1,156,821

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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Int. Cl.:—F 02 b 19/04.

COMPLETE SPECIFICATION.

Compression Ignition Internal Combustion Engine.

I, ERNEST EDWARD CHATTERTON, a British subject, of 24, Wood Lane, Ruislip, Middlesex, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to reciprocating internal combustion engines operating on the compression ignition system, that is to say of the kind in which the combustion of fuel is initiated in the working chamber of the engine by compressing air into which the fuel is introduced to a degree such as to raise its temperature to the self-ignition temperature of the fuel. In reciprocating internal combustion engines operating on the compression ignition system as at present made, the usual practice is to employ a compression ratio such that air admitted to and compressed within the working chamber will reach a temperature above the self-ignition temperature of the fuel which is injected into the compressed air charge, and it is an object of the present invention to provide an improved form of reciprocating internal combustion engine operating on the compression ignition system in which the devices required for admission of fuel may be simplified and the mixing of fuel and air with a view to obtaining complete combustion facilitated, with a corresponding increase in the utilisation of the air and increase in power output.

A reciprocating compression-ignition internal combustion engine according to the present invention has means for admitting into the working chamber a combustible charge of fuel and air for compression between the relatively reciprocating parts, the charge being in a condition capable of compression self-ignition on admission, and in which engine there is provided on one of the said relatively reciprocating parts at least one projection formed integrally with or fixed to the said part, which projection, towards the end of the compression stroke, enters a co-operating close-fitting recess formed in the other of the relatively reciprocating parts so as to trap a portion of the charge in the recess, the relative dimensions of the various parts being such that the portion of the charge trapped in the recess by the projection will be subjected by the relative movement of the projection into the recess during the remainder of the compression stroke to a higher compression pressure than the portion of the charge remaining outside the recess, the said higher compression pressure being sufficient to raise the temperature of the portion of the charge trapped in the recess to self-ignition temperature and thereby ignite the charge in the recess.

The projection may be adjustably fixed to the said part so as to enable the compression ratio in the recess to be varied.

When the invention is applied to an engine having at least one main cylinder containing a single reciprocating piston, the projection or projections may be formed on the piston and the recess or recesses in the cylinder head, or the projection or projections may be formed on the cylinder head and the recess or recesses in the piston.

The invention is also applicable, however, to internal combustion engines comprising at least one main cylinder containing two oppositely moving pistons—generally called opposed piston engines—in which the projection is formed on one of the two pistons in each cylinder and the recess in the head of the other piston.

The dimensions of the appropriate parts are chosen so that the pressure applied to the portion of the charge compressed in the recess will be sufficient to raise it to fuel ignition temperature despite any leakage of the charge through the working clearance between the projection and the circumferential wall of the recess under conditions of maximum working clearance. Thus, the nominal working clearance between the projection and the recess must be such as to allow for a small degree of relative generally transverse movement between the parts on which the projection and in which the recess are formed as well as variations in working clearance due to temperature changes.

Moreover in the case of engines comprising one or more cylinders each containing a single reciprocating piston, means may be provided for varying the clearance volume of the recess as by axial adjustment of the projection or the part containing the recess.

The invention may be carried into practice in various ways and a number of constructions and modifications of them according to the invention as applied to a single-cylinder engine will now be described by way of example with reference to the accompanying drawings, in which

Figure 1 is a cross-section through one form of engine according to the invention in a plane containing the cylinder axis and at right angles to the crank-shaft axis,

Figure 2 shows in cross-section a modification of the arrangement shown in Figure 1,

Figure 3 is a similar view to Figure 1 of an alternative form of engine according to the invention,

Figure 4 is a cross-section of a modification of a kind which may be incorporated in constructions operating similar to those shown in Figure 1, Figure 2, Figure 3, or in Figure 5, Figure 6 or Figure 8 hereinafter referred to,

Figure 5 is a further cross-section showing an alternative form of construction which may be incorporated in an engine according to the invention,

Figure 6 is a cross-section of a still further modification which may be incorporated in an engine according to the invention,

Figure 7 is a plan view of the construction shown in Figure 6, and

Figure 8 is a cross-section showing one way in which the invention may be incorporated in an engine of the opposed piston type.

