(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 222 981 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.07.2002 Bulletin 2002/29

(51) Int Cl.[7]: **B22D 19/00**, F02F 7/00

(21) Application number: **01300276.1**

(22) Date of filing: **12.01.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: **Ford Global Technologies, Inc.**
Dearborn, Michigan 48136 (US)

(72) Inventor: **Tompkins, Robert Frederick**
Cardiff CF14 5DB (GB)

(74) Representative: **Farrow, Robert Michael et al**
Land Rover,
Gaydon Engineering Centre,
53/G/9/1, Banbury Road
Lighthorne, Warwick CV35 ORG (GB)

(54) **Engine cylinder block manufacture**

(57) An internal combustion engine cylinder block 11 is manufactured as a casting by supplying preformed cylinder liners 12 of centrifugal cast iron and casting aluminium alloy around the outer periphery of the liners 12 to form a cylinder block casting 13. In this condition the block casting 13 includes an as-cast head face 14 which is flush with an end face of each liner. In a first machining operation, a face mill which rotates about an axis which is substantially perpendicular to the head face 14 is fed axially in line with the axis of each liner 12 to machine a recess 22 in the head face 14 concentric with the liner 12. In a second machining operation, another face mill which also rotates about an axis which is substantially perpendicular to the head face 14 is fed laterally relative to the cylinder block 11 to machine the as-cast head face 14. This produces a finished head face 32 and reduces the depth of the recess 22 to a second predetermined depth D2, the face mill 31 removing an amount of metal D1-D2. The finished recess 22 accommodates and radially supports a thickened annular portion of a head gasket.

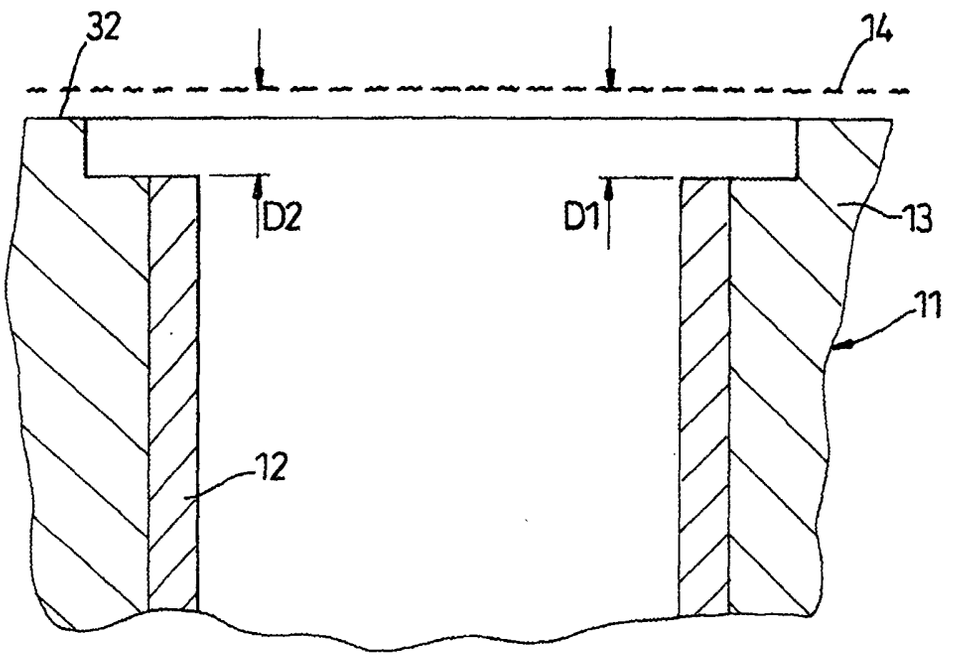

Fig. 6

EP 1 222 981 A1

Description

[0001] The invention is related to the manufacture of internal combustion engine cylinder blocks of the kind in which a pre-formed cylinder liner of one material is in intimate contact with a cylinder block body of another material. Typically, the liner material is ferrous, e.g., cast iron, and the cylinder block body is an aluminium alloy which is cast around the liner. US-A-5,361,823 illustrates the manufacture of such a cylinder block.

[0002] A cylinder block of the kind referred to above causes problems in the machining of the cylinder head joint face. Typically, such machining is carried out using a face mill rotating about an axis perpendicular to the head face and traversing across it. This requires the cutting edges of the milling cutter to cut both the material of the liner and the material of the block body. The tooling life is limited by the need to cut the liner cleanly, resulting in high tooling costs and down time in the machining process. Also, material machined or broken away from the liner can damage the normally softer surface of the block material even in the case where, to minimise this unwanted effect, the chosen cutting parameters are a compromise. Rapid wear of the tool tip is found even where a Poly Crystalline Diamond (PCD) tip is used and the rate of wear is greater than experienced when optimised parameters are used in the cutting of cast iron or aluminium alloy alone.

[0003] The present invention has as an object of the provision of a manufacturing process or engine cylinder block which obviates the above mentioned disadvantages.

[0004] According to a first aspect of the invention there is provided a method of machining a head face of an internal combustion engine cylinder block comprising one or more pre-formed cylinder liners of a first material in intimate contact with a cylinder block body of a second material, the or each liner having an annular end face adjacent the head face, the method comprising the steps of machining the or each liner end face to form a respective cylindrical recess concentric with the or each liner, the recess so formed having a first predetermined depth and machining the head face of the block body to reduce the depth of the recess to a second predetermined depth.

