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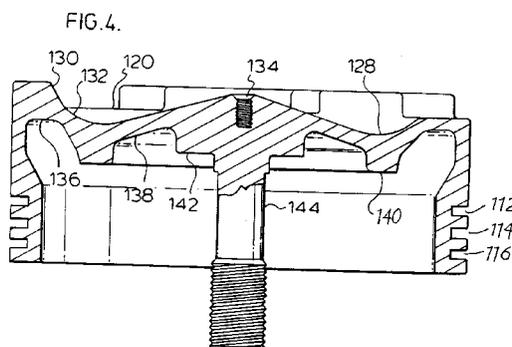
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**54) Piston cap for a diesel engine.**

**57)** A piston cap for a composite piston of a medium size internal combustion diesel engine, said piston being of the shape of a shallow cylinder, having a diameter of about 9 inches and a sidewall depth of about 3.5 inches, said piston cap having a top surface composed of a bowl shaped depression (128) located symmetrically with the centre (134) of the piston cap surrounded by a narrow, flat annular outer surface (118) extending from said depression to the sidewall of said piston cap, a recess formed in the bottom surface of the piston cap extending upwardly toward the top surface so that said piston cap is essentially hollow, the upper surface of said recess which is located somewhat below said top surface and having a pair of circular concentric grooves formed therein, an outer groove (136) having a complex shape and rising to a distance of about 2.8 inches above the bottom surface of said cap and an inner groove (138) spaced from the outer groove by a narrow annular shaped flat land (140), said inner groove rising about 2.7 inches above the bottom surface of said cap and a shaft (144) formed integrally in the upper surface of the centre of said recess which extends downwardly a predetermined distance from said upper surface.



This invention is directed to the cap or crown of a piston for a diesel engine, for example a medium size diesel engine.

The diesel engine is characterized by the fact that the fuel air mixture is ignited by heat produced during the compression of the air in the cylinder. The air of the cylinder is compressed to a predetermined pressure to ensure that the required temperature for fuel ignition is reached before the piston has reached top dead centre so that when the fuel is begun to be injected into the hot air combustion will take place. Combustion begins before the piston reaches top dead centre and the pressure in the cylinder continues to increase until the piston reaches top dead centre where upon the combustion continues for a predetermined period of time with the maximum cylinder pressure occurring shortly after top dead centre. The piston is driven to the bottom of the cylinder (where the exhaust stroke begins) and it is only during the power stroke that useful work is accomplished by the burning fuel.

In the past, this particular diesel cycle type of operation has been employed in engines all over the world that are characterized by long life in which the operation tends to be more efficient than the gasoline powered internal combustion engine.

Recently, environmental considerations have been responsible for careful study of the modern diesel operation in order reduce the amount of fuel consumed in the engine as well as to reduce the harmful emissions of exhaust gases which are delivered to the atmosphere. The design of the engine and in particular, the design of the piston for a modern diesel can be extremely critical. The designer must be careful to ensure that the piston will withstand the maximum cylinder pressures which will be encountered by the piston and caution must be taken to ensure that the fuel air mixture is burned in the most efficient manner possible to decrease the amount of pollutants which are produced during the combustion process and subsequently delivered to the atmosphere. At the same time, the peak pressures in the cylinder imposes load on the piston which can place a severe burden on the lubricating medium and in the long term damage both piston and bearings associated therewith.

Thus the piston in a modern diesel must be as light as possible in order to reduce the mass of material which is reciprocated for each stroke of the engine. The piston must also have sufficient strength to withstand the severe loads placed upon it during combustion and the piston must also maintain a temperature profile which will give the "best" combustion of the fuel air mixture for reasons of efficiency and environmental considerations. It is to this end that the piston of the present invention has been developed.

Improved engine efficiency has been a primary goal for diesel engine designers and while the task presents a significant challenge to the designer of a

"new" engine, the task has proven to be extremely difficult in instances where the design parameters are largely already defined, such as would be the case of older, proven engines where it is desired to "rebuild the engine" with components that increase engine efficiency, reduce exhaust pollutants and do not jeopardize engine life.

