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(54) Advance arrangement

(57) An advance arrangement for use in adjusting the angular position of a cam arrangement (18) is disclosed which comprises an advance piston (40) slidable within a bore, and spring biased towards one end of the bore. Fuel under pressure can be applied to the piston (40) to move the piston (40) against the action of the spring. The piston (40) includes an opening or recess (40c) into which a peg or tooth (38) provided on the cam arrangement (18) extends to transmit movement of the piston (40) to the cam arrangement (18). A sleeve (42) is located within the opening or recess (40c) to reduce damage to the piston (40).

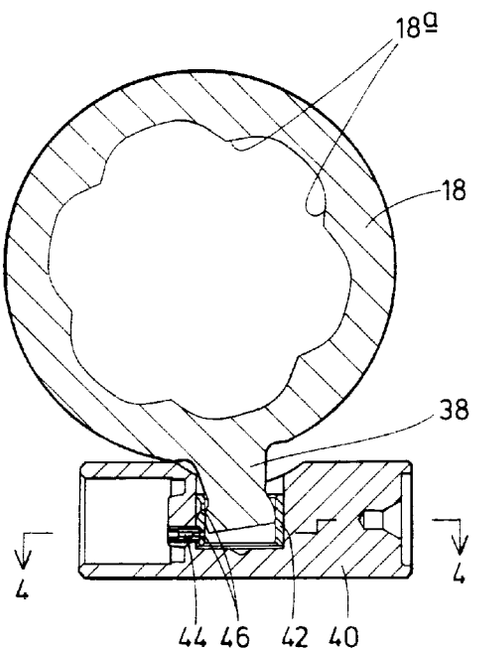

FIG 3

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Description

This invention relates to an advance arrangement for use in adjusting the timing of fuel delivery by a fuel pump.

A known fuel pump comprises a distributor member which is rotatable within a sleeve. Part of the distributor is surrounded by a cam ring the inner surface of which is shaped so as to include a plurality of cam lobes. The distributor member is provided with bores within which plungers are reciprocable in order to pressurize fuel within the bores. The outer end of each plunger carries a shoe and roller, the roller being arranged to cooperate with the inner, cam surface of the cam ring to cause reciprocating motion of the plungers.

The angular position of the cam ring is adjustable in order to adjust the timing at which inward movement of the plungers commences, and hence the timing of fuel delivery. The cam ring is adjustable by means of an advance piston slidable within a bore provided in a housing. Fuel is applied to an end of the piston to move the piston against the action of a spring. The piston includes a recess within which a peg mounted on or forming an integral part of the cam ring engages. It will be appreciated, therefore, that movement of the piston due to a change in the fuel pressure applied thereto results in a change in the angular position of the cam ring.

When the rollers engage the cam lobes, a large torque is applied to the cam ring, thus a force is applied to the advance piston by the peg. If the engagement between the peg and advance piston does not lie on the centre line of the advance piston, a torque is applied to the advance piston resulting in increased wear between the advance piston and the housing. Such wear may result in increased leakage which, in turn, may result in unacceptable movement, in use, and require a large amount of fuel to be supplied to the advance piston between each pumping cycle and the next in order to maintain the correct injection timing.

In order to maintain a constant clearance, irrespective of the operating temperature, between the advance piston and its bore, it is convenient to use the same material for the advance piston and the housing. The housing is commonly constructed of relatively soft aluminium alloy, thus the wear resistance of the housing is relatively low. If the advance piston is also constructed of aluminium alloy, the wear resistance of the advance piston is also low, thus the piston is susceptible to damage by the peg, in use.

Another type of fuel pump includes a rotatable plunger having a cam surface provided at an end thereof, and a plurality of rollers mounted within a cage located to cooperate with the cam surface so that rotation of the plunger results in reciprocating motion thereof. The cage is angularly adjustable by an advance piston as described hereinbefore to adjust the timing of fuel delivery by the pump.

It is an object of the invention to provide an advance arrangement in which these disadvantages are reduced.

According to the present invention there is provided an advance arrangement for an angularly adjustable cam arrangement, the advance arrangement comprising an advance piston slidable within a bore and biased towards an end of the bore by resilient means, the piston and bore defining a chamber to which fuel is supplied, in use, to urge the advance piston against the action of the resilient means, the advance piston being provided with a recess within which a peg of the cam arrangement is cooperable, wherein a sleeve is provided within the recess the peg being located within the sleeve, relative movement of the sleeve with respect to the advance piston being substantially prevented.

