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[54] **PISTON WITH CENTRAL COMBUSTION CHAMBER FOR INJECTION-TYPE INTERNAL COMBUSTION ENGINES**

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[63] Continuation of Ser. No. 254,219, May 17, 1972, abandoned.

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[51] **Int. Cl.**^{2} **F02F 3/02;** F02F 3/14; F02F 3/26

[58] **Field of Search** .... 123/193 R, 193 P, 32 B, 123/32 C, 41.35, 191 SP; 92/213, 92/214, 224, 108

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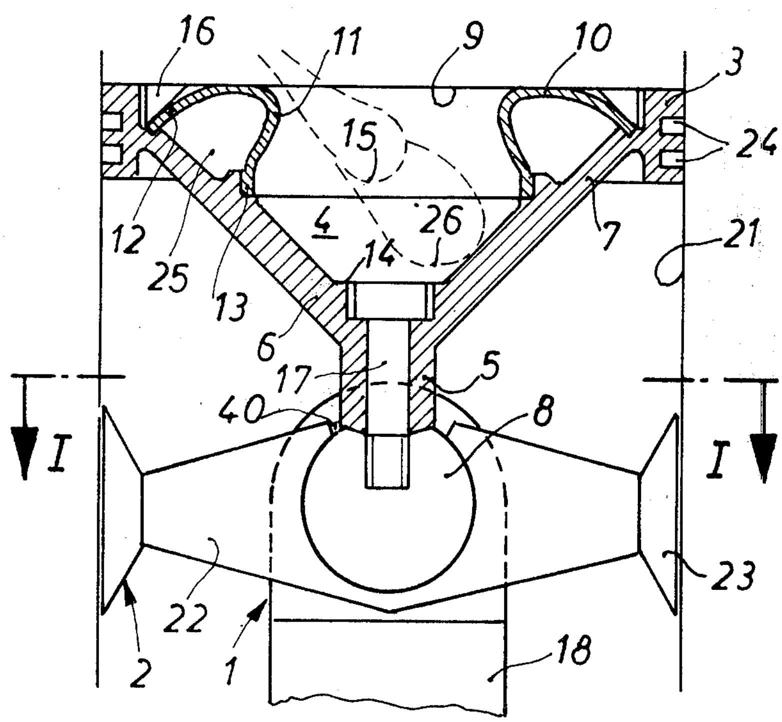
[57] **ABSTRACT**

A piston with a central combustion chamber for injectiontype internal combustion engines, in which the combustion chamber is provided in the piston head and is equipped with heat accumulating means for retaining the heat resulting from the combustion of the fuel in the combustion chamber while the mantle surfaces of the piston which slidably engage the cylinder wall are provided with guiding and sliding means. Within the range of the combustion chamber opening there is provided an annular glowing part having a rim tapering toward the center or axis of the combustion chamber while between the annular glowing part and the piston head which forms an annular support there is provided the heat accumulating means, e.g. in the form of a chamber. These heat accumulating means together with the glowing part have a ring width substantially equalling the injection depth of the fuel jet when the engine is idling. The annular support together with the mantle of the fuel chamber is detachably connected to at least one guiding or sliding body, sliding block, or sliding ring by means of a piston foot and a crosshead.