The engine shown in Figure 1 comprises a conventional cylinder 1 secured to a crank case 2 in which is supported a crankshaft 3 the crank pin 4 of which is surrounded by the big end bearing 5 of the connecting rod 6 having its small end 7 connected by the usual small end bearing 8 and a gudgeon pin 9 to a piston 10, all in conventional manner.

Connected to the upper end of the cylinder block is a cylinder head 11 provided with inlet and exhaust valves 12 and 13 respectively controlling inlet and exhaust ports communicating respectively with inlet and exhaust passages 14 and 15 for the flow of the working charge to and of the exhaust gases from the working chamber.

A carburettor having a fuel jet 16, a choke 17 and a throttle 18 is provided for the delivery of a fuel air mixture to the inlet.

The piston 10 has a centrally disposed projection 20 on its upper face constituting a subsidiary piston which is arranged to enter a cylindrical recess 21 in the cylinder head 11 with as close a clearance as is practicable, and thus to trap in the recess part of the charge in the working chamber towards the end of each compression stroke. The compression ratio in the working chamber during the part of each compression stroke before the projection 20 enters the recess 21, is determined by the total volume of the complete working chamber including the recess 21 and the height of the projection 20 relatively to the total piston stroke, and in one construction this compression ratio may be about 8.5:1 corresponding to a pressure of approximately 275 p.s.i.a. When the projection 20 enters the recess 21 the gases in the working chamber are divided into two separate parts and the dimensions of the projection 20 and the recess 21 are such that the parts of the charge which are then respectively trapped in the recess 21 and not so trapped will be compressed to different degrees such that whereas the final compression pressure of the part of the charge which is not trapped in the recess 21 is less than that which will bring this part of the charge to fuel ignition temperature, the part of the charge which is trapped in the recess 21 is compressed to a degree sufficient to raise it to a temperature somewhat above fuel ignition temperature. Typical total compression ratios respectively for the part of the charge trapped in the recess 21 and the part of the charge not so trapped would be of the order of 16:1 for the trapped part and 10.5:1 for the part not so trapped.

Thus, as the piston reaches the top of the compression stroke combustion will be initiated in the part of the charge trapped in the recess 21 and this part of the charge will be subject to a rapid increase in pressure and temperature approximating to true constant volume combustion, wth the result that the pressure in the recess, assuming the fuel and air to be in correct proportions for complete combustion of both, will rise to a value approaching say 2,500 p.s.i.a. This high pressure is confined to the recess 21 and the pressure in the part of the charge outside the recess will of course be much lower, say 350 p.s.i.a., so that the average pressure applied to the complete piston area at this time will not be excessive. For example, if the area of the projection is one-tenth of the area of the total piston face, the pressure of 2,500 p.s.i.a. in the recess will be the equivalent of only 250 p.s.i.a. over the whole piston face area, to which must be added at this time only the compression pressure of, say, 350 p.s.i.a. present in the part of the charge not trapped in the recess and acting only on a proportion of the piston face. Thus, the major components of the engine are not subjected to excessive loading due to the high pressure in the part of the charge trapped and burnt in the recess 21.

After ignition has occurred in the recess 21 the piston will be forced downwards and at a point shortly after top dead centre the projection 20 will leave the recess 21, at which point the pressure in the recess will have fallen by expansion from its maximum value of, say, 2,500 p.s.i.a. to about, say 1,150 p.s.i.a. At the point when the projection 20 leaves the recess 21, the pressure in the part of the charge not trapped in the recess is that corresponding to the compression ratio of, say, 8.5:1, that is about 275 p.s.i.a., so there will be a vigorous expansion of high temperature combustion gases from the recess into the fuel/air mixture in the remaining part of the complete working chamber. As the temperature of the gases ejected from the recess is still higher than that required to initiate combustion of the mixture in the remaining part of the working chamber, the fuel/air mixture in the remaining part of the working chamber will be ignited.

