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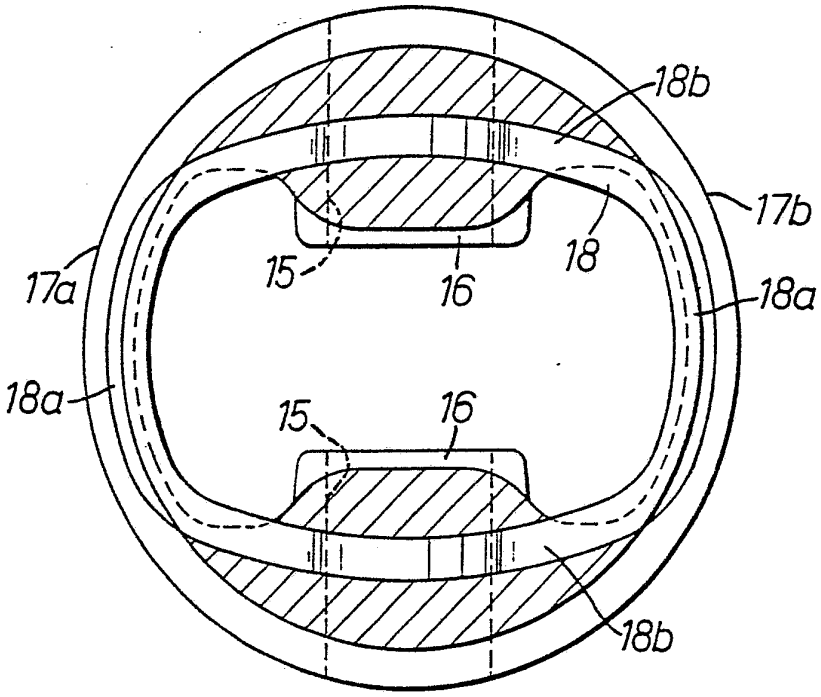
(54) Title: LIGHT METAL PISTONS

(57) Abstract

A light metal piston for an internal combustion engine or a comprssor comprises a crown, a gudgeon pin bore, and a skirt. The skirt includes portions forming opposed thrust faces on opposite sides of the plane including the piston axis and the gudgeon pin bore axis. An upper end of at least one skirt portion is spaced from an adjacent crown portion by an axially and circumferentially extending gap. An insert of a material of lower coefficient of thermal expansion than the material of the crown on the skirt is provided with the insert including a curved section or a plurality of consecutive curved sections lying in a plane generally normal to the piston axis. The curved section, or at least one of the plurality of curved sections, is within said gap so that the crown is supported on the skirt. In addition, the curved section, or at least two of the plurality of curved sections, is embedded in the piston material to support the insert.



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LIGHT METAL PISTONS

The invention relates to a piston of light metal for an internal combustion engine or a compressor. The term "light metal" as used herein includes aluminium, aluminium alloys, magnesium and magnesium alloys.

Such pistons have a crown, a gudgeon pin bore and a skirt including portions forming opposed thrust and counter-thrust faces on opposite sides of a plane including the piston axis and the gudgeon pin bore axis. In order to control the thermal expansion of the skirt, an axially and circumferentially extending gap is commonly provided between an upper end of one or both skirt portions and a lower end of the crown. However, problems arise if this gap is left unfilled because the crown is not fully supported and because, during expansion and contraction of the crown and skirt, the ends of the gap are stressed and this can lead to piston failure. It has therefore been proposed to fill this gap with an insert of a metal having a coefficient of expansion which is lower than the coefficient of expansion of the piston material.

One such proposal is shown in British Patent Specification 1,292,807 where the insert is of a ferrous

material and includes two diametrically opposed segmental portions which contact and separate respective upper ends of the skirt portions and the lower end of the crown and extend to the exterior surface of the skirt and crown. In addition the insert includes cranked strut portions which are connected at an angle to the ends of the segmental portions and are embedded in the piston material to locate the insert.

It is a disadvantage of pistons with such inserts that their configuration makes them difficult to manufacture. It is an object of the invention to mitigate or overcome this disadvantage.

According to the invention there is provided a piston of light metal for an internal combustion engine or a compressor and of the kind comprising a crown, a gudgeon pin bore, a skirt including portions forming opposed thrust faces on opposite sides of a plane including the piston axis and the gudgeon pin bore axis, an upper end of at least one skirt portion being spaced from an adjacent crown portion by an axially and circumferentially extending gap, and an insert of a material of lower coefficient of thermal expansion than the material of the crown and skirt, characterised in that the insert includes a curved section or a

plurality of consecutive curved sections lying in a plane generally normal to the piston axis, the curved section or at least one of the plurality of curved sections being within said gap so that the crown is supported on the skirt, and the curved section or at least two of the plurality of curved sections being embedded in the piston material to support the insert.

The following is a more detailed description of some embodiments of the invention, by way of example, reference being made to the accompanying drawings in which:-

Figure 1 is a vertical cross-section through a first embodiment of light metal piston;

Figure 2 is a section on the line A-A of Figure 1;

Figure 3 is a vertical cross-section through a second embodiment of light metal piston;

Figure 4 is a plan view of an alternative embodiment of an insert for incorporation in the pistons of Figures 1 to 3.