[0005] The invention also provides, according to a second aspect thereof, a method of manufacturing an internal combustion engine cylinder block including the steps of supplying one or more pre-formed cylinder liners of a first material, casting a cylinder block body of a second material around an outer periphery of the or each cylinder liner to form a cylinder block casting, said casting including an as-cast head face substantially flush with an end face of the or each cylinder lining, machining the or each liner end face to form a respective cylindrical recess concentric with the or each liner, the recess so formed having a first predetermined depth and machining the head face of the block body to reduce the depth of the recess to a second predetermined depth.

[0006] The first material may be ferrous, e.g. cast iron, and the second material may be aluminium or an aluminium alloy which may be cast around the or each liner.

[0007] The method according to said first or said second aspect of the invention may include a machining operation in which a face mill which rotates about an axis which is substantially perpendicular to the head face is fed axially to machine the recess. Such a method may also include a machining operation in which a face mill which rotates about an axis which is substantially perpendicular to the head face is fed laterally relative to the cylinder block to machine the head face, in which case the face mill may be fed longitudinally parallel to a crankshaft axis of the cylinder block to machine the head face.

[0008] The invention also provides, according to a third aspect thereof, an internal combustion engine cylinder block manufactured by a method according to said first or said second aspect.

[0009] The invention will now be described by way of example and with reference to the accompanying drawings, of which:-

Fig.1 is a diagrammatic perspective view of an internal combustion engine cylinder block manufactured according to the invention;

Fig.2 is a diagrammatic cross-section on the line II-II in Fig.1 showing the cylinder block prior to machining;

Fig.3 is a view based on Fig.2 showing a first machining operation;

Fig.4 is a view based on Fig.2 showing the cylinder block after completion of the first machining operation but prior to a second machining operation;

Fig.5 is a partial side elevation of the cylinder block shown in Fig.1 as viewed in the direction of arrow A in Fig.1 showing a face mill during the second machining operation;

Fig.6 is a view similar to Fig.2 showing the cylinder block after the second machining operation;

Fig.7 is a scrap section based in Fig.6 showing the machined cylinder block together with a head gasket and cylinder head;

Fig.8 is a diagrammatic cross-section based on Fig. 2 showing a first modification to the cylinder block prior to machining;

Fig.9 is a diagrammatic cross-section based on Fig. 2 showing a second modification to the cylinder block prior to machining;

Fig.10 is a diagrammatic cross-section showing the cylinder block with a third modification and after completion of the first machining operation but prior to the second machining operation; and

Fig.11 is a diagrammatic cross-section showing the cylinder block of Fig.10 after the second machining operation.

[0010] An internal combustion engine cylinder block 11 is manufactured as a casting by supplying four preformed cylinder liners 12 of a first material, namely cast iron typically made using a of centrifugal casting process and with a machined bore. A second material, namely aluminium alloy is then cast around the outer periphery of the liners 12 to form a cylinder block body or casting 13. In this condition the block casting 13 includes an as-cast head face 14 which is substantially flush with an end face 15 of each liner 12 (Figs.1 and 2).

[0011] In a first machining operation, a face mill 21 (Fig.3), which rotates about an axis which is substantially perpendicular to the head face 14 is fed axially in line with the axis of each liner 12 to machine a respective recess 22 in the head face 14 to a first predetermined depth D1. Each recess 22 encompasses and is substantially concentric with the respective liner 12 to fully expose the block material 13 around the liner.

[0012] In a second machining operation, another face mill 31 (Fig.5), which also rotates about an axis which is substantially perpendicular to the head face 14, is fed laterally relative to the cylinder block 11 in a longitudinal direction parallel to a crankshaft axis X (Fig.1) to machine the as-cast head face 14. This produces a finished head face 32 and reduces the depth of the recess 22 to a second predetermined depth D2, the face mill 31 removing an amount of metal D1-D2.

[0013] The finished recess 22 accommodates a thickened annular portion 35 of a head gasket 36 (Fig.7) which also includes a generally flat portion 37 sandwiched between the finished head face 32 and a cylinder head 38. The annular gasket portion 35 provides a seal for cylinder gas pressure between the end face of the liner 12 and the cylinder head 38 whilst the flat gasket portion 37 provides a seal for coolant passages, oil drainage passages and oil feed passages in the conventional manner. The cylindrical wall 24 of the recess 22 helps to support the annular gasket portion 35. Instead of being formed as one assembly the gasket 36 can be replaced by separate sealing rings corresponding to the annular gasket portion 35 and a flat gasket corresponding to the flat gasket portion 37 in a manner generally as described in US-A-1,880,643.

[0014] During the second machining operation to provide the finished head face 32, there is no machining of the liners 12 so that the design of the face mill 31 and its cutting inserts can be optimised for cutting the material of the block casting 13 both in terms of speed of cutting and final finish. By cutting a single material there is no problem of the harder material of the liner 12 scoring the softer material of the casting 13. Such scoring is a problem with internal combustion cylinder block head faces because it impairs the sealing of the head gasket. A further advantage is that the forces generated in cutting the block material alone during the second machining operation are very much less than if both the liner and the block are machined together as has hitherto been the practice. Reducing the forces reduces the amount of deflection of the tooling (i.e. the mill 31 and its supporting structure) and of the workpiece (i.e. the block 11). This in itself helps to improve both surface finish and dimensional stability.