Aspects of the invention are specified in the claims. One illustrative embodiment of the present invention is a replacement piston for an engine which is fairly large, and which engine has a proven service record, and the specific engine to which this relates is the ALCO® Model 251 Series "V"-type diesel engine previously manufactured under license by Bombardier Inc. in Quebec, Canada and now manufactured by General Electric Canada Inc. in Quebec, Canada. The constraints on the designer of the piston are such that the same components be used in association with the redesigned piston, ie the block, crankshaft and connecting rods and bearings used previous to the "new" piston design may be successfully utilized in the modified ALCO® 251 engine, and yet be able to realize the desired improvement in operation.

According to an illustrative embodiment of the present invention, there is provided a replacement piston for an ALCO® Model 251 diesel engine which piston is of two piece construction. A crown or cap (which is the subject of this invention) is attached to a body such that the two parts from an integral piston which will provide more efficient engine operation than the piston of the prior art ALCO® 251 diesel engines.

For a better understanding of the present invention, reference will now be made to the accompanying drawings in which:

Figure 1 is a view of a known composite piston assembly.

Figure 2 is a sectional view of a known piston cap showing the body sleeve in phantom;

Figure 3 is a top perspective view of the cap of the piston which is the subject of this invention.

Figure 4 is a sectional view piston cap of this invention.

Figure 1 is shown to illustrate the general nature of the composite piston assembly to which this invention relates.

Figure 2 illustrates a piston cap or crown of the prior design for the ALCO® 251 V16 engine. It will be appreciated that the piston cap shown is the upper part of the piston assembly shown in Figure 1 which acts as a seal in the cylinder, however the lower part of the piston assembly, ie the cylindrical sleeve or body which houses a connecting rod pin will not be shown further or described in detail herein because the present invention relates to the cap. The piston cap shown in Figure 2 has a nominal diameter of about 9" and a height from the bottom surface to the

top of the crown of about 3 1/2". The piston cap shown is composed of a steel alloy and is provided with three grooves and adjacent lands for receiving piston rings in the lower part of the skirt. These grooves are designated as 12, 14, and 16. The top of piston 10 has a flat annular surface 18 which is provided with four valve pockets 20, 22, 24 and 26.

The piston cap is provided with a depression or bowl 28 which is curved sharply downwardly at the surface 30 near the exterior of the piston cap 10 to a point of maximum depression at 32 and the bowl rises at a shallow angle to a high point 34 at the center of the bowl and cap. The point of maximum depression in this instance will be about 1.1" below surface 18. The lower surface of the crown is a complex shape formed by surfaces of revolution so that it is essentially hollow. Near the exterior at the top of the lower surface of the piston cap is a circular groove 36 which rises deeply into the piston cap 10 at ever increasing diameter but at substantially constant width. A second concentric groove 38 spaced somewhat inwardly from groove 36 is formed at the lower surface of the piston cap 10. Between grooves 36 and 38 is a first flat land 40 which will be used to bear on the lower part of the piston assembly, such as that shown in Figure 1. A second flat land 42 is also shown on a lower surface of the piston cap 10 for support of the centre of the piston bowl. Finally the lower surface of the piston cap is produced into a single shaft 46 which is provided with a threaded end 48 so that the piston cap 10 may be rotatably secured to the lower body of the piston assembly.

The ALCO® Model 251 piston cap 10 of the prior art has functioned satisfactorily in the transportation industry for many years in circumstances wherein the compression ratio to be withstood by the piston 10 would be in the order of 11.5 to 1.

Referring now to Figures 3 and 4 a piston cap 110 of the present invention is shown having a nominal diameter of 9" and a depth of about 3.5". Piston cap 110 has grooves 112, 114, and 116 for receiving piston rings at the lower part of the skirt. The top of piston cap 110 has an annular flat surface 118 of about 0.6 inches width which is interrupted by four valve pockets 120, 122, 124 and 126 formed therein. The central top portion of the top surface has been provided with a shallow bowl 128 which is shaped such that the bowl surface 130 slopes downwardly and inwardly in a shallow angle to reach its maximum depth at 132, which is about 0.9" below surface 118. The surface rises in a shallow angle to a shallow apex 134 at the centre of the top surface of bowl 128. Apex 134 rises almost to the height of annular surface 118. The maximum diameter of the bowl is about 7.75 e.g. 7.78 inches.