5 Claims, 3 Drawing Figures



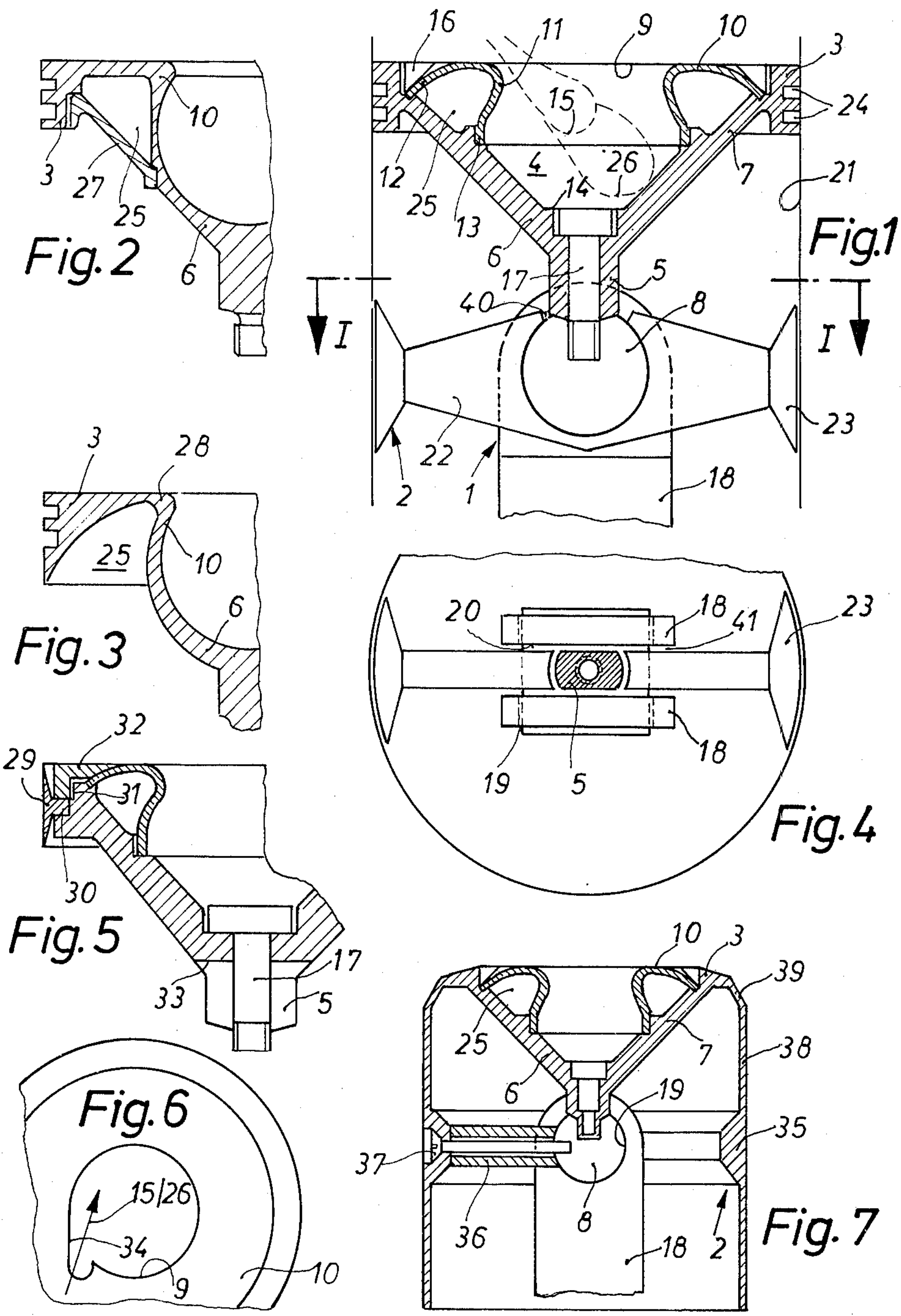


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

PISTON WITH CENTRAL COMBUSTION CHAMBER FOR INJECTION-TYPE INTERNAL COMBUSTION ENGINES

This is a continuation of application Ser. No. **254,219**, filed May **17, 1972**, now abandoned.

This invention relates to a piston having a central combustion chamber for injection-type internal combustion engines, the combustion chamber being arranged in the crown of the piston and fittet with heat-insulating means to retain the heat due to combustion of the fuel in the combustion chamber and guiding and sliding members on its periphery which slide in the cylinder.

