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(54) Positive displacement pumps.

(57) A pump comprises a casing (15) and a rotor (26) rotatably mounted on a pintle (24) fixed in the casing (15). The rotor (26) has four cylinder bores (32) angularly spaced by 90° in which ball elements (33) are slidably and sealingly disposed. A cam track (35) formed in the casing (15) encircles the rotor (26) and causes the balls (33) to reciprocate as the rotor (26) rotates, and the inner ends of each cylinder bore (32) comes into communication alternately with inlet and outlet apertures (38, 40) in the pintle (24) to produce a flow of the working fluid. The profile of the cam track (35) is arranged so that the sum of the inward velocities of each two adjacent balls (33) during their delivery strokes is constant.

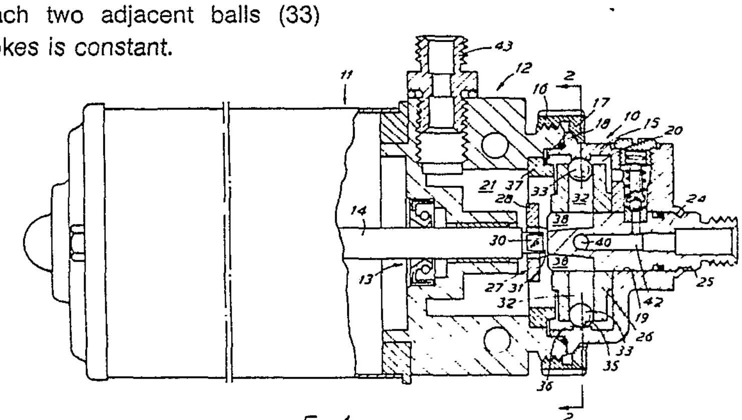

FIG. 1

EP 0 335 535 A1

POSITIVE DISPLACEMENT PUMPS

This invention relates to positive displacement pumps.

According to this invention there is provided a positive displacement pump comprising a hollow cylinder the internal surface of which is of cam form, an annular body disposed within the cylinder and having a plurality of generally radially extending bores therein, a piston disposed in each bore for axial sliding movement in the bore and arranged for rolling engagement with the cam surface of the cylinder, and a pintle disposed within the annular body and having therein a plurality of inlet apertures and a plurality of outlet apertures spaced about its periphery for the fluid to be pumped and respectively communicating with inlet and delivery passages, the pintle and the cylinder being fixed against rotational movement relative to each other, and the body and the pintle and cylinder being rotatable relative to each other about the axis of the pintle, whereby the pistons are caused by the cam surface to reciprocate in said bores in timed relationship with communication of the inner ends of said bores with said inlet and outlet apertures alternately, so that the reciprocation of each piston causes fluid to be drawn into its bore from one of said inlet apertures, and then discharged therefrom through one of said outlet apertures, and the cam surface being shaped to cause the rate of inward displacement of each individual piston during its working stroke to increase progressively from zero to a predetermined maximum velocity and subsequently to decrease progressively to zero, and to cause the rate of inward displacement of another or others of the pistons to be matched instantaneously to the velocity of inward movement of such piston whereby in inward movement of the pistons between their outer and inner dead centres the sum of the absolute values of the inward velocities of the pistons is constant at a constant pump speed.

Preferably said bores are disposed in diametrically opposing pairs, the pistons in the bores of each pair being moved inwardly simultaneously with each other and outwardly simultaneously with each other. In one preferred arrangement said bores are four in number and are angularly spaced apart by 90° about the axis of the pintle.

According to a preferred feature of the invention, each piston is constituted by a ball engaged in rolling contact with the cam surface. The ball may be backed by a slide element which is in sliding sealing engagement with the wall of the bore and provides at its radially outer end an annular seating for the ball and which has a passage extending centrally axially therethrough. Preferably said passage is a restricting passage.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows a pump according to the invention in axial section,

Figure 2 is a sectional view on the line 2-2 of Figure 1, and

Figures 3 and 4 illustrate modifications.

Referring to Figures 1 and 2, the pump 10 forms part of an assembly comprising also an electric motor 11 driving the pump, and an inlet block 12 for the working fluid of the pump. The inlet block forms an end member of the casing of the motor and carries a bearing 13 for the drive end of the motor shaft 14.

The pump 10 has a fixed casing 15 which is secured to the inlet block by a screw-threaded ring 16 having a chamfered internal shoulder 17 which engages a complementary chamfer on an external flange 18 of the casing.