Figure 5 is a vertical cross-section through a third

embodiment of light metal piston;

Figure 5A shows an elevation (left-hand side) and a plan (right-hand side) of an insert for incorporation in the embodiment of Figure 5;

Figure 6 is a section on the line B-B of Figure 5;

Figure 7 is a vertical cross-section through a fourth embodiment of light metal piston;

Figure 8 is a section on the line C-C of Figure 7;

Figure 9 is a half plan view (upper part) and an elevation (lower part) of an insert for incorporation in the piston of Figures 7 and 8;

Figure 10 is a vertical cross-section through a fifth embodiment of a light metal piston;

Figure 11 is a section on the line D-D of Figure 10; and

Figure 12 is a plan view (upper part) and an elevation (lower part) of an insert for incorporation in the piston of Figures 10 and 11.

The pistons of all the embodiments have features which are at present in all embodiments and these will be described initially without specific reference to any one embodiment.

Each piston is formed by casting in a light metal such as aluminium or an aluminium alloy or magnesium or magnesium alloy. Each piston comprises a crown 10 which includes an annular portion 11 formed with three axially spaced circumferentially extending ring grooves 12, 13, 14. Each groove has spaced radially extending side walls interconnected by a base.

The piston also includes two axially aligned gudgeon pin bores 15 formed in respective gudgeon pin bosses 16.

The piston also includes a skirt 17. Since a connecting rod (not shown), connected to the piston by a gudgeon pin extending through the gudgeon pin bore 15, will not act along the piston axis, diametrically opposed portions 17a, 17b of the skirt 17 will be urged towards an associated cylinder during reciprocation of the piston. These portions will thus lie on opposite sides of the plane including the piston axis and the gudgeon pin bore axis. The surfaces of these portions 17a, 17b are known as the thrust and counter-thrust faces

respectively; the thrust face being the face urged towards the associated cylinder during the expansion stroke and the counter-thrust face being the face urged towards the associated cylinder during the compression stroke.

The upper end of each skirt portion 17a, 17b is spaced from the lower end of the crown by an axially and circumferentially extending gap to assist in the control of the thermal expansion of the skirt. The gap is formed in the lower side walls and the base of the lowermost piston ring groove 14 and is filled by a curved section 18a, 28, 37a, 41 of an insert 18, 25, 36, 40 whose various alternative constructions will be described below. Each curved section 18a, 28, 37a, 41 has a lower radially extending surface which sits in a radially inwardly facing rabbet formed at the upper end of each thrust surface and has an upper radially extending surface contacting a corresponding surface at the lower end of the crown. The insert is supported and located by being embedded in the piston material forming the gudgeon pin boss 16.

The embodiments of the piston illustrated in the drawings vary in the construction and arrangement of the inserts and these will now be described.

Referring first to Figures 1 and 2, the insert 18 of this embodiment is a generally annular shape (as best seen in Figure 2) of constant width along its length and comprises two pairs of curved sections 18a, 18b. The insert 18 lies generally in a plane normal to the piston axis. Two of the opposed curved sections 18a separate and contact the crown 10 and the skirt portions 17a and 17b and the two remaining curved sections 18b interconnect the ends of the first curved sections 18a and are embedded in and pass through the material of the piston forming the gudgeon pin bosses 16. In view of the positionof the gudgeon pin bore 15, the further curved sections 18b are provided with upwardly arcuate portions 19 which pass around the gudgeon pine bore 15.

The construction of Figure 3 is generally the same as that of Figure 2 except that a second insert 19 is provided which forms a reinforcement member for the lower ends of the skirt portions. The second insert 19 is also made of a material whose coefficient of thermal expansion is less than that of the crown 10 and skirt 17, and has portions 19a received in the interior surfaces of said skirt portions 17a, 17b and portions embedded in the piston material.

Figure 4 shows an insert 40 which may be substituted for

the insert 18 in the piston of Figures 1 to 3. The insert 40 comprises two curved sections 41 which separate and contact the crown and the skirt portions 17a, 17b. The curved sections 41 have their ends interconnected by curved side sections 44, each of which comprises initial portions 44a having substantially parallel curved edges and leading from respective ends of the curved sections 41 and a central portion 44b whose curved edges converge towards the middle of each side section to form a neck. The central portions 44b may be upwardly arcuate, where necessary, to allow them to pass around the gudgeon pin bore 15.

Referring next to Figures 4, 5A and 6, the third embodiment of piston includes two inserts 25 each having an upper curved portion 28 which contacts and separates the crown and the upper end of a skirt portion and whose ends are embedded in the piston material forming the gudgeon pin boss 16 and having a lower curved section 29 which forms a reinforcing member for the lower ends of the skirt portions and has the ends thereof embedded in the piston material forming the gudgeon pin boss 16. Two connecting sections 30 extend within the piston material between the ends of the upper and lower curved sections 28, 29.