It has been known, especially in slow-running large engines, to use so-called crosshead pistons which are distinguished by low weight, low friction and exact guidance of the piston in the cylinder. In the case of engines, such as Diesel engines, with high unit ratings the pistons are normally designed with the piston bosses for the pin connecting the piston and the piston skirt guiding the piston are integral with the ring-sealed head of the piston. In this way, the crosshead pin becomes a piston or gudgeon pin. The intention of this design is to transmit the heat to be dissipated over the shortest possible distance via large contact areas to the inner surface of the cylinder. For this reason, light alloys are frequently used as a material for pistons because of their high heat conductivity. Thorough tests have, however, shown that existing theories are defective inasmuch as optimum combustion of the fuel/air mixture demands that only the bottom part of the combustion chamber should be well cooled whilst the throat of the combustion chamber should be maintained at a substantially higher temperature level.

On the strength of these findings, it is the object of this invention to provide a piston for reciprocating internal combustion engines which will ensure optimum combustion of the fuel/air mixture by efficient temperature control of the combustion chamber, which, furthermore, is of a straight-forward and weight-saving design and affords low-wear guidance in the cylinder, and which, moreover, protects the piston rings from excessive heating.

This objective is attained according to the present invention by a piston of the type referred to initially comprising a ring-shaped incandescent wall member in the area of the combustion chamber throat which is formed with a rim narrowing towards the centreline of the combustion chamber, heat-insulating media between the incandescent member and the piston head, this being in the shape of an annulus, and having a combined depth with the incandescent member equal to the penetration depth of the fuel spray during idling of the engine, and detachable connection of the annular piston head with the shell of the combustion chamber via a piston foot and a crosshead to at least one guiding and sliding member.

As repeated tests with a piston according to this invention, having the above features, have shown, it is necessary for optimum combustion of the fuel/air mixture in the combustion chamber to control the temperatures of the combustion chamber in the piston according to a well-defined pattern in a manner that effective heat build-up is maintained in the area of the combustion chamber throat whereas good heat dissipation exists at and near the bottom of the combustion chamber.

These measures ensure that optimum temperature control of the combustion chamber is maintained also during idling of the engine resulting in the engine operating with a high efficiency both in the idling and part-load modes. Added to this is the fact that the physical design of the piston according to the invention permits robust and low-wear construction so that, in spite of a reduced engineering effort, high unit outputs can be achieved. A further advantage of the piston according to the invention is that its uncomplicated concept not only affords weight savings but also permits simple production which is a most decisive factor for the competitiveness of a mass-produced article of this type.

An advantageous version of the invention features an incandescent member in the form of an insert fixed to the piston head and a shield sealing off the hollow space of the insert against the cylinder space. This design of the piston offers an advantage in that its component parts, such as the incandescent member, can be produced as simple interchangeable parts which can be easily replaced after wear, same as the piston rings.

In order to enable the incandescent member to conform readily to fluctuating heat expansions, this is, according to a further feature of the invention, highly convexed towards the centreline of the piston and provided with an expansion fold at the combustion chamber throat which, at the same time, may be designed as the entrance channel for the fuel spray.

For further advantageous versions of the invention reference is made in particular to the other claims. All these features of the invention, which may be applied individually or in combination with others, permit a piston to be produced for internal combustion engines that is statically determinate, has a low weight and ensures optimum combustion of the fuel/air mixture. The influence of the piston design, in particular, on the process of mixing the fuel with the air for combustion derives from the fact that the convex surface of the combustion chamber throat which is constructed as an incandescent member extends as far down into the combustion chamber as the fuel spray will penetrate, during idling into the compressed air contained in the combustion chamber. This arrangement prevents liquid fuel being swept by the swirling motion of the combustion air onto too cool an area of the combustion chamber wall where it would evaporate only very slowly and, consequently, a proportion of unburnt fuel would be discharged from the combustion chamber, i.e., emitted through the exhaust. Such unburnt fuel is the cause of such an unfavourable phenomenon as blue smoke in Diesel engines. Since the temperatures at which blue smoke is liable to form are well established, it is possible with the piston according to this invention to match the amount of heat insulation, the wall thickness and heat conductivity of the incandescent member in a simple manner to suit the requirements. This also permits the temperature of the incandescent member to be determined also for full load of the engine. These temperatures are selected high enough to cause the incandescent member to glow. Moreover, the provision of an incandescent member in the combustion chamber of the piston offers the advantage that too high a rate of combustion of the fuel at full load is avoided by flaring the part of the incandescent member extending into the combustion chamber so that the injection energy with a large amount of fuel is sufficient to prevent the fuel spray coming into contact with the wall or only in that area of the lower part of the combustion chamber where the wall is kept cool. In this manner, it is possible, by controlling the temperature of the lower part of the combustion chamber, to delay evaporation of the fuel at full load until the mixing swirl which is inherent in the process has brought sufficient fresh air to the fuel spray. This makes it possible also with simple means to proportion the cooling of the lower part of the combustion chamber and insulation of the incandescent part so as to match the swirling rate of the combustion air and the position of the fuel spray at any time.