[0015] It will be appreciated that initial depth D1 of the recess 22 does not need to be significantly greater than the amount that needs to be machined from the as-cast head face 14 to produce the finished face 32 and the final recess depth D2 would typically be 0.5mm. For machining purposes the diameter of the recess cylindrical wall 24 need only exceed the outer diameter of the liner 12 by a small amount sufficient to remove all of the liner from the recess 22. Apart from these considerations, the radial width and depth of the recess 22 can be conveniently chosen to suit the design of the cylinder head gasket 36.

[0016] The face mill 21 is preferably of an out-feed type in which each individual cutting insert 23 can be moved or fed radially outwardly. The inserts 22 are held at a first radius while the mill 21 is fed axially to the required depth D1 and the mill is then axially held while the inserts 23 are moved to a second radius to give the required diameter for the cylindrical wall 24 of the recess 22. However, the cutter inserts 23 may be fixed and the axis of the mill 21 moved orbitally relative to the cylinder axis to produce a recess 22 of the required diameter. Alternatively, the face mill 21 may form a simple plunge or counter-bore operation but this is less likely to give as good a finish as with the other methods just mentioned.

[0017] As described above, the as-cast head face 14 which is normally substantially flush with the end face 15 of each liner 12. In the casting process, there may be a certain thickness of the block material flash over the ends of the liners and this would normally be machined away by the end mill 21 in the first machining operation. Fig.8 shows a first modification to the cylinder block 13 in which the extent of the flash-over 41 is increased so as to reduce the amount of machining of the liner 12, the end 15 of each liner 12 being offset from the as-cast head face 14 by an amount D3 somewhat less than D1. Fig.9 shows a second modification, based on the first modification, in which a recess 22A is formed during the casting of the block 13. This recess 22A is of a lesser depth and diameter than the recess 22 as formed during the first machining operation as shown in Figs.3 and 4, thereby reducing the amount of machining of the block material during the first machining operation.

[0018] Figs.10 and 11 show a third modification to the cylinder block 13 in which the as-cast head face 14B is at an oblique angle to the cylinder axes rather than perpendicular as conventional. In a first machining operation, a face mill similar to the face mill 21 (Fig.3) rotates about an axis which is substantially perpendicular to the as-cast head face 14B and at an acute angle "a" fixed with respect to the axes of the liners 12. The face mill is fed axially to machine a recess 22B in the head face

14B similar to the recess 22 and to fully expose the material of the block 13 around the liner as shown in Fig. 10. In a second machining operation, another face mill similar to the face mill 31 (Fig.5), which also rotates about an axis which is substantially perpendicular to the as-cast head face 14B (and at the same angle "a" to the cylinder axes), is fed laterally relative to the cylinder block 11 in the longitudinal direction parallel to the crankshaft axis X to machine the as-cast head face 14B. This produces a finished head face 32B and reduces the depth of the recess 22B to a second predetermined depth as previously described. If required, the face mill in the second machining operation may rotate about an axis which is at a different angle to the angle "a" to produce a recess of a depth which varies around its circumference and alters the angle of the head face somewhat.

[0019] Whilst the invention has been described in relation to a four cylinder engine it may be applied to engines with any number of cylinders, including single cylinder engines and engines with more than one bank of cylinders, e.g., V6 and V8 configurations.

Claims

1. A method of machining a head face of an internal combustion engine cylinder block comprising one or more pre-formed cylinder liners of a first material in intimate contact with a cylinder block body of a second material, the or each liner having an annular end face adjacent the head face, the method comprising the steps of machining the or each liner end face to form a respective cylindrical recess concentric with the or each liner, the recess so formed having a first predetermined depth and machining the head face of the block body to reduce the depth of the recess to a second predetermined depth.

2. A method of manufacturing an internal combustion engine cylinder block including the steps of:-

   supplying one or more pre-formed cylinder liners of a first material;
   casting a cylinder block body of a second material around an outer periphery of the or each cylinder liner to form a cylinder block casting, said casting including an as-cast head face substantially flush with an end face of the or each cylinder lining;
   machining the or each liner end face to form a respective cylindrical recess concentric with the or each liner, the recess so formed having a first predetermined depth and machining the head face of the block body to reduce the depth of the recess to a second predetermined depth.

3. A method according to claim 1 or claim 2 wherein the first material is ferrous and the second material is aluminium or an aluminium alloy.

4. A method according to claim 3 wherein the first material is cast iron.

5. A method according to any preceding claim wherein the cylinder block body is cast around the or each liner.

6. A method according to any preceding claim wherein a face mill which rotates about an axis which is substantially perpendicular to the head face is fed axially to machine the recess.

7. A method according to any preceding claim wherein a face mill which rotates about an axis which is substantially perpendicular to the head face is fed laterally relative to the cylinder block to machine the head face.

8. A method according to claim 7 wherein the face mill is fed longitudinally parallel to a crankshaft axis of the cylinder block to machine the head face.