Referring next to Figures 7 to 9, this embodiment of piston is substantially the same as that described above with reference to Figure 3 but in this case two diametrically opposed struts 35 are provided each extending axially along the interior of the associated skirt portion 17a, 17b and interconnecting the curved sections 18a, 19a of the two inserts 18, 19.

Referring finally to Figures 10 to 11, the embodiment of piston shown therein comprises two inserts 36 each formed by an upper portion 37 having a curved section 37a contacting and separating the upper end of the associated skirt portion 17a, 17b and the crown 10 and having curved end sections 37b embedded in the piston material forming a gudgeon pin bore 16 and a lower portion 38 having a curved section 38a forming a reinforcing member for the lower end of the associated skirt portions 17a, 17b and having curved end portions 37b embedded in the piston material forming the gudgeon pin boss 16. A strut 38 extends axially along the interior of each skirt portion to interconnect the upper and lower portions.

It will be appreciated that the various inserts 18, 25, 37, 40 described above with reference to the drawings have a number of common features. They all include a

single curved section or a plurality of consecutive curved sections lying in a plane normal to the piston axis. This form of construction is easy to produce since it can be made by pressing or bending. In addition, an insert of this shape has thermal expansion characteristics which can be determined. Since each insert is wholly or substantially wholly surrounded by or in contact with the material of the piston, the inserts can be readily cast into the piston without the difficulties caused by the need for substantial gaps or voids around the insert.

In addition, the fact that in the illustrated embodiments, the inserts form at least a part of a piston ring groove of the associated piston, allows the overall height, and thus the overall weight, of the piston to be somewhat reduced.

In addition, the sections of the inserts which contact and separate the skirt portions and the crown all terminate radially inwardly of the outer surface of the skirt 17. This prevents the insert contacting and damaging an associated cylinder when in use. This also removes the need to try and machine the insert and the skirt surface together to produce a satisfactory surface.

These sections also lie in radially inwardly facing rabbets in the skirt portions 17a, 17b. Thus, after casting and at ambient temperatures, the radially inward contraction of the piston is limited by the insert, so that the piston is stressed with radially inwardly directed forces from the piston being opposed by a reaction force from the insert. As the piston is heated, in use, therefore, the piston stresses tend to disappear until an operating temperature is reached at which there is zero stress in both the piston and the insert. Thus, the amount of radial expansion and contraction of the piston is controlled by the insert.

It will be appreciated that it may be desirable to split the inserts 18, 40 shown in Figures 1, 2, 3, 4, 7, 8 and 9 into two parts lying on opposite sides of a plane including the piston axis and the gudgeon pin bore axis. This will give an arrangement similar to that shown in Figures 10, 11 and 12 and has the advantage of eliminating piston cracking under thermal loads in certain designs of piston.

CLAIMS

1. A piston of light metal for an internal combustion engine or a compressor and of the kind comprising a crown, a gudgeon pin bore, a skirt including portions forming opposed thrust faces on opposite sides of a plane including the piston axis and the gudgeon pin bore axis, an upper end of at least one skirt portion being spaced from an adjacent crown portion by an axially and circumferentially extending gap, and an insert of a material of lower coefficient of thermal expansion than the material of the crown and skirt, characterised in that the insert (18; 25; 36; 40) includes a curved section or a plurality of consecutive curved sections (18a, 18b; 28; 37a, 37b; 41; 44a) lying in a plane generally normal to the piston axis, the curved section or at least one of the plurality of curved sections (18a; 28; 37a; 41) being within said gap so that the crown (10) is supported on the skirt (17), and the curved section or at least two of the plurality of curved sections (18B; 28; 37b; 44a) being embedded in the piston material to support the insert.

2. A piston according to claim 1 characterised in that the curved section or sections (18a, 18b; 28; 37a; 37b; 41; 44a) is or are of substantially constant width along

the length thereof.

3. A piston according to claim 1 or claim 2 characterised in that the curved section or sections (18a; 28; 37a; 41) separating the crown (10) and skirt (17) terminate radially inwardly of the outer peripheral surfaces of the crown and skirt.

4. A piston according to any one of claims 1 to 3 characterised in that a single curved section (18a; 28; 37a; 41) separates and contacts the skirt portion (17) and the crown (10) with a lower radially extending surface thereof being received in a corresponding radially inwardly facing rabbet in the upper end of the skirt and an upper radially extending surface thereof contacting a corresponding surface of the crown.

5. A piston according to any one of claims 1 to 4 characterised in that the piston has at least one piston ring groove (14) and in that the insert (18; 25; 36; 40) forms, over the circumferential extent of the skirt portion, at least a part of one side wall and/or of the base of said groove.

6. A piston according to claim 5 characterised in that the insert (18; 25; 36; 40) forms a portion of the base

and an adjoining portion of a lower side wall of the piston ring groove.

7. A piston according to any one of claims 1 to 6 characterised in that the insert includes a plurality of curved sections, in that gaps are provided between both skirt portions and the crown and in that a first curved section (18a; 41) is within one gap and contacts said one of the skirt portions (17a) and said crown (10), a second of said curved sections (18a; 41) being within the other gap and contacting the other of the said skirt portions (17b) and said crown with further curved sections (18b; 44a) interconnecting said first and second curved sections and being embedded in the piston material.