Typical embodiments of the invention are shown schematically in the accompanying drawing, viz:

FIG. 1 is a longitudinal section through a piston movable in a cylinder, the piston having an insert-type incandescent member in the combustion chamber,

FIG. 2 is a longitudinal section through the top of the piston provided with an insert-type shield of the incandescent member,

FIG. 3 is a longitudinal section through a piston provided with a thinning between the incandescent member and the ring carrier to serve as a thermal barrier,

FIG. 4 is a section through the cylinder and the piston guided in it in plane I — I in FIG. 1,

FIG. 5 is a longitudinal section through a piston according to FIG. 1 with a sleeve seal provided on the piston head,

FIG. 6 is a plan view onto the piston with an incandescent member formed with an expansion fold, and

FIG. 7 is a longitudinal section through a piston having a shell adjoining the piston crown and provided with guiding means.

The piston according to the design in FIG. 1 is constructed in the fashion of a crosshead piston and essentially formed by a crosshead 1 with guiding elements 2 and a piston head 3 incorporating a combustion chamber 4. To save weight, the piston head 3 is designed as a narrow annulus and connected via the shield 7 forming the combustion chamber top, and piston foot 5 and combustion chamber bottom 6 to a pin 8 in the crosshead 1. The combustion chamber 4, provided inside the piston head 3, with combustion chamber top or shield 7 and combustion chamber bottom 6, is provided with an insert at its throat 9 preferably in the form of a thin-walled incandescent annular wall member 10. The shell 11 of the incandescent member 10 is of a pronounced convex shape towards the centre of the combustion chamber or piston centreline and its edges 12, 13 which are directed towards the outside, are anchored to the piston head 3 and the combustion chamber bottom 6 respectively. The depth of the incandescent member 10 from the edge of the combustion chamber throat 9 down towards the bottom 14 of the combustion chamber 4 is as large as the penetration depth of the fuel spray 15 during idling of the engine. Fixing the incandescent annular wall member 10, in particular to the piston head 3, may be in the form of screw ring 16 applied from the top, but it is naturally also possible to fix it by rolling, preferably the outer rim 12 of the incandescent member into the piston head. The connection of the crosshead 1 to the piston foot 5 is by means of screw 17 passing through the bottom 14 of the piston to screw into pin 8 of crosshead 1. This pin 8 is provided with a thread for the screw 17 and the piston foot 5 is centrally located on this pin. In order to receive the crosshead 1 with the piston foot 5 connected to it, the connecting rod 18 is provided with a hole 19 for the pin and a slot 20 disposed perpendicularly to it for the piston foot. This slot 20 is, moreover, extended beyond the piston foot 5 and adapted to receive means guiding the piston on the cylinder surface 21. These means in the embodiment illustrated take the form of webs 22 which, at their free ends, are provided with guiding elements 2 in the form of sliding blocks 23. Connecting the webs 22 with the sliding blocks 23 to the end of the connecting rod 18 is by means of a pin 8 and in a fashion that the sliding blocks are capable of transmitting the normal forces, i.e., the radial forces. As a result, the length of pin 8 at the end of the connecting rod 18 can be made as short as the width of the small end 19 of the connecting rod which again brings about a substantial saving in weight. Pin 8, which is movable in the small end 19 of the connecting rod permits self-aligning action of the piston head 3 on the cylinder head surface 21, without the piston rings 24 being subjected to heavy radial forces which would be liable to cause considerable friction on the cylinder surface. The incandescent part 10 in this embodiment takes the form of a ring-shaped insert and its interior space 25, which faces the cylinder surface 21, is closed by the combustion chamber top acting as shield 7. The combustion chamber bottom 6 and, consequently, the depth of the combustion chamber 4 correspond to the penetration depth of the fuel spray 26 at full load. This design of the piston permits sub-division of the piston into two zones, namely, a hot combustion chamber top, i.e., the incandescent member 10, and a relatively cold combustion chamber bottom 6 whereby the desired fuel combustion in accordance with the predetermined heat pattern is obtained.