The presence of the sleeve reduces damage to the advance piston due to engagement between the advance piston and the peg, the sleeve conveniently being of a relatively hard material so that damage to the sleeve is also minimised.

Conveniently, the sleeve is secured against movement with respect to the advance piston by means of a grub screw.

The invention will further be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a view of a fuel pump incorporating an advance arrangement in accordance with an embodiment of the invention;

Figure 2 is a side view of the advance arrangement;

Figure 3 is a sectional view through the advance arrangement (with the cam ring in a different angular position);

Figure 4 is a sectional view along the line 4-4 of Figure 3;

Figures 5a and 5b are views illustrating assembly of the advance arrangement;

Figure 6 is an enlarged view of part of Figure 1; and

Figure 7 is a sectional view through the advance piston of the advance arrangement.

The fuel pump illustrated in Figure 1 comprises a distributor member 10 rotatable within a sleeve 12. The distributor member 10 includes a plurality of through bores within which pumping plungers 14 are slidable, the outer end of each plunger member 14 carrying a shoe and roller arrangement 16 the roller of which is arranged to cooperate with the cam surface of a cam ring 18 which as illustrated in Figures 2 and 3 is provided with a series of cam lobes 18a. The through bores communicate through an axially extending passage 20 pro-

vided in the distributor member 10 with a series of radially extending inlet passages 22, and also with a radially extending delivery passage 24 which is axially spaced from the inlet passages 22.

The inlet passages 22 are positioned so as to be registerable with an inlet port 26 provided in the sleeve 12 which is supplied with fuel through a suitable metering arrangement 28 by a low pressure vane pump 30 which is mounted upon and driven by an end of the distributor member 10. A valve arrangement 32 is connected between the inlet 30a and outlet 30b of the vane pump 30 in order to control the fuel pressure at the outlet 30b. The delivery passage 24 is arranged to register, in turn, upon rotation of the distributor member 10 with a series of delivery ports 34 provided in the sleeve 12, each delivery port 34 communicating with a respective injector (not shown) of an associated engine.

The distributor member 10 is keyed to a drive shaft 36 which is driven at a speed associated with engine speed.

The cam ring 18 includes an outwardly extending peg 38 which may be integral with the cam ring, or alternatively may be a separate component rigidly secured to the cam ring 18. The peg 38 has a part-spherical end region which is received within a large diameter drilling or recess 40c provided in an advance piston 40. The piston 40 is slidable within a bore provided in a housing and is arranged such that axial movement of the piston causes movement of the peg 38 resulting in angular movement of the cam ring 18 with respect to the sleeve 12.

The material used for the cam ring 18 and the peg 38 is extremely hard in order to withstand the forces applied thereto. The part-spherical end region of the peg makes a line contact with the cylindrical wall of the recess 40c and the load which is applied through this line interface in use is sufficiently high as to risk indentation or other damage to the wall of the recess 40c in the absence of protective intervention. In order to minimise such risk, according to the invention a hard steel sleeve 42 is received within the recess 40c of the advance piston 40, the sleeve 42 being of tubular nature, the peg 38 being received within the sleeve 42.

The length of the peg is such that the engagement between the peg 38 and the sleeve 42 lies close to or on the centre line of the advance piston 40 thus when the rollers associated with the plungers 14 engage the cam lobes 18a, the resulting torque applied to the cam ring 18 results in the peg 38 applying a force to the advance piston 40 substantially along the centre line of the advance piston 40 thus any torque applied to the advance piston 40 is relatively small.

As illustrated in Figures 4 and 5, the advance piston 40 is of generally cylindrical nature, and includes a cylindrical recess 40a at an end thereof arranged to receive a helical spring (not shown) to bias the advance piston 40 towards an end of the bore within which the advance piston 40 is received, in use. The other end of the advance piston 40 is provided with a recess 40b which, together with an end part of the bore, defines a pressure chamber which is arranged to be supplied with fuel by the vane pump 30. In the embodiment illustrated in Figure 1, the vane pump 30 and valve 32 operate in such a manner that the pressure at the outlet 30b of the vane pump 30 is related to the engine speed. The pressure applied to the pressure chamber of the advance piston 40 is therefore associated with engine speed, and the axial position of the advance piston 40 and hence angular position of the cam ring 18 are also related to engine speed.