8. A piston according to any one of claims 1 to 7 characterised in that said further curved sections comprise two curved sections (18b; 44a) each extending through the piston material between respective ends of the first and second curved sections, thus forming an annular insert.

9. A piston according to any one of claims 1 to 6 characterised in that gaps are provided between both skirt portions (17a, 17b) and the crown, and in that

said insert is one of two such inserts (25; 36), the other of said inserts being within the other gap and contacting the other of said skirt portions and the crown.

10. A piston according to claim 9 characterised in that each insert includes a single curved section (28).

11. A piston according to claim 9 characterised in that each insert includes three curved sections (18a, 18b), one (18a) being within a gap and contacting the associated skirt portion and the crown and the remaining two sections (18b) leading from respective ends of said one curved section and being embedded in the piston material.

12. A piston according to any one of claims 1 to 11 characterised in that the lower ends of the thrust faces of the skirt are reinforced by respective reinforcing members (19; 29; 38) of a material having a coefficient of expansion which is lower than the coefficient of expansion of the material of the skirt and crown, the reinforcing members being received in the interior surface of said skirt portions and being embedded in the piston material.

13. A piston according to claim 11 characterised in that a single crown-end insert is provided, and in that the reinforcing members for the lower ends of the thrust faces (17a, 17b) form part of a second insert (18; 36) parallel to said first mentioned insert, there being provided two diametrically opposed struts (35) each extending axially along the interior of the associated thrust face and interconnecting the two inserts.

14. A piston according to claim 12 characterised in that two crown-end inserts (25) are provided and in that each reinforcing member for the lower ends of the thrust faces (17a, 17b) forms part of one of said two inserts.

15. A piston according to claim 14 characterised in that each insert (25) includes two connecting sections (30) each extending within the piston material between an end of one of the curved sections embedded in the piston material and an end of the reinforcing member embedded in the piston material.

16. A piston according to claim 14 characterised in that an axially extending strut (39) interconnects the skirt-contacting curved section (37) and the reinforcing

member (38) of each insert (36).

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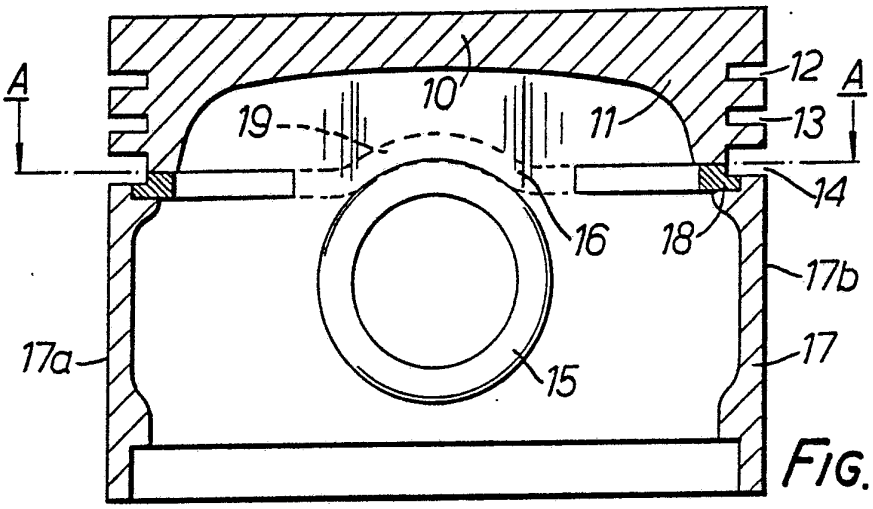

FIG.1.

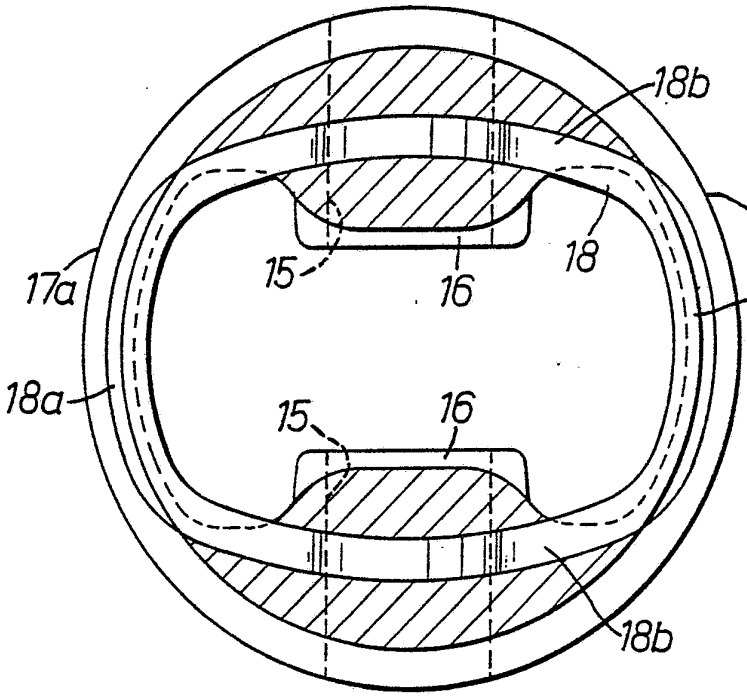

FIG.2.