9. An internal combustion engine cylinder block manufactured by a method according to any preceding claim.

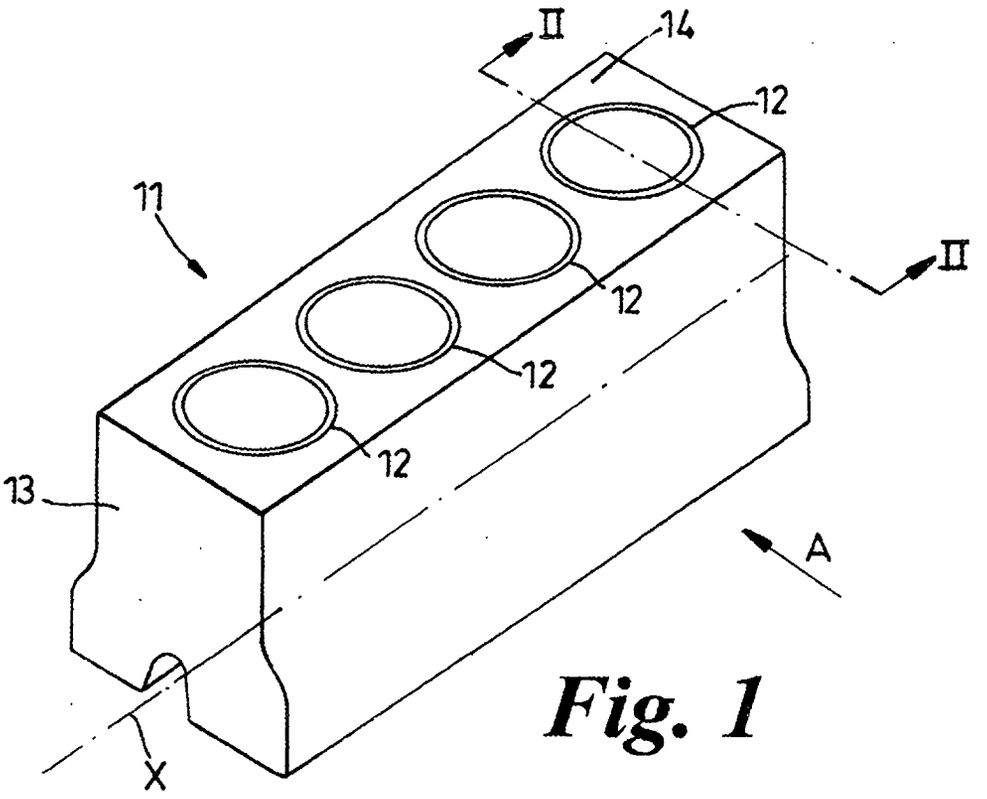

Fig. 1

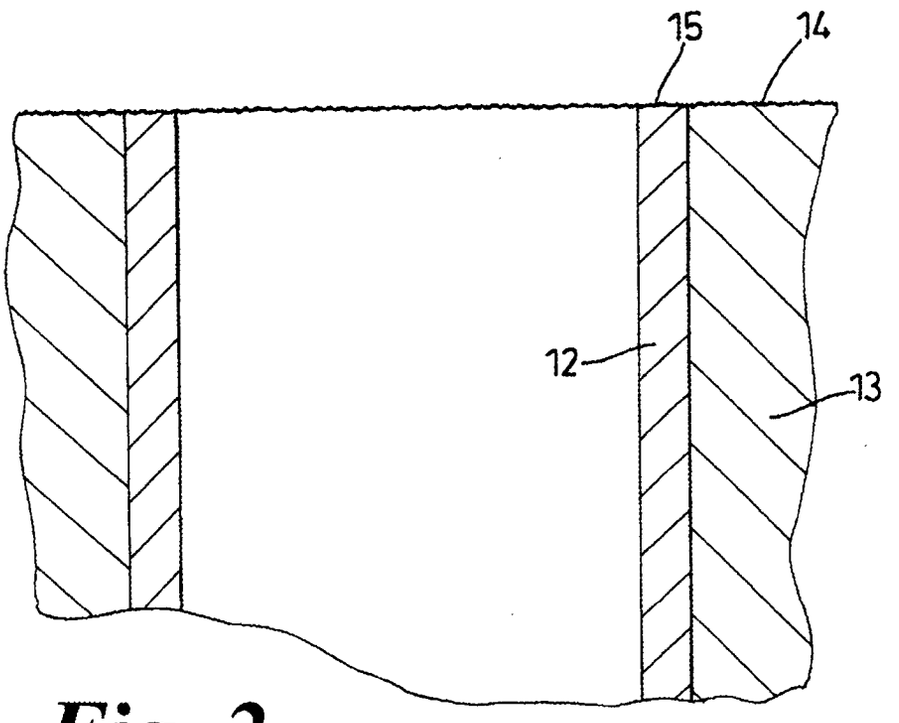

Fig. 2

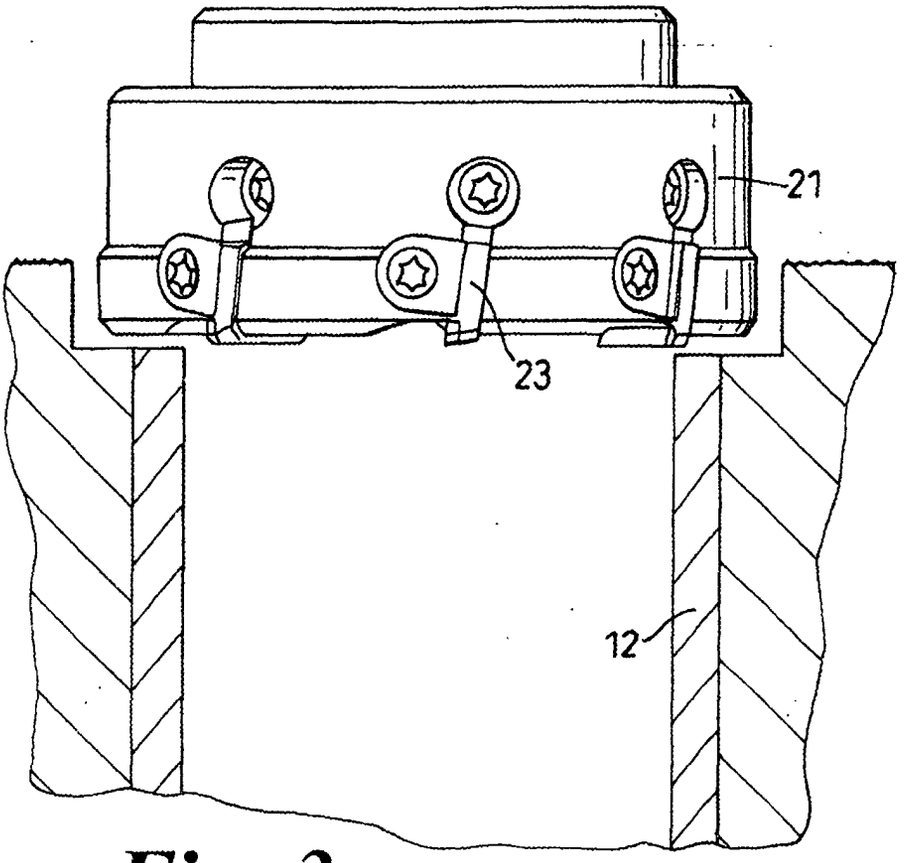

Fig. 3

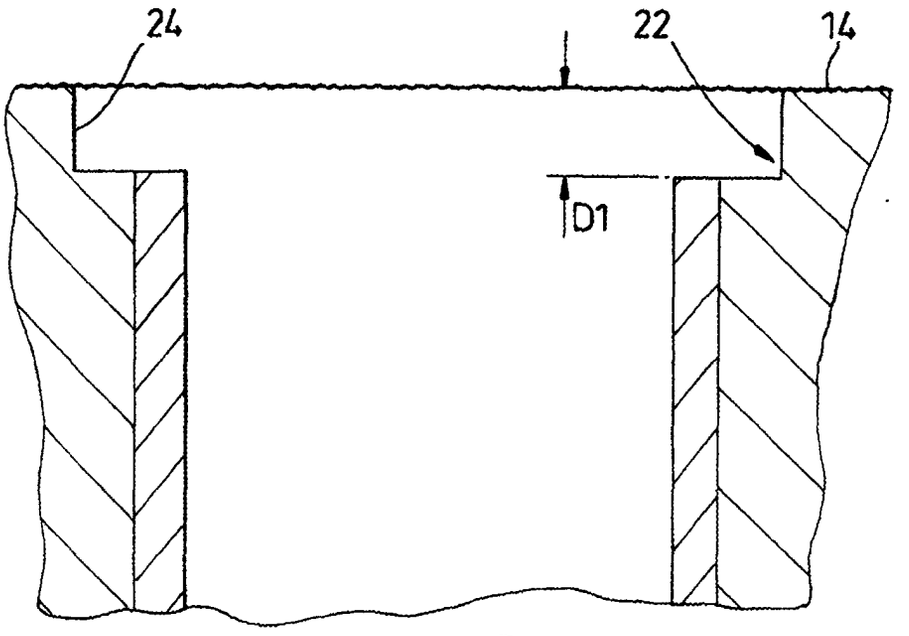

Fig. 4

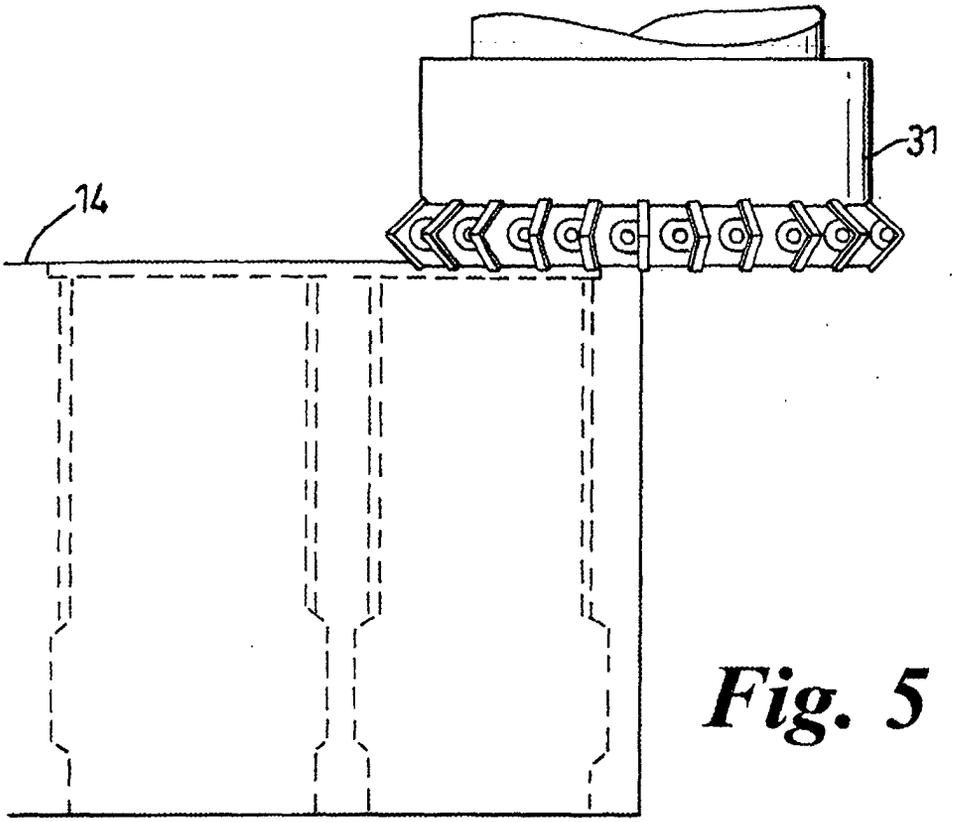

Fig. 5

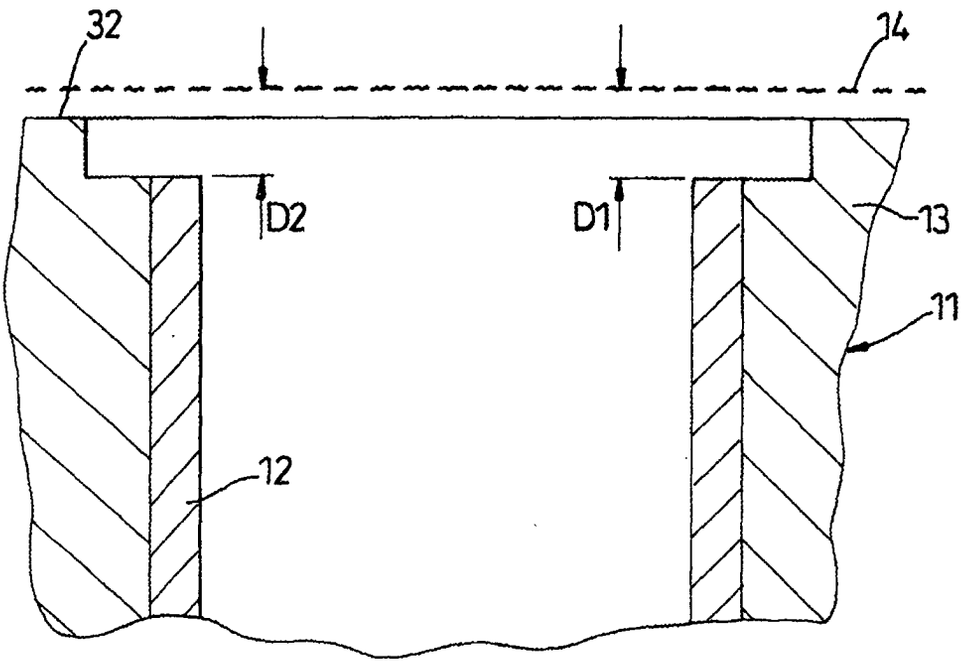