The upper surface of the advance piston 40 adjacent the recess 40c is cut away, and it will be appreciated that such shaping of the advance piston 40 enables the cam ring 18 to move through a greater range of angular positions than would otherwise possible. The advance piston 40 is further provided with a horizontally extending milled slot 40d which opens into the recess 40c, the width of the slot 40d being slightly smaller than the diameter of the recess 40c.

As illustrated in Figures 5a and 5b, the sleeve 42 is of tubular form, the outer surface of the sleeve 42 being provided with a pair of diametrically opposed flat surfaces 42a, and the width of the slot 40d is such that when the flats 42a are presented to the sides of the slot 40d the sleeve 42 can be slid through the slot until the sleeve 42 lies completely within the recess 40c. Once in this position, the sleeve 42 can be rotated about its axis until it lies in the position illustrated in Figure 5a. It will be appreciated that in this position, the sleeve 42 cannot return along the slot 40d without first being rotated to the position in which the flats 42a lie adjacent the sides of the slot 40d.

As shown in Figures 3 and 4, a drilling is provided in the advance piston 40 extending from the recess 40a to the recess 40c. This drilling receives a grub screw 44. The sleeve 42 is provided with a pair of indentations 46 which, as shown in Figure 3, are located such that when the sleeve 42 is correctly positioned within the advance piston 40, one of the indentations 46 aligns with the drilling so that tightening of the grub screw 44 results in the end of the grub screw 44 being received within that indentation 46 to securely mount the sleeve within the recess 40c. It will be appreciated that by providing two indentations 46 in the sleeve 42, assembly of the advance arrangement is simplified as it does not matter which way up the sleeve 42 is when it is introduced into the recess 40c.

It is envisaged that the housing within which the advance piston 40 is located and the advance piston itself may be constructed of aluminium alloy. In order to improve the wear resistance of the advance piston 40 and housing, the advance piston may be hard anodised and a hard chrome plating may be provided on the surface of the bore within which the advance piston 40 is slidable. It will be appreciated that if both the advance piston 40 and the housing are constructed of aluminum alloy,

thermal expansion of the advance piston 40 and housing will occur at the same rate. Thus in use the clearance between the advance piston 40 and its housing will remain constant. As described hereinbefore, the peg 38 is located so as to engage the sleeve 42 in a position lying substantially on the centre line of the advance piston 40 thus minimising tilting of the advance piston 40, in use. In use, when the cam ring 18 moves under the influence of the advance piston 40, the position of the engagement between the peg 38 and the sleeve 42 changes thus it is not possible to have the peg 38 lying on the advance piston centre line throughout the range of movements of the cam ring 18. The length of the peg 38 is chosen so as to minimise the offset of the engagement from the advance piston centreline throughout the range of angular movement of the cam ring 18.

In use of the pump, in the position shown, fuel is supplied through the inlet port 26 and one of the inlet passages 22 to the through bores thus pushing the plungers 14 radially outwards. Rotation of the distributor member 10 results in the inlet passages 22 being moved to a position in which registration with the inlet port 26 is broken, and subsequently the delivery passage 24 registers with one of the delivery ports 34. Shortly after such registration, the rollers engage the leading flanks of respective cam lobes 18a causing the plungers 14 to be pushed radially inwards pressurizing the fuel in the through bores and resulting in fuel being delivered to the delivery passage 34 aligned with the delivery port 24. Inward movement of the plungers 14 continues until the rollers ride over the crests of the cam lobes 18a, after which the pressure within the through bores falls. Continued rotation of the distributor member 10 results in the communication between the delivery passage 24 and the selected delivery port 34 being broken, and subsequently in another of the inlet passages 22 registering with the inlet port 26. Such registration results in fuel being supplied to the through bores pushing the plungers 14 outwardly as described hereinbefore. The quantity of fuel supplied to the through bores is controlled by the metering arrangement 28.

As the cam ring 18 is angularly adjustable, and its position is dependent upon the speed of rotation of the engine, if the engine speed increases, an increased fuel pressure is applied to the pressure chamber at an end of the advance piston thus the advance piston 40 moves against the action of the spring to move the cam ring 18 in a clockwise direction in the orientation illustrated in Figure 3, the distributor member 10 rotating in an anticlockwise direction in this orientation. The movement of the advance piston 40 therefore advances the timing of injection. At slower engine speeds, the reverse happens, the advance piston 40 returning under the action of the spring to retard the timing of fuel injection.