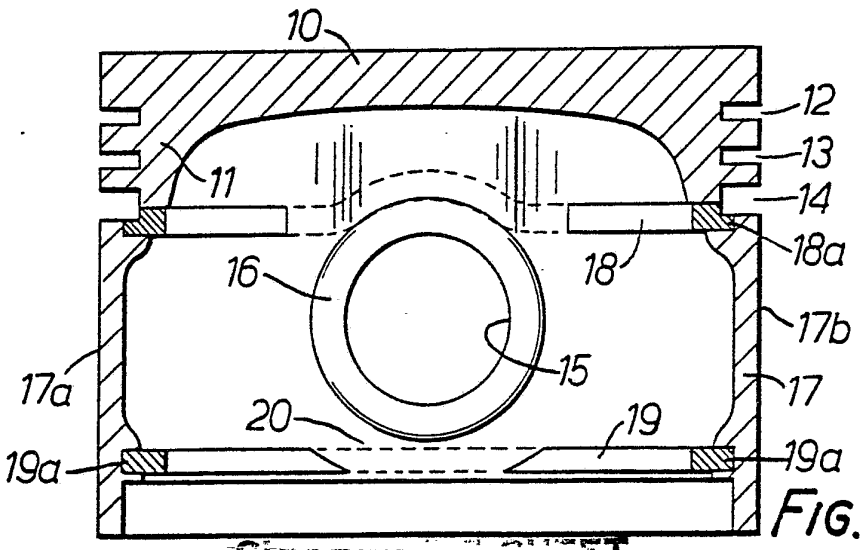

FIG.3.

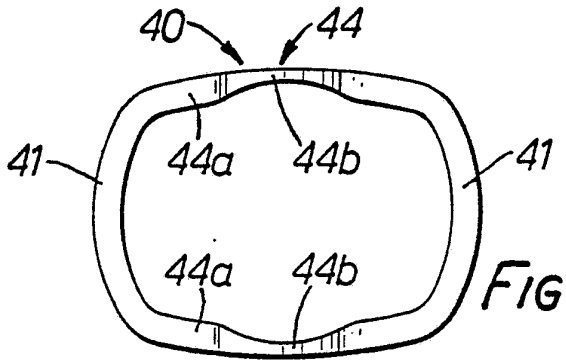

FIG. 4.

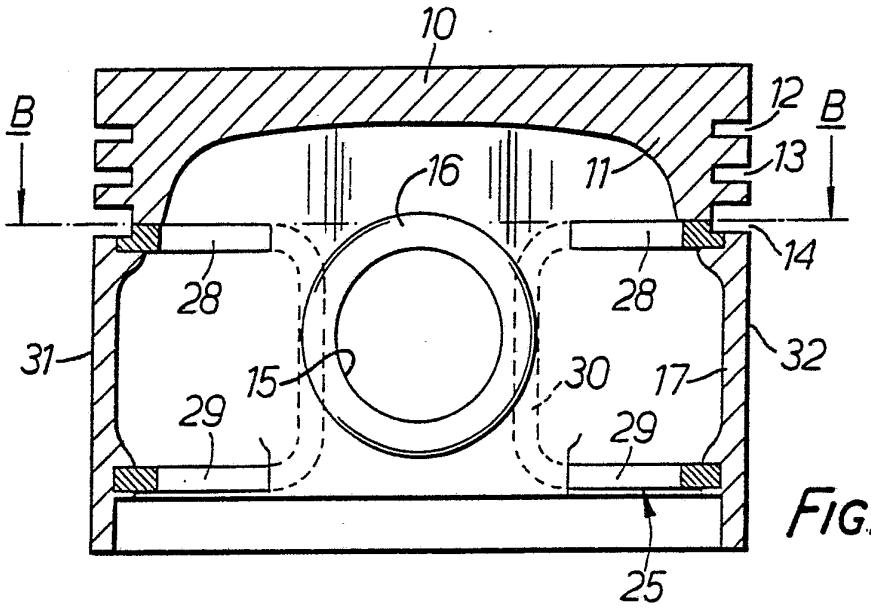

FIG. 5.