Fig. 6

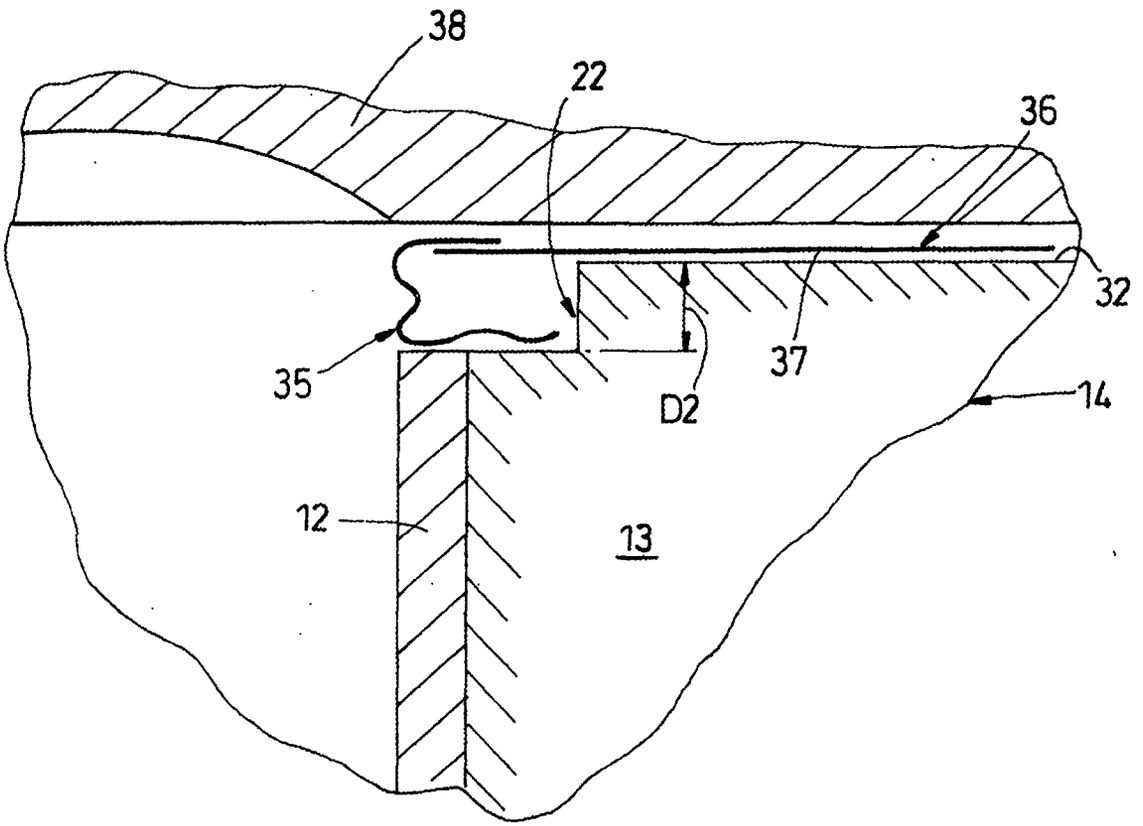

Fig. 7

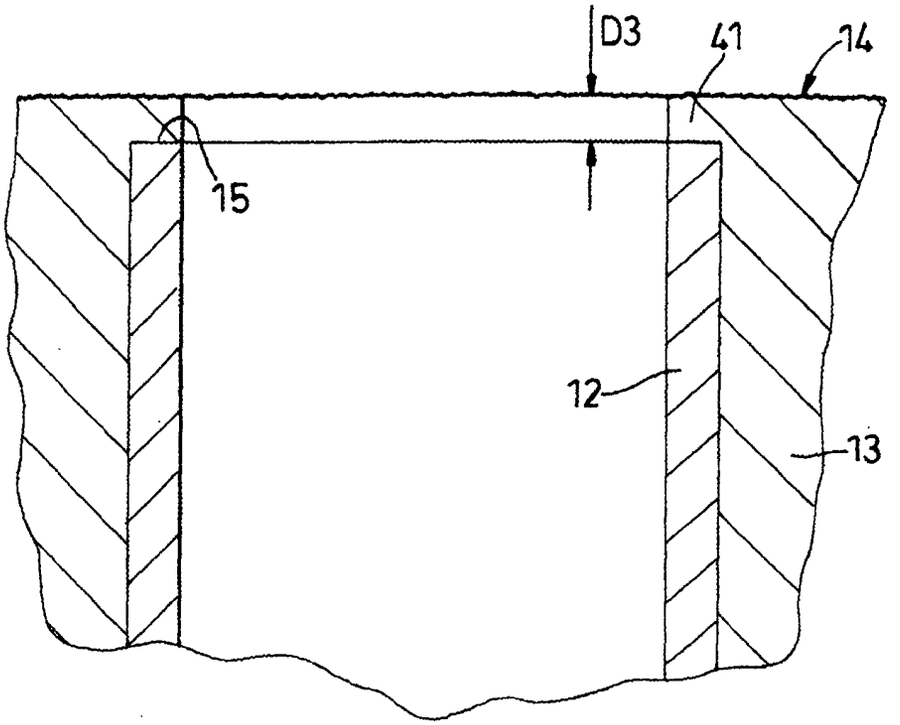

Fig. 8

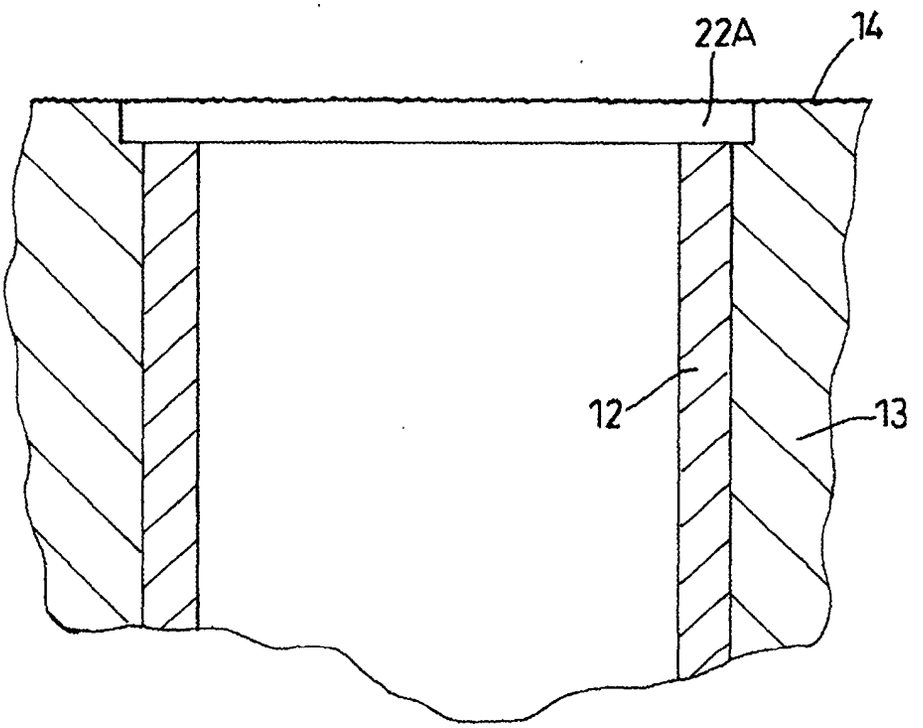

Fig. 9

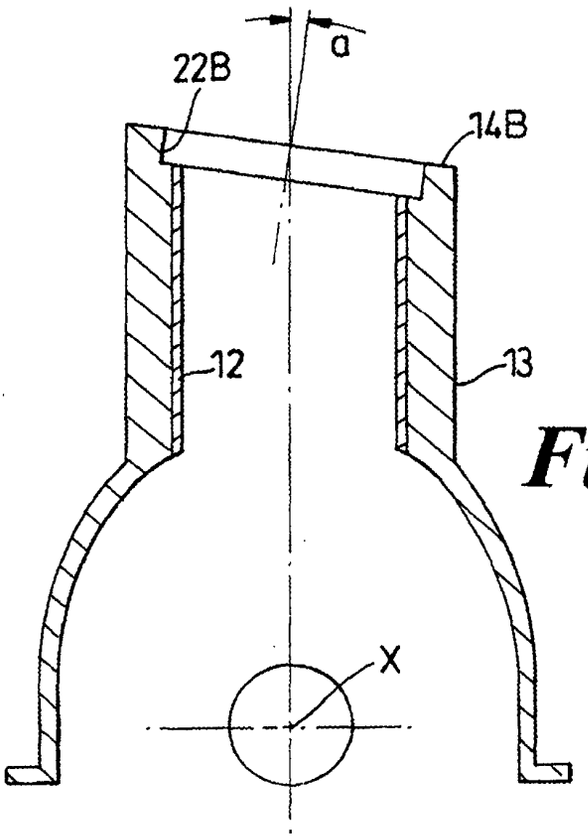

Fig. 10

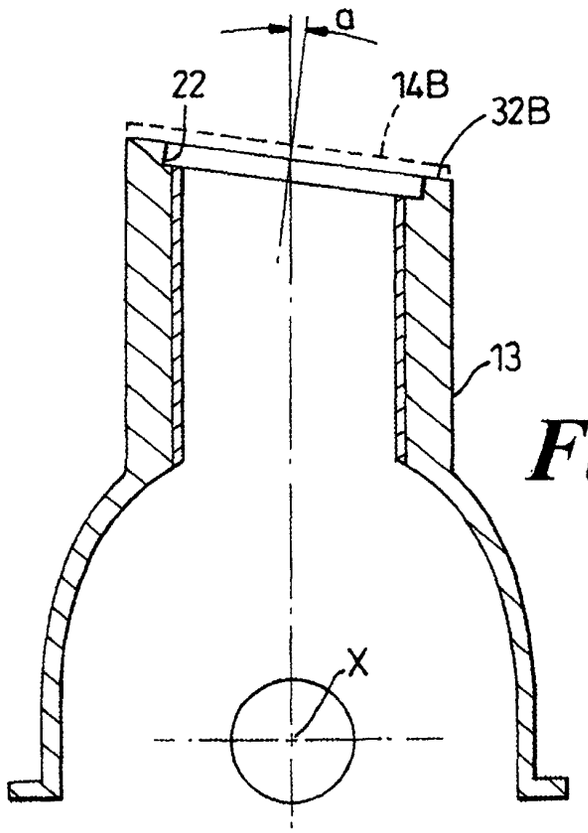

Fig. 11

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 0276

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.7)
