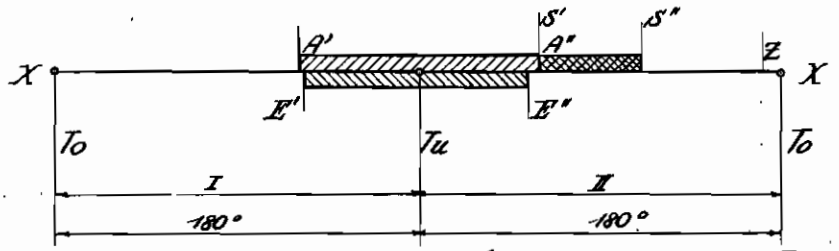


Fig. 4.

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INJECTION INTERNAL COMBUSTION ENGINE ESPECIALLY FOR LIGHT FUELS WITH TIMED SPARK IGNITION

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This invention relates to an improvement in internal combustion engines with relatively low compression and plug ignition especially such which are working with light fuels. It has been found that a cause for the knocking is that even in the case of very thorough fuel diffusion and enrichment of the combustion air with fuel by a single injection nozzle a so-called poor mixture with low fuel content is present in the combustion chamber, chiefly in the zone lying in the injection shadow in proximity to the nozzle mouth. If the ignition is started on the sparking plug electrodes in the zone of the mixture rich in fuel, a pressure wave moves in advance of the combustion flame and causes the highly explosive mixture poorer in fuel to ignite prematurely. This initial ignition then causes an undesirable knocking with the known disagreeable results. The arrangement of two injection nozzles renders it unnecessary to sharply deflect the fuel jets towards the wall on which the nozzle is arranged. The arrangement of two nozzles in the above mentioned type of engine is more preferable than a single nozzle with a larger number of directed injection jets because the injection procedure takes place during the suction stroke, that is at a time of great turbulence as regards the movement of air and mixture in the cylinder.

Following the above knowledge the present invention consists in that several injection nozzles, that is at least two, are arranged in such a manner that their injection jets spread over the whole combustion chamber so that there is not produced at any point a zone with a poor fuel-air mixture. This is chiefly obtained by providing the nozzles in a certain distance from each other, preferably two nozzles being opposite to each other or nearly opposite to each other. Advantageously they are arranged in about the same height of the cylinder wall. Apart therefrom a more favourable combustion is attained by the more uniform enrichment of the compression air with fuel, resulting in that the internal combustion engine can be driven with an extraordinarily low fuel consumption for the same preformance. The saving in fuel is considerable.

The number of nozzles and sparking plugs is unlimited as such. Two nozzles and one sparking plug may also be provided. A particularly advantageous arrangement has been found to be the arrangement of two sparking plugs and of two nozzles so that a sparking plug and a nozzle are actually opposite one another on the suction and exhaust sides and a sparking plug and a nozzle are actually directly side by side. In this case— and also when using more plugs and nozzles— the sparking plugs are advantageously arranged in about the farest possible distance from each other. It is also advisable to actually arrange the plug on the one side opposite the injection nozzle on the other side in such a manner that the plug electrodes are directly impinged upon by the fuel jet of this nozzle. Other fuel jets of the injection nozzles are, however, distributed over the combustion chamber so that every combustion zone is uniformly supplied with fuel. If valves are present, fuel jets from both injection nozzles are directed also towards these valves which are cooled by the fuel evaporating on them.

The invention is especially useful in case of engines where the fuel is injected rather early, i. e. already during the suction stroke of the engine. This, because such engines offer special difficulties to obtain an uniform distribution of the fuel.

An embodiment of the invention is illustrated diagrammatically by way of example in the accompanying drawing, in which

Fig. 1 shows in longitudinal section an internal combustion engine cylinder equipped with an admission and an exhaust valve, two sparking plugs and two injection nozzles.

Fig. 2 is a cross-section through the cylinder shown in Fig. 1.

Fig. 3 is a lineal diagram for a four stroke cycle engine and

Fig. 4 is a lineal diagram for a two stroke cycle engine.