Although the embodiment described hereinbefore is of a fuel pump in which the quantity of fuel supplied is determined by a metering valve 28, it will be appreciated that the advance arrangement of the invention is equally suitable to a fuel pump in which the quantity of fuel delivered is controlled using a spill valve arrangement. Further, although the description hereinbefore is of a pump in which the pressure of fuel applied to the advance piston 40 is dependent upon the speed of rotation of the engine, the invention is also applicable to a fuel pump in which the pressure of fuel applied to the advance piston 40 is controlled by an advance actuator valve, for example in the form of an electromagnetically operated valve, thus the timing of injection may be controlled electronically.

During assembly of the pump, it is envisaged that the sleeve 42 be carried by the peg 38 for example using a blob of grease or the like to hold the sleeve 42 on the peg 38, the sleeve 42 being oriented so that the flats 42a extend parallel to the axis of the cam ring. The cam ring 18 is then inserted into the housing using a tilt and slide technique, movement of the cam ring 18 continuing until the sleeve 42 lies in the position shown in Figure 5b with respect to the advance piston 40. Final positioning of the cam ring 18 can then take place, and subsequently the sleeve 42 is rotated about its axis until the position shown in Figure 5a is achieved. Once in this position, the grub screw 44 is tightened to secure the sleeve 42 to the advance piston 40. As the grub screw 44 is located on the side of the advance piston which is at relatively low pressure, the majority of the forces act away from the grub screw 44, thus the grub screw 44 is not subject to high loads.

Since the main forces applied to the advance piston are applied in the axial direction, it is thought that the reduced bending strength of the piston due to the provision of the slot 40d will not result in the advance piston 40 being significantly weaker, or having a shorter working life than in conventional arrangements.

The provision of the sleeve 42 reduces the risk of damage to the advance piston 40 due to the engagement thereof with the peg 38, permitting the use of the same, relatively soft, material for both the advance piston and its housing, thus the disadvantages associated with the prior art arrangements are reduced.

Claims

1. An advance arrangement for an angularly adjustable cam arrangement, the advance arrangement comprising an advance piston (40) slidable within a bore and biased towards an end of the bore by resilient means, the piston (40) and bore defining a chamber to which fuel is supplied, in use, to urge the advance piston against the action of the resilient means, the advance piston (40) being provided with a recess (40c) within which a peg (38) of the cam arrangement is cooperable, wherein a sleeve (42) is provided within the recess (40c), the peg (38) being located within the sleeve (42), relative movement of the sleeve (42) with respect to the advance

piston (40) being substantially prevented.

2. An arrangement as claimed in Claim 1, further comprising a grub screw (44) in screw-threaded engagement with the piston (40), the grub screw (44) engaging the sleeve (42) to secure the sleeve (42) in position relative to the piston (40).

3. An arrangement as claimed in Claim 1 or Claim 2, wherein the piston (40) is provided with a slot (40d) through which the sleeve (42) is passed, during assembly.

4. An arrangement as claimed in Claim 3, wherein the slot (40d) is of width smaller than the diameter of the sleeve (42), the sleeve (42) being provided with at least one flattened region (42a) permitting the sleeve (42) to be received within the slot (40d).

5. An arrangement as claimed in any one of the preceding claims, wherein the sleeve (42) is formed from a relatively hard material.