The lower surface of the piston cap 110 is essentially hollow and provided with an exterior groove 136 which rises in a complex shape at an increasing diam-

eter and variable width. The exterior groove 136 rises to about 2.8 inches above the lower surface of the skirt. Concentrically located in the lower surface is a second groove 138 somewhat spaced from groove 136 and between which is a flat annular shaped land 140 which is provided for support of the lower surface on the lower body assembly of the composite piston (which is not shown). The second groove rises about 2.7 inches above the lower surface of the skirt.

A second flat annular land 142 is formed in the interior of the lower surface of the piston cap 110 adjacent to which is developed a shaft 144, which projects downwardly from the centre of the lower surface of the piston cap 110. Threaded portion 146 of shaft 144 corresponds to threaded section 48 of piston cap 10 of Figure 1.

The piston cap shown in Figures 3 and 4 is formed of a steel alloy and has the same nominal outer diameter as the piston cap shown in Figures 2 and 3. However, it will become immediately apparent to the reader that the top surface of the piston cap 110 is substantially different from the piston cap shown in Figure 1. The bowl of 128 of the piston cap 110 is of a much shallower nature than the bowl 28 of the piston cap 10. Both piston caps are intended for operation in cylinders of the same nominal diameter and piston cap 110 provides an overall improvement in fuel efficiency of approximately one and half percent (1.5%). In an engine which may use as many as 12 or 16 cylinders of a nominal diameter of about 9" this improvement is substantial over its operating life.

It is not entirely understood why the improvement results, however, it is believed that the piston cap 110 leads to a more complete combustion of the fuel-air mixture than does piston cap 10.

The operation of a diesel engine is concerned with high internal pressures in a combustion chamber during the compression stroke, and a minimum amount of diesel fuel is injected into the hot compressed air usually beginning just before top dead centre. In most diesel engines, the fuel-air mixture is quite lean (in comparison to a gasoline burning engine) and the reasons for incomplete combustion of the burning fuel in a diesel are not well understood. The surface temperature of the parts of the piston and surrounding cylinder walls will certainly have a bearing on the combustion process within the cylinder. It will be seen that the bowl of the piston cap 110 is much shallower than the bowl of piston cap 10 of the prior art. The propagation of the flame front from the point of injection to the piston as it moves away from top dead centre will no doubt be substantially different for pistons caps 10 and 110.

The heat transfer of the surrounding cylinder is expected to remain a constant regardless of whether the piston cap 110 or piston cap 10 is employed, however, the piston cap 10 will have considerably different heat transfer properties through the head of the

piston than piston cap 110.

It is noted that the improvement in performance has resulted largely from a deviation from the previous shape of the prior art piston cap design. It is to be noted that there has been no change in material from which the piston cap is fabricated and there has been no attempt to alter the heat transmissibility of the piston cap by the use of exotic coatings. Indeed, the piston cap has been the only change that results in the improvement of engine fuel efficiency. Note that the compression ratio has not been altered by the new piston cap design.

While the piston cap described in this invention has been precisely described, minor changes will become apparent to those skilled in the art. For instance each cap may have at least two valve pockets which are preferably symmetrically arranged thereon.