D,A	US 5 361 823 A (KUHN JOHN W ET AL) 8 November 1994 (1994-11-08) * figure 8 * * abstract * * column 3, line 43 - line 52 * * column 2, line 51 - line 60 *	1-5,9	B22D19/00 F02F7/00
D,A	US 1 880 643 A (WOOLSON) 4 October 1932 (1932-10-04) * figure 1 * * page 1, column 2, line 61 - line 70 *	1,6	
A	DE 198 57 390 C (DAIMLER CHRYSLER AG) 6 April 2000 (2000-04-06) * figure 1 * * abstract *	1-5	
A	US 4 917 062 A (TAPPER THOMAS E ET AL) 17 April 1990 (1990-04-17) * figure 1 * * abstract * * column 4, line 1 - line 39 *	1,6,9	TECHNICAL FIELDS SEARCHED (Int.Cl.7) B22D F02F
A	FR 2 789 613 A (PEUGEOT CITROEN AUTOMOBILES SA) 18 August 2000 (2000-08-18) * figure 1 * * abstract *	1,7,9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 May 2001	Wassenaar, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 30 0276

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-05-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5361823 A	08-11-1994	NONE	
US 1880643 A	04-10-1932	NONE	
DE 19857390 C	06-04-2000	FR 2787044 A	16-06-2000
US 4917062 A	17-04-1990	JP 3043650 A	25-02-1991
FR 2789613 A	18-08-2000	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82