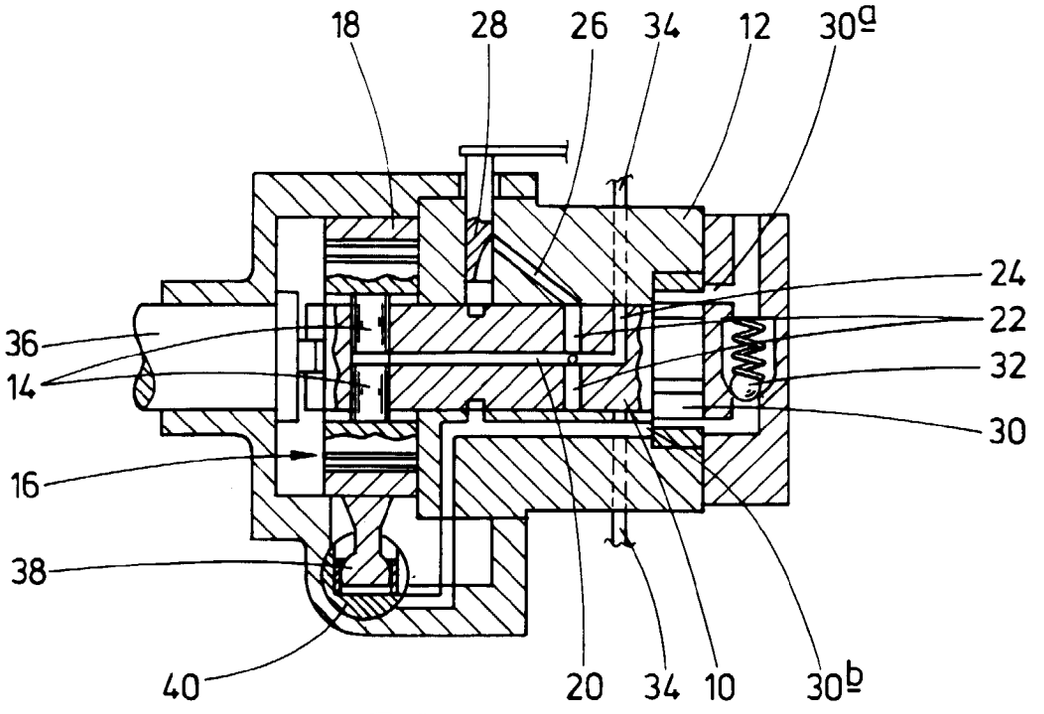
18
28
26
34
12
30a
24
22
36
14
32
30
16
38
40
20
34
10
30b