### Claims

1. A piston cap for a composite piston of a medium size internal combustion diesel engine, said piston being of the shape of a shallow cylinder, having a diameter of about 9 inches and a sidewall depth of about 3.5 inches, said piston cap having a top surface composed a bowl shaped depression located symmetrically with the centre of the piston cap surrounded by a narrow, flat annual outer surface extending from said depression to the sidewall of said piston cap, a recess formed in the bottom surface of the piston cap extending upwardly toward the top surface so that said piston cap is essentially hollow, the upper surface of said recess which is located somewhat below said top surface and having a pair of circular concentric grooves formed therein, an outer groove having a complex shape and rising to a distance of about 2.8 inches above the bottom surface of said cap and an inner groove spaced from the outer groove by a narrow annular shaped flat land, said inner groove rising about 2.7 inches above the bottom surface of said cap and a shaft formed integrally in the upper surface of the centre of said recess which extends downwardly a predetermined distance from said upper surface.
2. A piston cap as claimed in claim 1 wherein said piston is composed of steel, and has three piston ring grooves in the lower portion of the sidewall, said bowl having a maximum diameter of about 7.75 inches and extends to a maximum depth of 0.9 inches below the narrow flat annular outer surface, said narrow flat surface having four valve pocket recesses in spaced relationship located therein.
3. A steel piston cap for a medium size diesel en-

gine, said piston cap having a crown and skirt integrally formed into the shape of a shallow hollow closed cylinder having nominal dimensions of about 9.0 inches in diameter, and about 3.5 inches in height, the crown having a continuous closed surface which has a bowl shaped recess extending substantially across a major portion of the top surface of said crown, and being surrounded by a narrow flat annular surface at the exterior thereof, said bowl having a surface which extends downwardly at a shallow angle to a maximum depth of about 0.9 inches below the surface of said flat annular outer surface with the surface rising toward the centre to a point just below the height of said outer annular surface, the outer annular surface having of at least two valve pockets formed therein equidistantly spaced in a symmetrical fashion, the skirt of said cap having three grooves formed therein for receiving suitable piston rings, the interior of piston cap skirt being formed into a cavity of a predetermined complex shape by surfaces of revolution, and having a central shaft integrally formed in the top surface of said cavity and extending downwardly a predetermined distance below the lower surface of said skirt.

4. The piston cap of claim 1, wherein the diameter of said bowl is about 7.75 inches and the upper surface of said cavity comprises a first and second spaced apart annular shaped concentric grooves, the first groove being at the exterior of said upper surface and having a complex predetermined shape and being separated from the second interior groove by a first narrow flat land, a second land formed on the inside of said second groove, said central shaft being surrounded by said second land.
5. The piston cap of claim 4 wherein the first and second grooves rise about 2.8" and about 2.7" respectively above the lower surface of said skirt.
6. For use in an internal combustion diesel engine, a steel piston cap which forms part of a composite piston assembly for reciprocation in said engine, said piston cap comprising:
  - a shallow, substantially hollow cylinder of diameter of about 9 inches and a height of about 3.5 inches having a top surface, and a lower surface, and three piston ring grooves in the cylindrical side wall near said lower surface, said top surface having a narrow flat annular surface at the exterior thereof, and a shallow bowl extending inwardly and downwardly to a maximum depth of about 0.9 inches below said flat annular surface and rising slightly into a peak at the cen-

ter of said top surface, a recess extending upwardly from said lower surface such that the lower portion of said cap is hollow, said recess extending upwardly a predetermined distance toward said top surface, and being formed of surfaces of revolution so that said recess is essentially cylindrical in nature, such that the upper surface of said recess is formed by a pair of spaced apart concentric annular grooves, the outer groove having a complex shape such that the groove extends outwardly and upwardly toward the top surface of said piston cap said second groove being spaced inwardly of said first groove, and separated by a first flat annular shaped land, said second groove extending inwardly and upwardly toward the top surface of said piston cap, the inward wall of said second groove being adjacent a second annular shaped land, the surface of which is slightly above said first land, said second land surrounding a shaft which extends downwardly from the center of the recess to a point a predetermined distance below the lower surface of said piston cap.