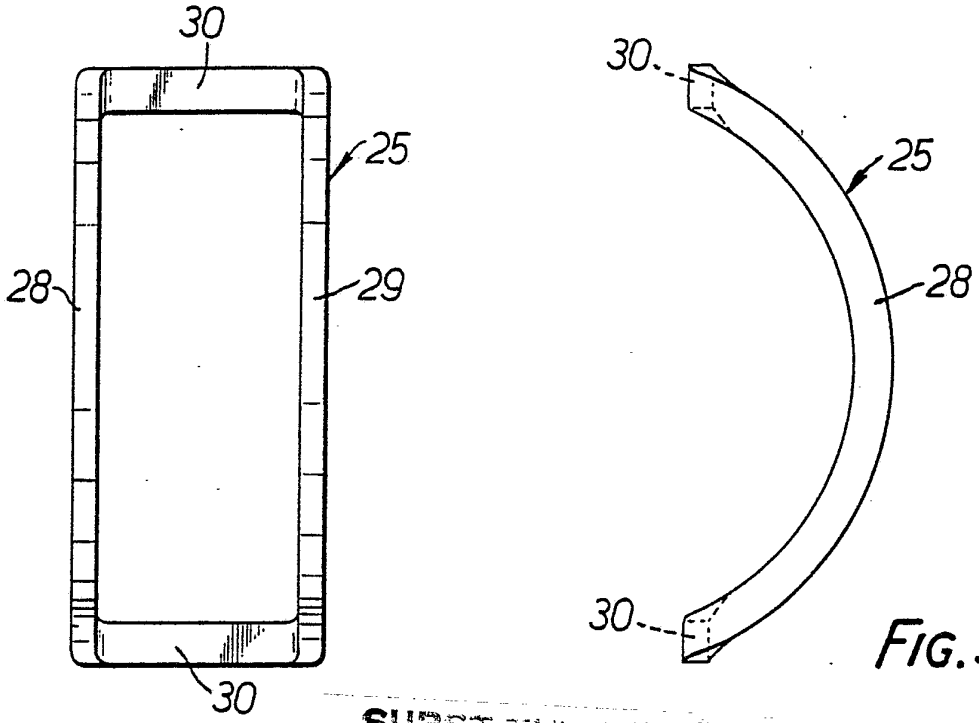

FIG. 5A.

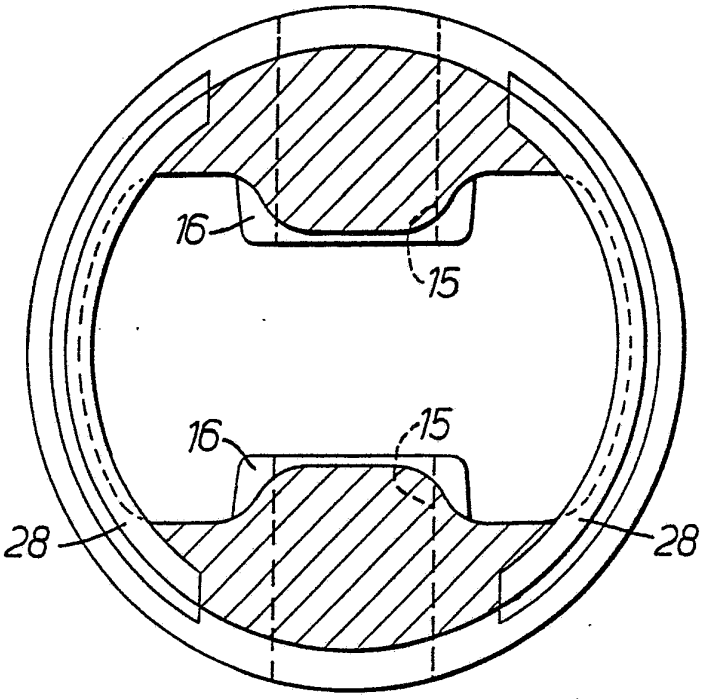

FIG. 6.

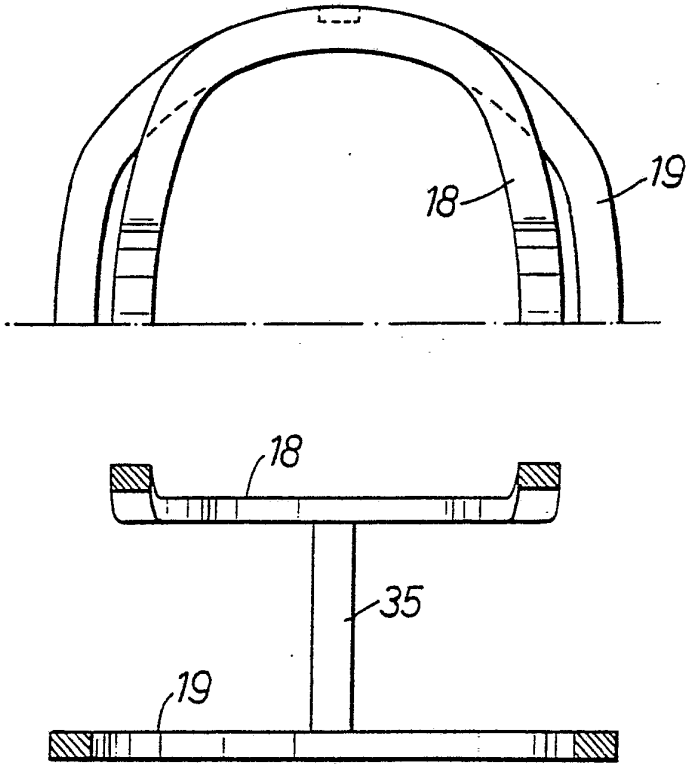

FIG. 9.