An axial bore 19 extends from the outer end of the casing and opens at its inner end to an annular chamber 20 formed within the casing. This chamber is in open communication with a working fluid reservoir 21 formed in the inlet block.

A pintle 24 is disposed in the bore in the casing and has its outer end protruding from the casing and has its inner end disposed in the chamber 20. The pintle is fixed in a pre-determined position in the casing 15 by deformation of part of the casing into a peripheral groove 25 in the pintle. The end of the pintle projecting into the chamber 20 provides a spigot mounting for a rotor 26 which is driven in rotation by the motor shaft 14 through an Oldham coupling 27. In the illustrated arrangement the intermediate member of the coupling comprises a disc member 28 disposed coaxially with the motor shaft and the pintle. A rectangular slot is formed in the plate member and the motor shaft has a end portion 30 formed with two flats which are slidingly engaged in the slot. Two dogs 31 project axially from the opposite face of the plate member and are respectively engaged in radial slots 31a in the rotor at locations diametrically opposite each other and angularly spaced from the major axis of the rectangular slot by 90° about the axis of the plate member.

The rotor has four generally radially extending cylinder bores 32 in which are respectively disposed four pistons in the form of balls 33. In rotation of the rotor 26 the balls are flung outward by centrifugal force and engage in rolling contact with an annular cam track 35 formed on an annular rib 36 on the internal surface of the casing. The cam track is arcuate in section, and the rotor is free for a degree of axial floating movement to enable the balls to become centred in the cam track. The Oldham coupling accommodates this floating movement. The floating movement is limited in the rightward direction as shown in the drawings by an internal radially extending surface of the casing, and is limited in the opposite direction by an abutment ring 37 secured in a rebate in the inlet block.

Two surface channels 38 are formed diametrically opposite each other in the inner end portion of the pintle for conveying working fluid from the reservoir 21 to the inner ends of the bores 32 in the rotor. At right angles to a common axial central diametral plane of the two channels 38, a cross-bore 40 extends diametrically through the pintle the ends of which cross-bore are arranged for communication with the radially inner ends of the bores 32, and an outlet passage 42 extends axially through the pintle from the cross-bore 40 to the outer end of the pintle for conveying pumped fluid to a point of utilisation. From the point of utilisation, the working fluid is returned to the reservoir 21 through an inlet connection 43 on the inlet block.

The inlet channels 38 have a dimension circumferentially of the pintle which is smaller than the diameter of the bores 32 to prevent the balls 33 from dropping into the inlet channels when the rotor 26 is stationary, but each of the bores 32 may have at its inner end two diametrically opposite inward protrusions to limit the radially inward movement of the balls.

In operation of the pump, rotation of the rollers causes the balls to be thrown outward into engagement with the cam track, and the cam track is arranged to cause each ball to move inward and outward twice in each revolution of the rotor to carry out two pumping cycles. Each two diametrically opposite balls 33 move inwardly in unison and outwardly in unison along the bores so that the pump is balanced. The angular position of the pintle relative to the casing about the central axis is such that during radially outward movement of two diametrically opposite balls the inner ends of their bores 32 are respectively in communication with the inlet channels 38 causing fluid to be drawn into the bores from the reservoir 21, and so that during radially inward movement of the balls, their respective bores are in communication with opposite ends of the cross-bore 40, causing the working fluid in the bores to be expelled into the cross-bore and thence along the axial passage 42 to the point of utilisation.

In the illustrated construction each bore 32 is in communication with an inlet channel 38, and the cross-bore 40 for approximately 45° and 135° respectively of rotation of the rotor in each cycle.

The cam track 35 is so profiled that at a constant pump speed the delivery of the pump is smoothly constant throughout each revolution of the rotor. In the delivery movement of each ball, the cam track is arranged to accelerate the inward movement of the ball to a speed V which is then maintained constant over the major part of the continuing inward movement of the ball. Then as the ball approaches the end of its inward movement, the cam track is shaped to reduce the inward velocity of the ball progressively to zero, but in order to maintain the required constant delivery, the inward movement of the next following ball is commenced at the same instant as the velocity of the preceding ball starts to fall, and the velocities of the two balls are controlled by the cam profile so that the sum of the inward velocities of the two balls is equal to the constant speed V. The cam profile provides for a dwell of about 1° at inner and outer dead centres to allow an instant for the changeover from connection of the bores from inlet to outlet and vice versa, so as to give improved sealing.