FIG 1

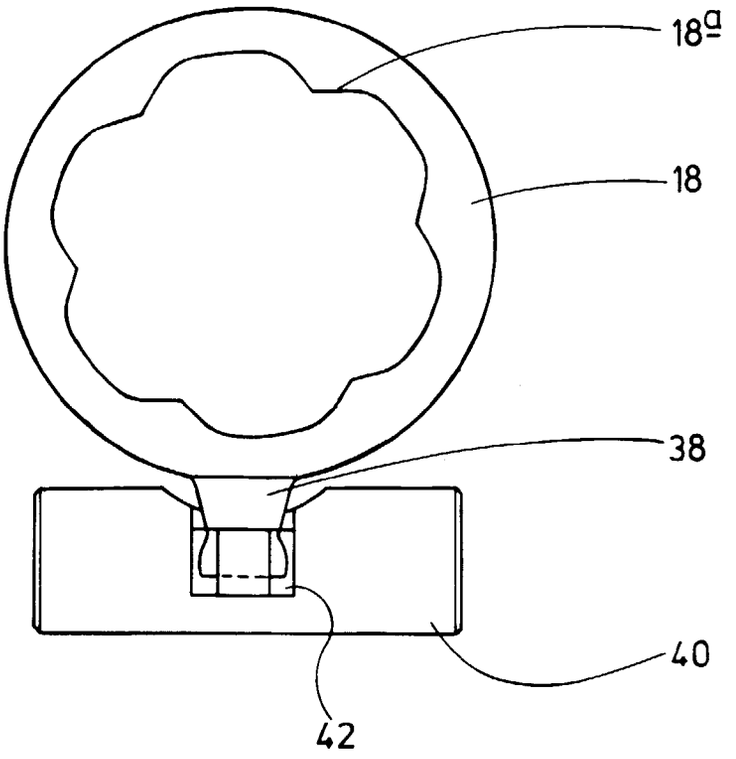
18a
18
38
40
42

FIG 2

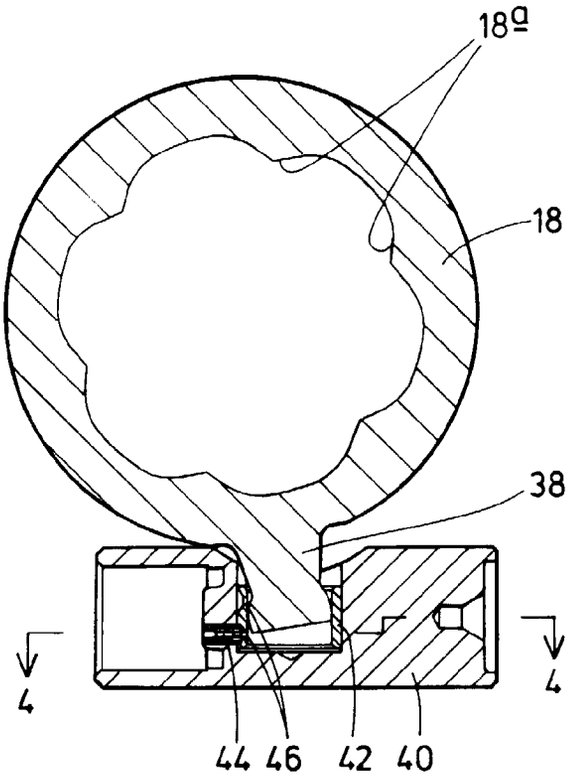

FIG 3

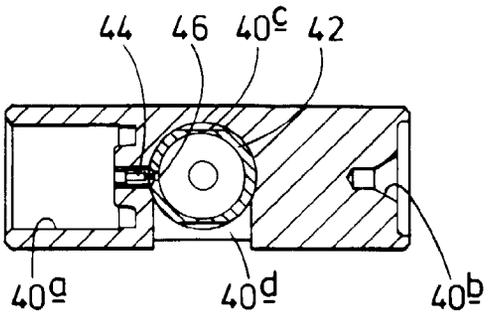

FIG 4

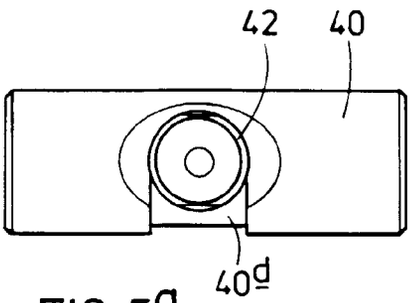

FIG 5a

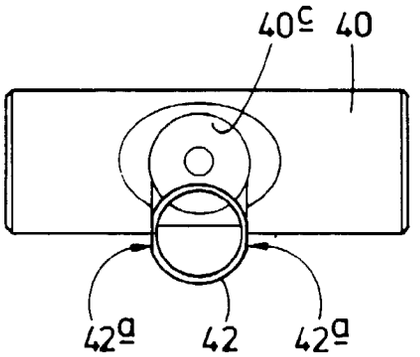

FIG 5b

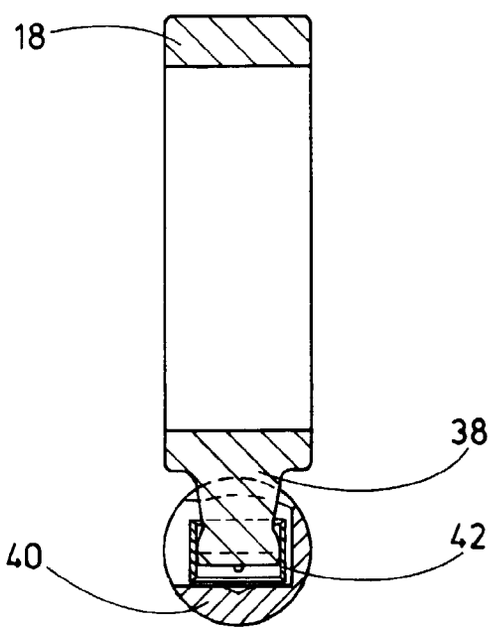

FIG 6

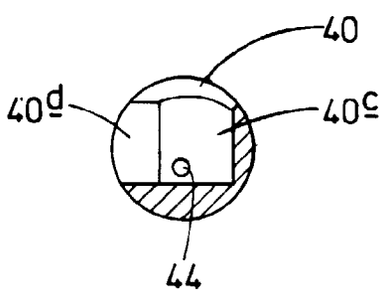

FIG 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 6734

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.6)
A	GB 736 451 A (VERNON DAVIS ROOSA) * page 3, line 79 - line 98; figures *	1	F02M41/14
A	US 3 116 728 A (C.A.V. LTD.) * column 2, line 35 - line 44; figures *	1	
A	EP 0 597 250 A (BOSCH GMBH ROBERT)		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 January 1998	Sideris, M

CATEGORY OF CITED DOCUMENTS

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