Designing the piston according to the invention enables a substantial weight saving to be achieved which makes it possible to use steel for the piston instead of a light alloy, such as aluminium alloy. Steel pistons, because of their reduced wear are far superior to aluminium alloy pistons and considerably enhance the service life of the engine.

The piston illustrated in FIG. 2 differs from that shown in FIG. 1 only in that it is the shield 27 which is an insert and not the incandescent annular wall member 10. In this case, the shield 27 is clamped between the combustion chamber bottom 6 and the piston head 3 forming the closure of space 25 of the incandescent member 10 which faces the cylinder surface 21.

In the piston design illustrated in FIG. 3, space 25 of the incandescent member 10 is not shielded off and the heat barrier between the incandescent member and the piston head 3 is produced by a thin section 28. Apart from that, this piston is built up in the same way as the pistons described above.

The piston according to FIG. 5 also corresponds to the designs described above from which it differs only in that there is a sleeve seal 29 provided on the periphery of the piston head 3 which bears with its inner periphery, designed as an inward-directed ring flange 30 on the walls of a piston groove 31. It is via this sleeve seal 29 alone that the piston head 3 bears against the cylinder surface 21 and the radial forces are likewise transmitted via this seal to the cylinder surface. The method of mounting the piston through the intermediary of the piston foot 5 on the crosshead 1 is again in a manner that the piston bears against the cylinder surface 21 only by its friction moment. This seal sleeve 29 may for further improvement of the friction horsepower be of the closed type in which case the seal would be fixed by means of a clamping nut **32**, which locates the incandescent member **10**, to the piston head **3**. The joint **33** provided in this figure in the area of the piston foot **5** will exist only if the piston foot is made of steel and the remaining parts of the piston, such as combustion chamber bottom and top **6, 7** are made of light alloy.

FIG. 6 is a plan view of a piston according to the afore-described embodiments having a combustion chamber throat **9** and an incandescent member **10** arranged on the piston head **3**. This incandescent member **10** is designed with an expansion fold **34** which also provides an entrance for the fuel jet **35** and which shape makes the incandescent member flexible to accommodate expansion at its inner perimeter **11**. Additional flexibility of the incandescent member **10** is provided by the pronounced convex shape of the inner perimeter **11** facing the centre of the combustion chamber **4**, i.e., the gas pressure.

The piston according to the embodiment shown in FIG. 7 is especially suited for use in a two-stroke engine. The pin **8** is again rotatably mounted in the small end **19** of the connecting rod and provides the connection between the connecting rod **18** and the piston with its guide elements **2**. The guide elements **2** in this design of the piston are designed as a complete sliding ring **35** instead of the sliding blocks **23** used in FIGS. **1** and **4**. The connection between the sliding ring **35** and pin **8** or small end **19** of the connecting rod respectively, is achieved by support tubes **36** and screws **37** guided in these. Furthermore, the sliding ring **35** is connected to a thin-walled shell **38** to cover the two-stroke ports provided usually in the cylinder surface **21** which shell is attached to the piston head, or shield **7** respectively, of the combustion chamber top by an expansion zone **39**. As regards the incandescent member **10**, this is identical with that in the previous embodiments, whereas the sealing elements, such as piston rings **24** or the sleeve seal **29**, are replaced by the thin-walled shell **38**. Minimum shell-to-wall clearances are obtained due to the fact that the shell is protected from heat expansion of the shield by the expansion zone **39** and that this shell is required to transmit neither the gas pressure nor normal or radial forces.