Thus, it will be seen that combustion of the part of the fuel/air mixture not trapped in the recess is not dependant upon compression ignition but is initiated by direct contact with the high temperature gases ejected from the recess, which produces a rate of combustion equivalent to that in a spark ignition engine, and hence a maximum combustion pressure which may correspond to that normally obtained in a spark ignition engine.

The working stroke then continues in the normal way and the normal cycle of operations continues until the piston once again reaches the position where the projection 20 enters the recess 21, and so on.

In the construction shown in Figure 1 it will be understood that the carburettor would supply fuel and air in approximately correct proportions to provide for substantially complete combustion of both over the whole operating range of the engine, the control of engine speed and power being achieved by varying, by means of the throttle 18, the quantity of combustible mixture admitted during each induction period, as in spark ignition engines. While this may be convenient in some cases, however, the arrangement imposes losses due to throttling during operation under partial load conditions so that the partial load performance of the engine will approximate to that of a spark ignition engine, and this compares unfavourably with that of a compression ignition engine as at present used.

Since in engines according to the present invention the maintenance of a substantially constant fuel/air mixture strength is not essential, it may, therefore, in most cases be preferred to provide an arrangement in which the control of the power and speed output of the engine is varied by controlling the quantity of fuel only delivered, and Figure 2 shows one such arrangement which may then be employed in the cylinder head of an engine otherwise as shown in Figure 1.

In the construction shown in Figure 2 in which the same reference numerals are used as in Figure 1 for corresponding parts, fuel is assumed to be delivered by a metering pump through a tube 22 to a nozzle 23 in the inlet passage 14, the pump being arranged and timed so as to deliver a measured quantity of fuel during each induction period. The metering pump employed, which is not shown, may resemble a fuel injection pump as used in normal compression ignition engines but is subject to less exacting operating conditions since its delivery period can extend over substantially the whole of each induction period, and the pressure against which it operates is very much lower.

In the construction shown in Figure 2 it will be seen that losses due to throttling are avoided and the efficiency of the engine under partial load conditions can therefore be maintained at values comparable with those of a normal compression ignition engine as at present in use. Figure 3, in which corresponding parts are identified by the same reference numerals as in Figure 1, shows a construction which is particularly suitable for engines where a substantial proportion of the air entering the cylinder during each cycle passes through the cylinder and out of the exhaust passage for scavenging and/or cooling purposes, for example in engines operating in the 2 stroke cycle or to assist engine cooling and/or to avoid subjecting the turbine of an exhaust-driven turbo-compressor to excessive temperatures. In this case a fuel injection nozzle device 24 is arranged in the wall of the cylinder 1 and would have fuel delivered to it by a metering pump at timed intervals such that the fuel would be delivered early in each compression stroke after the inlet and exhaust ports have closed and before the projection 20 enters the recess 21. Thus, the fuel injection nozzle device 24 would receive fuel from a metering pump as in the arrangement described with reference to Figure 2 except for the timing of the delivery so that fuel delivery will take place during the initial part of each compression period, thus avoiding the carrying of fuel away with the air which passes through the cylinder for scavenging and/or cooling purposes. In Figure 3 since fuel is injected into the working chamber against low pressure and the duration and timing of injection with respect to piston movement are relatively unimportant, the metering pump is not subject to such exacting requirements as in compression ignition engines as at present used. It will also be seen that the fuel injection nozzle device is protected by the piston from contact with the burning gases during the high pressure and temperature phases of the combustion process, and the nozzle device may therefore be smaller and simpler than that required in compression ignition engines in which the nozzle device is subject to full working pressure and temperature.

In the construction shown in Figure 3 a piston device 25 is moreover provided in the recess 21 and is supported in position by means of a screwthreaded rod 26 engaging a screwthreaded bore in the cylinder head 27 and arranged to be actuated by means of a handle 28 so that by appropriate rotational movement of the handle 28 the effective volume of the recess 21 and hence the compression pressure achieved in the recess 21 may be varied.