7. A piston cap as claimed in claim 6 wherein the diameter of the bowl is about 7.75 inches and the outer groove and second groove rise upwardly from the lower surface of said cap to a maximum distance of about 2.8 and 2.7 inches respectively from the lower surface.
8. A piston cap as claimed in claim 9 wherein the top annular flat surface is interrupted by at least two valve pockets, symmetrically spaced therein.
9. A piston cap for a composite piston of a medium size diesel internal combustion engine, said piston cap being essentially of a hollow nature having a nominal diameter of 9 inches and a depth of about 3.5 inches between said top surface and the bottom of said piston cap, said cap having an integral skirt formed in the lower portion of said cap, said skirt having three piston ring receiving grooves formed therein, the cap having a cavity formed of surfaces of revolution such that a mating surface of a predetermined shape is formed at the top of the cavity, said mating surface being suitable for mating with a suitable piston body said mating surface having a pair of concentric grooves formed therein, an outer groove having a complex shape and rising to a distance of about 2.8 inches above the lower surface of the skirt, a second groove spaced inwardly of said first groove having a diameter substantially less than said outer groove and rising above the lower surface of said skirt by about 2.7 inches and a shaft formed integrally in the center of said lower surface, said shaft extending slightly below the low-

er surface of said skirt, and having a threaded portion formed thereon,

the top surface of said piston cap having an outer flat surface of approximately about 0.6 inches, width said surface being interrupted by at least two valve pockets formed therein,

said top surface having a shallow bowl formed in a concave manner extending downwardly from said outer flat surface at a shallow angle to a depth of about 0.9 inches below said top surface and then sloping upwardly to form an apex at the centre of said top surface to form a shallow apex therein, said apex rising to a height slightly below said outer flat top surface.

10. A piston cap as claimed in claim 9 wherein said grooves in said mating surface are separated by a flat annular land.
11. A piston cap as claimed in claim 10 in which the diameter of said bowl is about 7.75 inches.
12. For use in an internal combustion diesel engine, a steel piston cap which is part of a composite piston assembly for reciprocating movement in the engine, said piston cap comprising:
  - a shallow cylinder having a central axis and having a diameter of about 9 inches and a depth of about 3.5 inches, said piston cap having a top surface comprising a shallow bowl shaped depression which is concentric with said axis, said depression extending downwardly and inwardly from a narrow flat annular surface which extends from the periphery of the top surface of said piston cap to said depression, said annular surface having at least two valve pockets formed therein in a spaced symmetrical manner, the lower surface having a recess formed therein, said recess being formed from surfaces of revolution such that said recess extends upwardly a predetermined distance below said top surface such that the lower portion of the cap is hollow, said lower surface having a shaft extending downwardly therefrom for fastening said cap into said piston body
13. A piston cap as claimed in claim 12 in which said flat annular surface has a width of about 0.6 inches and said surface of revolution comprise a pair of spaced apart grooves concentric with said central axis, and a pair of annular shaped flat lands in juxtaposition with the grooves and spaced inwardly therefrom.