In Figs. 1 and 2 the cylinder space is designated by *a*, the injection nozzles by *b* and *b'* respectively, the sparking plugs by *c* and *c'* respectively, the admission valve by *d* and the exhaust valve by *e*. In the example chosen each injection nozzle is diametrically opposite another injection nozzle and the injection nozzles and sparking plugs on each side of the cylinder are arranged side by side (Fig. 2). Furthermore, a sparking plug is always opposite an injection nozzle in such a manner that the ignition electrodes of the plugs are directly impinged upon by a fuel jet, as indicated for example by the reference *f* in Fig. 1. Other fuel jets *g* of the injection nozzles are preferably directed towards the valves nearest the injection nozzles, on which valves the fuel evaporates and thus cools the valves. Yet other fuel jets are distributed over the combustion chamber so that the whole combustion chamber is uniformly supplied with fuel and, if desired, the piston is cooled by the fuel sprayed on and evaporating thereon. As Fig. 2

shows the two injection nozzles produce a close network of intersecting fuel jets, this excluding the formation of poor mixture zones detrimentally influencing the combustion process. The fuel jets according to the invention may intersect or meet. Particular care must be taken that the zones of the combustion chamber in proximity to the injection nozzle mouths are effectively enriched with fuel. By the double arrangement of the sparking plugs the ignition takes place simultaneously at two opposite plugs and the pressure waves from explosion meet above the piston in the middle of the combustion chamber. In this manner the piston is centrally stressed in a favourable manner. If there are two admission and exhaust valves, as indicated for example by the references *d*, *d'* and *e*, *e'* respectively in Fig. 2, it must be seen that all four valve bodies are impinged on by cooling fuel jets.

The internal combustion engine is preferably driven in such a manner that the injection takes place still during the suction stroke, just about the closing, i. e. before the end, at the end or more or less after the end of the closing of the exhaust port, the admission and exhaust times preferably overlapping considerably for example by a crank angle of 40 to 140°. It is furthermore advantageous to drive the engine in such a way that the fuel is injected by so-called closed injection nozzles in such a manner that the fuel jets either cross or intersect (i. e. have to a certain extent a common plane when seen from above) and particularly an enrichment takes place in the fuel zones in proximity to the nozzles.

Fig. 3 shows the diagram of a four stroke cycle. The line X—X corresponds to two complete rotations of the crank shaft, comprising the working stroke I, scavenging stroke II, suction stroke III and compression stroke IV. To designates the upper and Tu the lower dead centre position of the working piston. A' designates the opening and A'' the closing of the exhaust. E' designates the opening and E'' the closing of the admission. The ignition takes place at Z by the jumping over spark.

As can be seen from Fig. 3 the exhaust and admission periods overlap in the region *x* of the upper dead centre position between the scavenging stroke II and the suction stroke III. At the moment the exhaust port is closed at A'' the injection proceeding *b* commences at S' and terminates for example at S''. A good scavenging effect is attained by the large overlap *x*. Loss of fuel is impossible on account of the late injection. The injection proceeding can also commence later and terminate earlier or later than indicated in Fig. 3. The limit of commencement of the injection exists when the injection proceeding takes place directly before the closing of the exhaust port. The extent to which this is possible without loss of fuel is dependent upon the type of scavenging process used or upon the path along which the injected fuel particles are carried along by the scavenging air from the inlection nozzle to the exhaust port. The important point is, that the fuel can no longer enter the exhaust through the open exhaust port.

Fig. 4 shows the diagram of a two stroke cycle engine. In this construction the line X—X represents one rotation of the crank shaft and the exhaust and admission times A', A'', E', E'' are controlled symmetrically to the lower dead centre position Tu between expansion stroke I and compression stroke II, for example by the piston. The fuel injection S'—S'' also takes place after the closure of the exhaust port and the ignition occurs at Z.

Special circumstances may make it appear advisable to arrange the fuel injection nozzle, inclined preferably downwardly, relative to the cylinder axis. The best arrangement has been found to be that in which the fuel injection nozzle arranged on the suction side of the cylinder forms an angle of about 20° with the cylinder axis, whereas for the injection nozzle located on the exhaust side an angle between 15 and 45° may be chosen. An inclination of 45° has been found particularly favourable. The nozzle mouths should preferably according to the invention be protected against the high explosion pressure and the hot explosion flame, so as to always maintain the injection diagram of the nozzles as uniform as possible. This is effected in a simple manner in that the nozzle mouths are arranged so deeply as possible below the upper piston dead centre position that the piston covers the nozzle mouths at the moment of ignition.

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