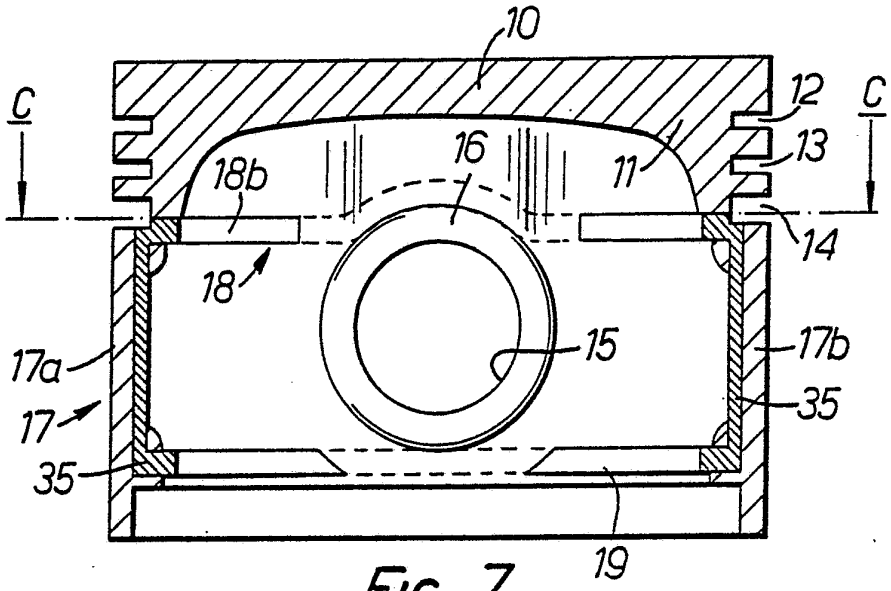

FIG. 7.

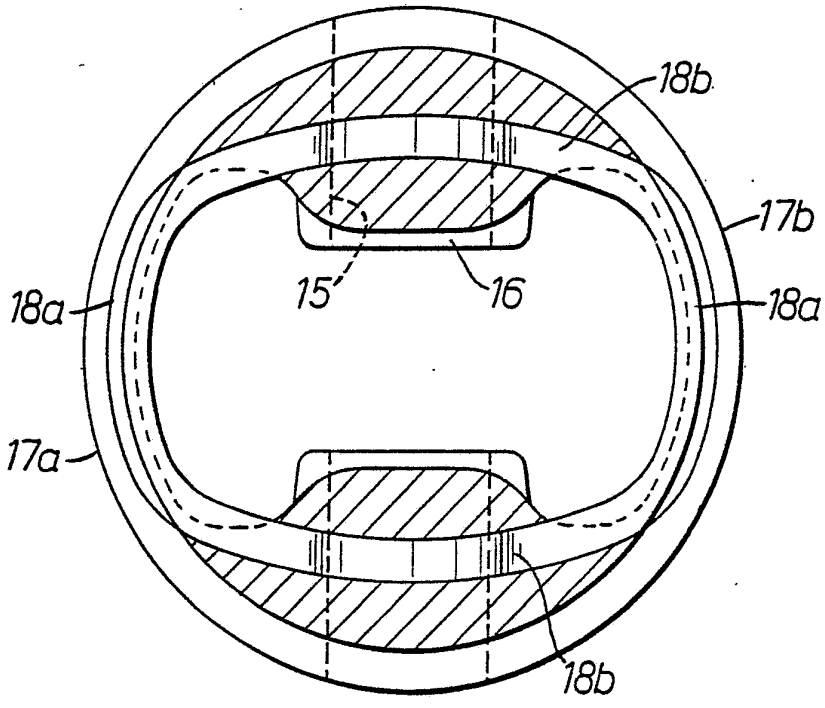

FIG. 8.

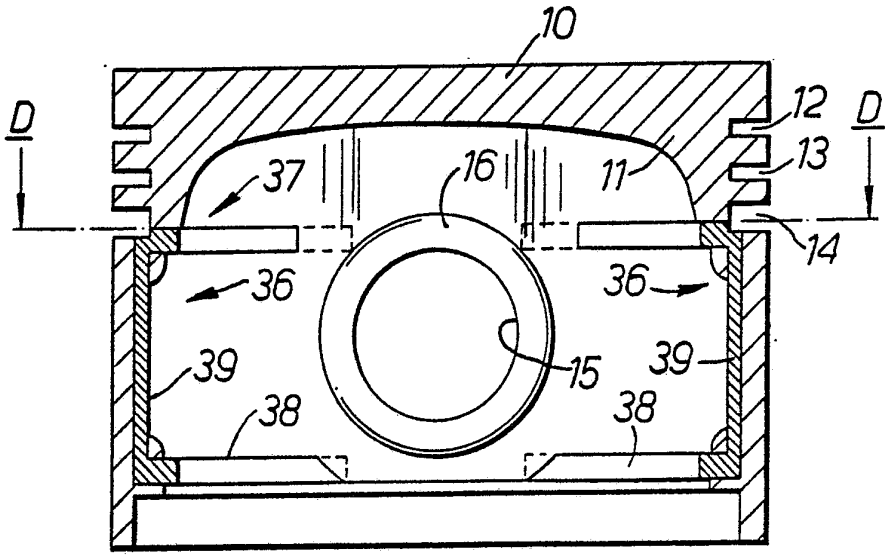

FIG. 10.