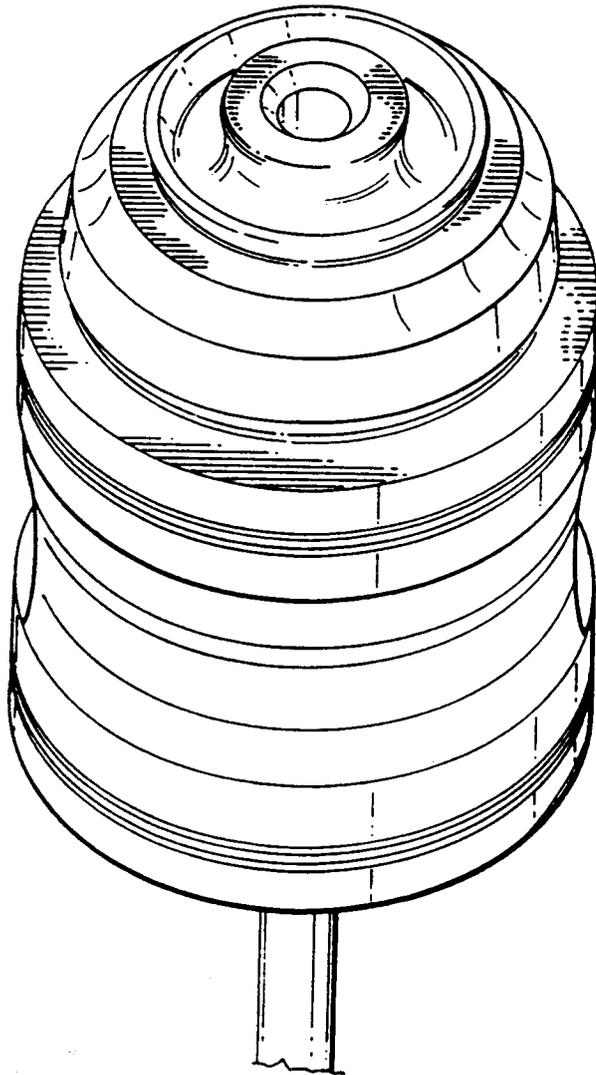
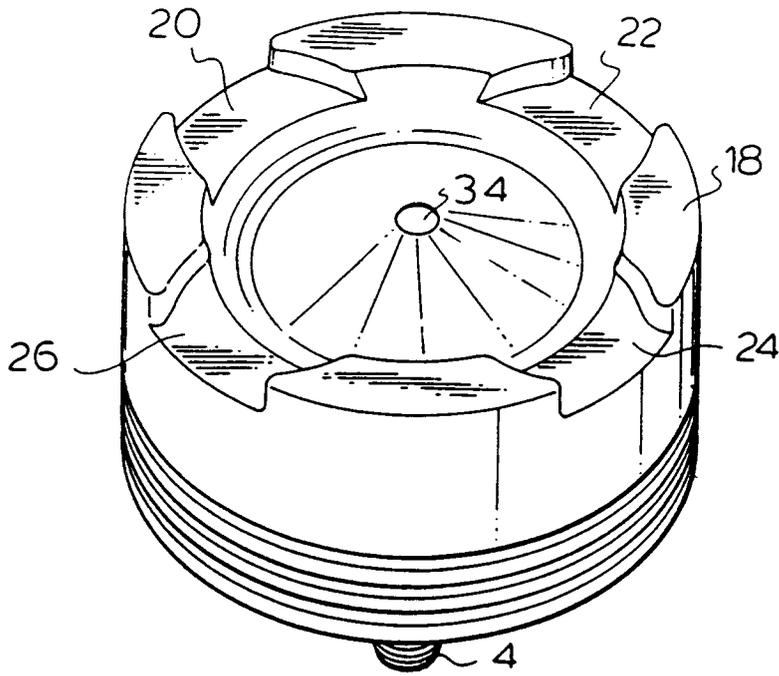