This may be desirable or necessary to causes or facilitate initiation of combustion during starting. The arrangement may also be employed in supercharged engines, that is to say engines in which the pressure, and therefore the mass of air in the working chamber at the beginning of the compression period is increased by the provision of a compressor or blower to vary the effective compression ratio to suit different operating conditions. Thus in such engines it may be necessary at high supercharger pressures to reduce the maximum pressure reached within the recess 21 at the end of the compression stroke and the consequent pressure resulting from combustion, but under starting and/or idling conditions when the pressure produced by the compressor or blower is low it may be necessary to increase the pressure achieved in the recess in order to initiate combustion within it.

Suitable markings may be provided corresponding to different rotational positions of the lever 28 and hence different pressure ratios attained with such different positions so that if desired the engine may be calibrated or adjusted to suit the fuel to be used and/or other factors.

Assuming the dimensions determining the effective compression ratios are correct for operation at maximum supercharging pressure, no adjustment is necessary in a supercharged engine to the pressure obtained in the part of the charge outside the recess to suit different operating conditions since the pressure obtained in this part of the charge will fall with loss of supercharging pressure under starting conditions so as to be even further below that at which combustion will be initiated than under full supercharging conditions, and this part of the charge will be ignited irrespective of its precise pressure by the burning gases from the recess.

In the construction shown in Figure 4, apart from modifications hereinafter described the general arrangement is similar to that shown in Figure 1 and the same reference numerals have been used for corresponding parts. In the construction shown in Figure 4, instead of a solid projection 20, as employed in the construction shown in Figure 1, the piston is provided with a projection 20A somewhat longer than the projection 20 and provided with a vertical passage 20B extending through the upper face of the projection and communicating at its lower end with the inner ends of two or more transverse passages 20C the outer ends of which open through the circumferential wall of the projection 20A. In this construction, therefore, the full trapping of the appropriate proportions of the charge in the recess 21 does not occur during each compression stroke until the outer ends of the passages 20C have been covered by the circumferential wall of the recess 21, and after initiation of ignition in the recess 21 by compression ignition, communication between this recess and the part of the working chamber surrounding the projection first occurs through the passages 20B, 20C during the working stroke when the outer ends of the passages 20C emerge from the recess 21, whereupon ignition of the part of the charge surrounding the projection is effected by the burning products of combustion ejected from the recess through the passages 20 and 20C. It will be seen that full communication between the recess 21 and the remainder of the working chamber occurs when the projection 20A is completely withdrawn from the recess 21.

In a modified arrangement operating on the same principle as that shown in Figure 4, instead of one or more passages in the projection, one or more passages may be arranged to extend between the circumferential wall of the recess and the part of the working chamber surrounding the projection and arranged to be covered by the projection at an appropriate point in its movement into the recess.

It will be appreciated that engines otherwise similar to those described with reference to Figure 1 or Figure 2 or Figure 4 may have means for varying the effective compression of the part of the charge trapped in the recess 21 similar to those shown in Figure 3.

Figure 5 shows an alternative arrangement similar to those shown in Figures 1 and 2 except that the piston 10 is provided with a recess 30 while the cylinder head is provided with a projection 31, the projection 31 serving to trap the appropriate proportion of the charge in the recess 30 and compress it to fuel ignition temperature in a similar manner to that effected by the projection 20 in the recess 21 in Figures 1 and 2.

A further alternative construction is shown in Figures 6 and 7 in which instead of there being only one projection co-operating with a recess, two segmental projections are provided, these being disposed adjacent to opposite sides of the cylinder head as shown at 33 and 34, and co-operating respectively with corresponding recesses 35 and 36 in the top of the piston. Although the parts 33 and 34 have been referred to as projections and the parts 35 and 36 as recesses, it will be understood that by appropriately proportioning the various parts the pressure achieved in the parts of the charge in recesses 35 and 36 might be below that required to initiate fuel ignition, and the pressure in the remainder of the working chamber might be arranged to rise above fuel ignition temperature, so that the said remainder of the working chamber would be in effect what has been previously referred to herein as a "recess" in which ignition is initiated and the recesses 35 and 36 would contain the part of the charge which is not compressed sufficiently to reach fuel ignition temperature. Further, a similar arrangement to that shown in Figures 6 and 7 might be employed but with the segmental projections formed on the piston and the recesses formed in the cylinder head.