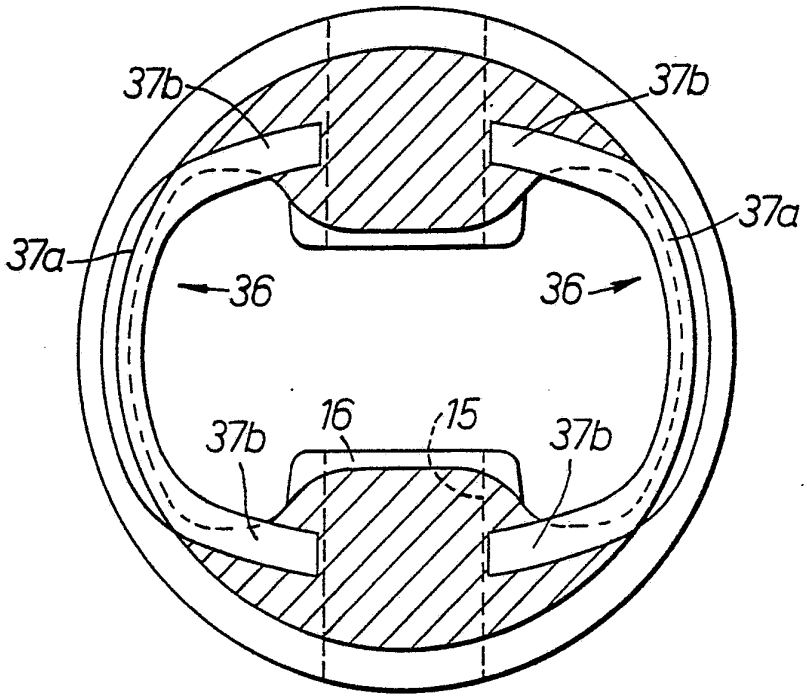

FIG. 11.

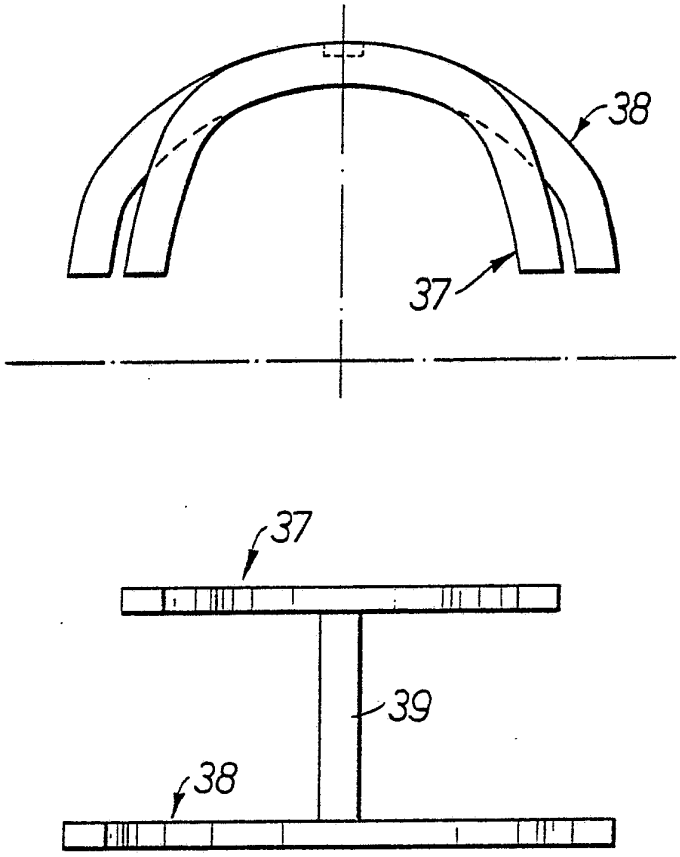

FIG. 12.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 82/00280

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[3]: F 02 F 3/08

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
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Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US, A, 2874011 (PETERSON) 17 February 1959 see column 2, lines 38-61; figure 2 --	1-8,10
A	GB, A, 1134245 (HEPWORTH) 20 November 1968 see page 1, lines 55-86 --	1-8
A	DE, C, 738948 (SCHMIDT) 29 July 1943 see page 2, lines 79-116 --	1-8,10,12, 14
A	FR, A, 1392295 (AGOSTINONE) 1 February 1965 see page 1 ------	

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
21st December 1982	10th January 1983
International Searching Authority [1]	**Signature of Authorized Officer [20]**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

Form PCT/ISA/210 (second sheet) (October 1981)