FIG. 1.  
PRIOR ART

FIG. 2.  
PRIOR ART

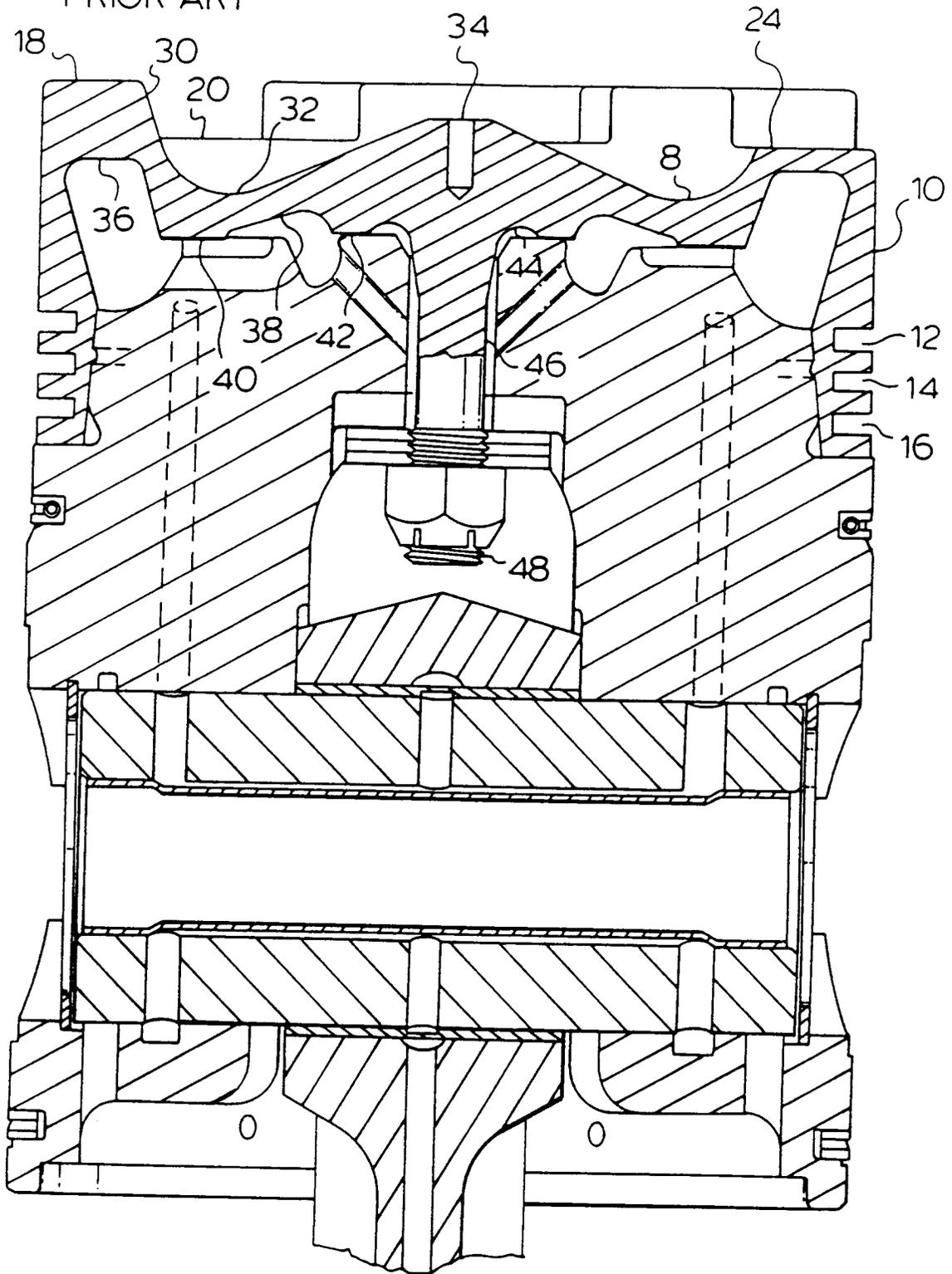


FIG. 3.