Figure 8 shows in cross-section the centre portion of the length of a cylinder of an internal combustion engine in which reciprocate towards and away from one another two pistons, 38 and 39, connected respectively to two crankshafts which rotate at the same speed, or to a single crankshaft, as in two known types of opposed piston engine, usually operating on the two-stroke cycle with inlet and exhaust ports controlled respectively by the two pistons. In this construction the piston 38 is provided with a projection 40 which enters a cylindrical recess 41 in the other piston 39 towards the end of each compression stroke to trap and compress and hence initiate ignition in the part of the charge in such recess. The general system of operation of the engine will be the same as that described with reference to Figure 1 except that operation would usually, as indicated, be on the two-stroke cycle.

The invention may be particularly applicable to a so-called multi-fuel engine, that is to say an engine intended for use in different environments with whatever liquid fuel or fuels happen to be available, since, provided that the ignition temperature of a particular fuel can be achieved in the recess, the engine will be capable of operating on that fuel.

It will be understood that arrangements similar to that shown in Figure 4 may be applied to constructions otherwise similar to those shown in Figure 2, or Figure 3, or Figure 5, or Figures 6 and 7, or Figure 8, by changing suitably the dimensions of the projection or projections and providing appropriate passages which will be respectively closed and opened to close and open communication between the recess or recesses and the remainder of the working chamber at an appropriate point in the movement of the projection or projections into and out of the recess or recesses.

It is also to be understood that the projection 31 in Figure 5 may be formed separate from the cylinder head and connected to it by adjusting mechanism similar to that employed for the piston 25 in Figure 3 so as to enable the effective compression ratio in the recess to be varied.

WHAT I CLAIM IS:—

1. A reciprocating compression-ignition internal combustion engine which has means for admitting into the working chamber a combustible charge of fuel and air for compression between the relatively reciprocating parts, the charge being in a condition capable of compression self-ignition on admission, and in which there is provided on one of the said relatively reciprocating parts at least one projection formed integrally with or fixed to the said part, which projection, towards the end of the compression stroke, enters a co-operating close-fitting recess formed in the other of the relatively reciprocating parts so as to trap a portion of the charge in the recess, the relative dimensions of the various parts being such that the portion of the charge trapped in the recess by the projection will be subjected by the relative movement of the projection into the recess during the remainder of the compression stroke to a higher compression pressure than the portion of the charge remaining outside the recess, the said higher compression pressure being sufficient to raise the temperature of the portion of the charge trapped in the recess to self-ignition temperature and thereby ignite the charge in the recess.

2. A reciprocating internal combustion engine as claimed in Claim 1 in which the

projection is adjustably fixed to the said part so as to enable the compression ratio in the recess to be varied.

3. A reciprocating internal combustion engine as claimed in Claim 1 or Claim 2 having at least one main cylinder containing a single reciprocating piston, in which the projection is formed on the piston and the recess in the cylinder head.

4. A reciprocating internal combustion engine as claimed in Claim 1 or Claim 2 having at least one main cylinder containing a single reciprocating piston, in which the projection is formed on the cylinder head and the recess in the piston.

5. A reciprocating internal combustion engine as claimed in Claim 1 or Claim 2 having at least one main cylinder containing two oppositely moving pistons, in which the projection is formed on one piston and the recess in the head of the other piston.

6. A reciprocating internal combustion engine as claimed in any one of the preceding claims in which means are provided for varying the clearance volume of the recess.

7. A reciprocating internal combustion engine as claimed in any one of the preceding claims, in which one or more passages are associated with the projection and recess and arranged so that during an initial part of the movement of the projection into the recess the passages will remain open and form a communication between the recess and the remainder of the working chamber, and during the subsequent part of the movement of the projection into the recess the passages will be closed by the movement of the projection into the recess.