The flexibility of the piston, especially that of the piston foot **5** and the guide elements **2**, and their webs **22** and support tubes **36** respectively, relative to the crosshead **1** is achieved in all piston versions by the fact that there are free gaps **40** and **41** between the piston foot and the webs, or support tubes respectively, on the one hand, and between the small end **19** of the connecting rod and its webs and support tubes respectively on the other hand. This flexibility permits the piston head to move with minimum wear on the cylinder surface **21** without any enhanced wear occurring on the guiding elements **2**, i.e., the sliding blocks **23** or the slide ring **35**. Special cooling of the pistons and, in this case especially of the combustion chamber bottom **6**, can be effected by spraying oil from below against the combustion chamber bottom.

What I claim is:

1. A piston assembly for a fuel injection type internal combustion engine having an annulus at its upper end and a central combustion chamber in the piston crown formed by a wall converging downwardly from said annulus to the bottom of said chamber, said combustion chamber comprising a hot top section for quick fuel vaporization and a relatively cold bottom section, and an annular wall portion in the combustion chamber throat at the top of said piston extending radially inwardly from said annulus at its top edge to a curved annular internal rim and thence downwardly to its lower edge secured to said converging wall at a point between said annulus and the bottom of said chamber, said wall portion being spaced from the converging wall of the piston between its top and bottom edges with a heat barrier means in said space, said annular member having an axial depth equal to the depth of the fuel spray during idling of the engine, whereby the annular wall portion becomes incandescent when the engine is operating as a fuel injection engine, and forms the hot combustion chamber section and the bottom section is cool and forms the cold chamber section.

2. A piston assembly for a fuel injection type internal combustion engine having an annulus at its upper end and a central combustion chamber in the piston crown formed by a wall converging downwardly from said annulus to the bottom of said chamber, said combustion chamber comprising a hot top section having a depth substantially equal to the depth of the fuel injection spray during idling of the engine and a relatively cold bottom section, and an annular wall portion in the combustion chamber throat at the top of said piston and formed by a separate wall member secured at its upper edge to said annulus and extending radially inwardly to an annular internal rim and thence downwardly to its lower edge secured to said converging wall and defining the bottom of said top chamber section, said wall portion being spaced from the converging wall of the piston between its top and bottom edges with a heat barrier means in said space, so that said annular wall portion becomes incandescent when the engine is operating as a fuel injection engine to form the hot combination chamber section while the bottom section remains cool.

3. A piston assembly for a fuel injection type engine comprising an annulus at its upper end for sliding contact with the walls of a cylinder, and a combustion chamber formed by a wall extending downwardly from said annulus and closed at the bottom to form said chamber, said chamber being divided into a hot upper zone formed by a top combustion chamber section and a cool lower zone formed by a bottom combustion chamber section, said top chamber section having a wall member with its top edge fixed adjacent the top of said chamber wall and extending radially inwardly from said annulus to an internal rim and then downwardly toward said chamber wall and joined to said wall at its lower edge between the top and bottom of said chamber to form said top section, said wall member being spaced from said chamber wall between its top and bottom edges and insulated from the chamber wall so that said wall member may become incandescent when said engine is operating as a fuel injection engine, so that the fuel injected at the top of the chamber is readily vaporized, the depth of said top chamber section being substantially equal to the depth of fuel spray during idling operation of the engine.

4. A piston assembly as claimed in claim **2**, in which said combustion chamber is provided at the bottom with means for mounting on a pin connected to a crosshead.

5. A piston assembly as claimed in claim **4**, in which a crosshead carries sliding blocks for sliding contact with walls of the cylinder.

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