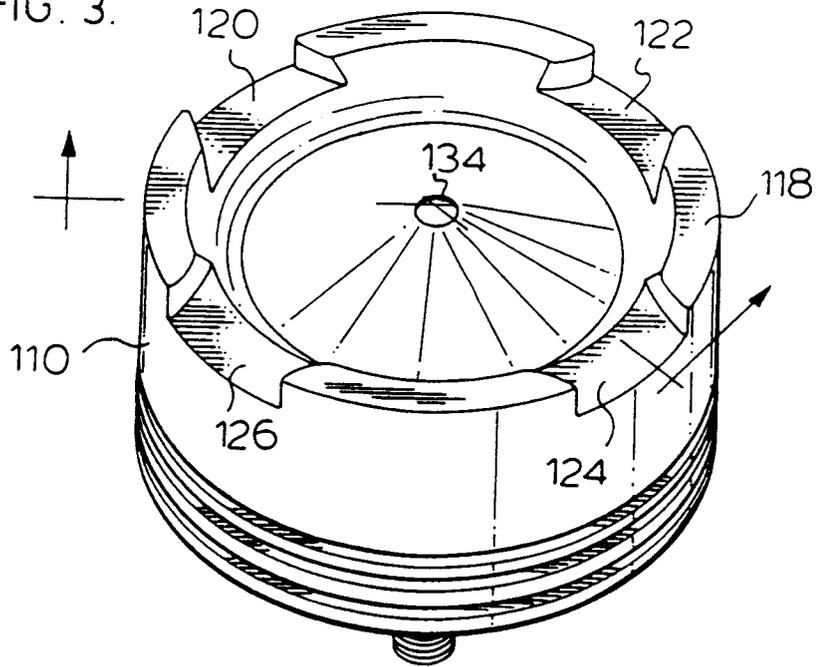
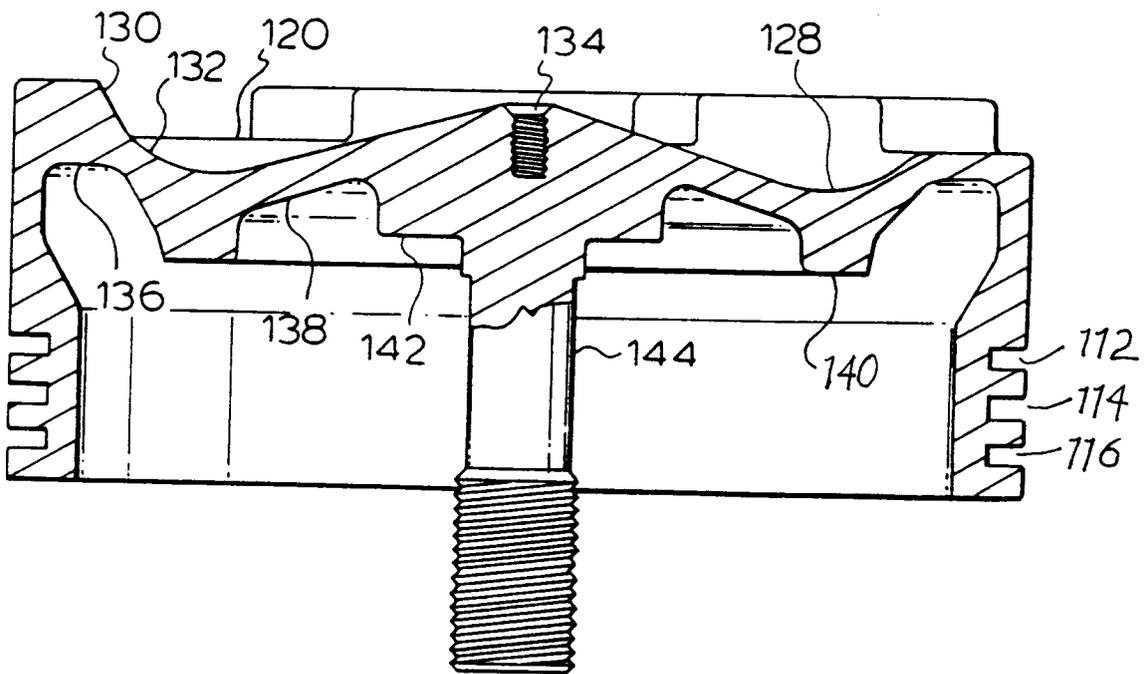


FIG. 4.





European Patent  
Office

EUROPEAN SEARCH REPORT

Application Number  
EP 93 31 0443

| DOCUMENTS CONSIDERED TO BE RELEVANT   |   |   |  |
|---|---|---|--|
| Category  | Citation of document with indication, where appropriate, of relevant passages               | Relevant to claim   | CLASSIFICATION OF THE APPLICATION (Int.Cl.5) |
| Y   | WO-A-83 02300 (ALCO POWER INC)<br>* page 8, line 10 - page 13, line 27;<br>figures *<br>--- | 1-13  | F02F3/00                                     |
| Y   | US-A-5 081 968 (BRUNI)<br>* column 2, line 53 - column 3, line 42;<br>figures *<br>---      | 1-13  |  |
| A   | GB-A-2 205 922 (MAHLE GMBH)<br>* page 2, line 13 - page 4, line 9; figure *<br>-----        | 1   |  |
|   |   |   | TECHNICAL FIELDS SEARCHED (Int.Cl.5)         |
|   |   |   | F02F   |
| The present search report has been drawn up for all claims  |   |   |  |
| Place of search   |   | Date of completion of the search  | Examiner                                     |
| THE HAGUE   |   | 10 February 1994  | Mouton, J                                    |
| CATEGORY OF CITED DOCUMENTS   |   |   |  |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |   | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |  |

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