8. A reciprocating internal combustion engine constructed substantially as described with reference to Figure 1 or to Figure 2 or to Figure 3 or to Figure 4 or to Figure 5 or to Figures 6 and 7 or to Figure 8 of the accompanying drawings.

KILBURN & STRODE,
Chartered Patent Agents,
Agents for the Applicant.

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1156821 COMPLETE SPECIFICATION

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Sheet 1

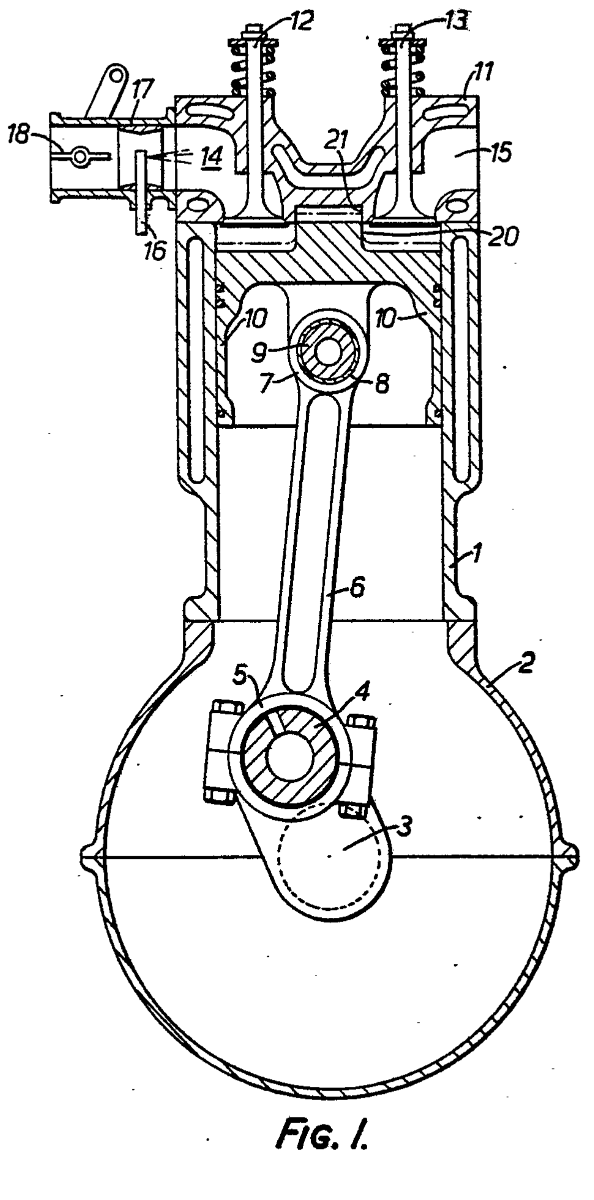

FIG. 1.

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Sheet 2

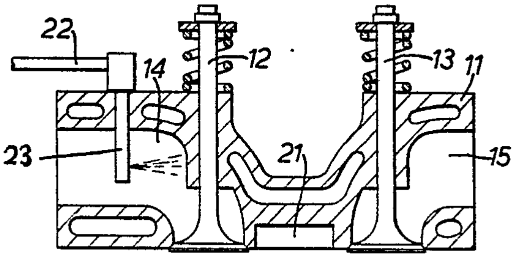

FIG. 2.

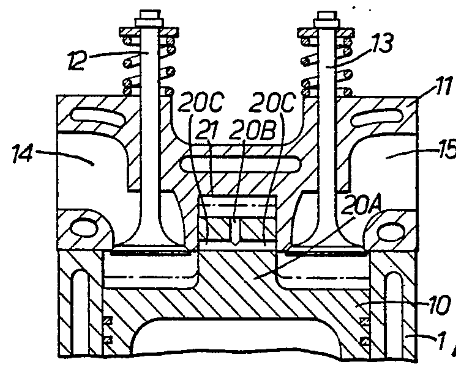

FIG. 4.

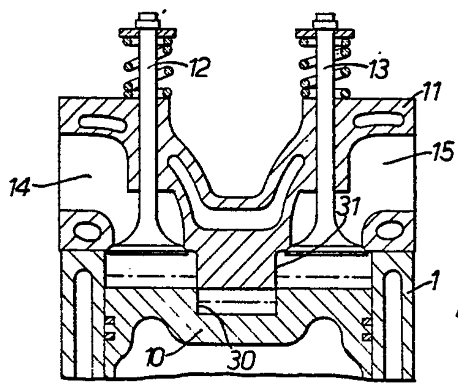

FIG. 5.

1156821 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

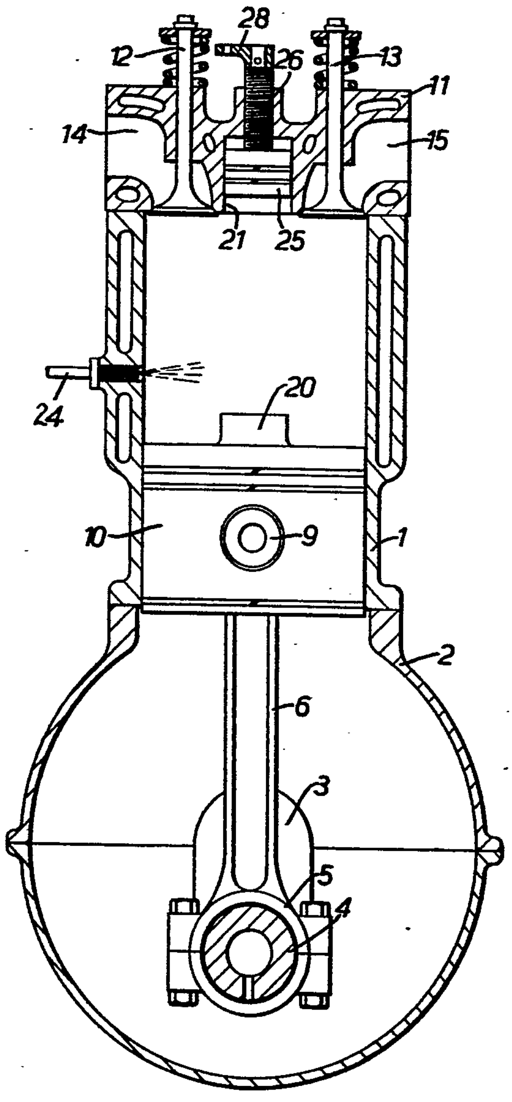

FIG. 3.

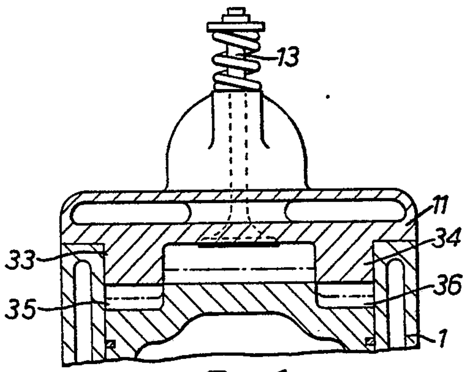

FIG. 6.

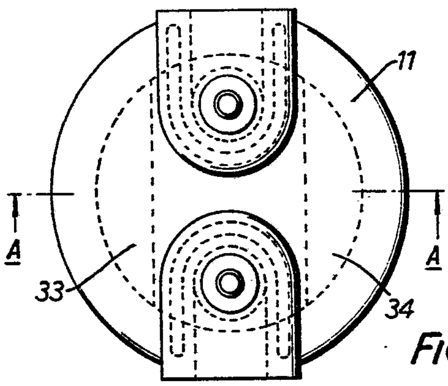

FIG. 7.

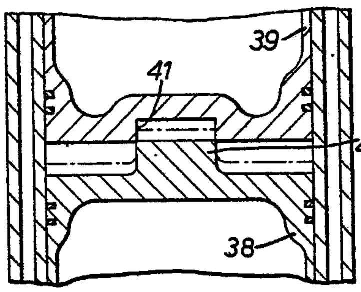

FIG. 8.