It is preferred that the inward velocity and hence the delivery rate of each pumping ball should change sinusoidally during its acceleration to and deceleration from its constant speed V so as to give a low noise level. Thus the curves leading to and from the constant flow rate trace may be of the form $\gamma(1-\cos\omega t)/2$ where γ is the maximum flow rate,t is the instantaneous time lapse from the adjacent end of the constant flow rate trace and ω is the rotational displacement from the position $t=0$, expressed in radians.

The profile of each of the intake portions of the cam track follows the same pattern as the outlet portions, but there is no overlap of the intake curves such as takes place on the delivery curves.

The opposing bores 32 of each pair are inclined at right angles to the cam track at its position of maximum delivery slope, causing the line passing through the contact point of ball and cam and the centre of the ball to be coincident with the centre line of the bore at approximately the mid point of the delivery arc of the cam, thereby eliminating the component of the load on the ball at right angles to the wall of the bore and reducing the friction force of the ball and bore.

Owing to the delivery period (135°) being three times that of the suction period (45°) the flow rate through the inlets is three times that through the outlets. The fluid in the intake will therefore develop considerable momentum and, by allowing each intake port to remain open past its theoretical closing point by say 2°, use can be made of this momentum to ensure that the bores in the rotor are completely full prior to the commencement of the delivery stroke.

Figure 3 shows a modified form of pintle 24 in which the inlet channels 38 are replaced by inclined passages 45 which open one end to a cylindrical recess 46 in the inner end face of the pintle and which at their other ends are arranged for communication with the inner ends of the bases 32. This is advantageous in providing an increased area of communication between the reservoir and the bores 32 on the suction stroke.

Figure 4 illustrates a modification which can be employed in pumps designed to deliver fluid at higher pressures. In this modification the ball in each cylinder bore is backed by a cylindrical sealing element 47 slidably mounted in the bore. The element has a central restricting passage 48 extending along its full length and provides at its radially outer end a sealing seat for the ball. The ball and sealing element cooperate to provide a more effective seal at high delivery pressures.

It will be clear that the angles of delivery and suction may be other than 135° and 45° respectively.

It will also be understood that more than four bores may be provided in the rotor and that in such cases the constant sum of the inward velocities of the pistons may be the sum of the inward velocities of more than two pistons.

Claims

1. A positive displacement pump comprising a hollow cylinder the internal surface of which is of cam form, an annular body disposed within the cylinder and having a plurality of generally radially extending bores therein, a piston disposed in each bore for axial sliding movement in the bore and arranged for rolling engagement with the cam surface of the cylinder, and a pintle disposed within the annular body and having therein a plurality of inlet apertures and a plurality of outlet apertures spaced about its periphery for the fluid to be pumped and respectively communicating with inlet and delivery passages, the pintle and the cylinder being fixed against rotational movement relative to each other, and the body and the pintle and cylinder being rotatable relative to each other about the axis of the pintle, whereby the pistons are caused by the cam surface to reciprocate in said bores in timed relationship with communication of the inner ends of said bores with said inlet and outlet apertures alternately, so that the reciprocation of each piston causes fluid to be drawn into its bore from one of said inlet apertures, and then discharged therefrom through one of said outlet apertures, and the cam surface being shaped to cause the rate of inward displacement of each individual piston during its working stroke to increase progressively from zero to a predetermined maximum velocity and subsequently to decrease progressively to zero, and to cause the rate of inward displacement of another or others of the pistons to be matched instantaneously to the velocity of inward movement of such piston whereby in inward movement of the pistons between their outer and inner dead centres the sum of the absolute values of the inward velocities of the pistons is constant at a constant pump speed.

2. A pump as claimed in claim 1, wherein said bores are disposed in diametrically opposing pairs, the pistons in the bores of each pair being moved inwardly simultaneously with each other and outwardly simultaneously with each other.

3. A pump as claimed in claim 2, wherein said bores are four in number and are angularly spaced apart by 90° about the axis of the pintle.

4. A pump as claimed in any one of the preceding claims, wherein the pistons are constituted by balls slidably and sealingly disposed in the said bores and arranged for rolling engagement with said cam surface.

5. A pump as claimed in claim 4 wherein each ball is backed by a cylindrical sealing element slidingly and sealingly mounted in the bore and having a central hole extending axially therethrough, the radially outer end of said sealing element providing a sealing seating for the ball.

6. A pump as claimed in any one of the preceding claims, wherein said inlet passages comprise axially-extending surface channels in the pintle.

7. A pump as claimed in any one of claims 1 to 5 wherein said inlet passages comprise drillings inclined axially and radially outward along the pintle to said inlet apertures from a recess formed in one end of the pintle.

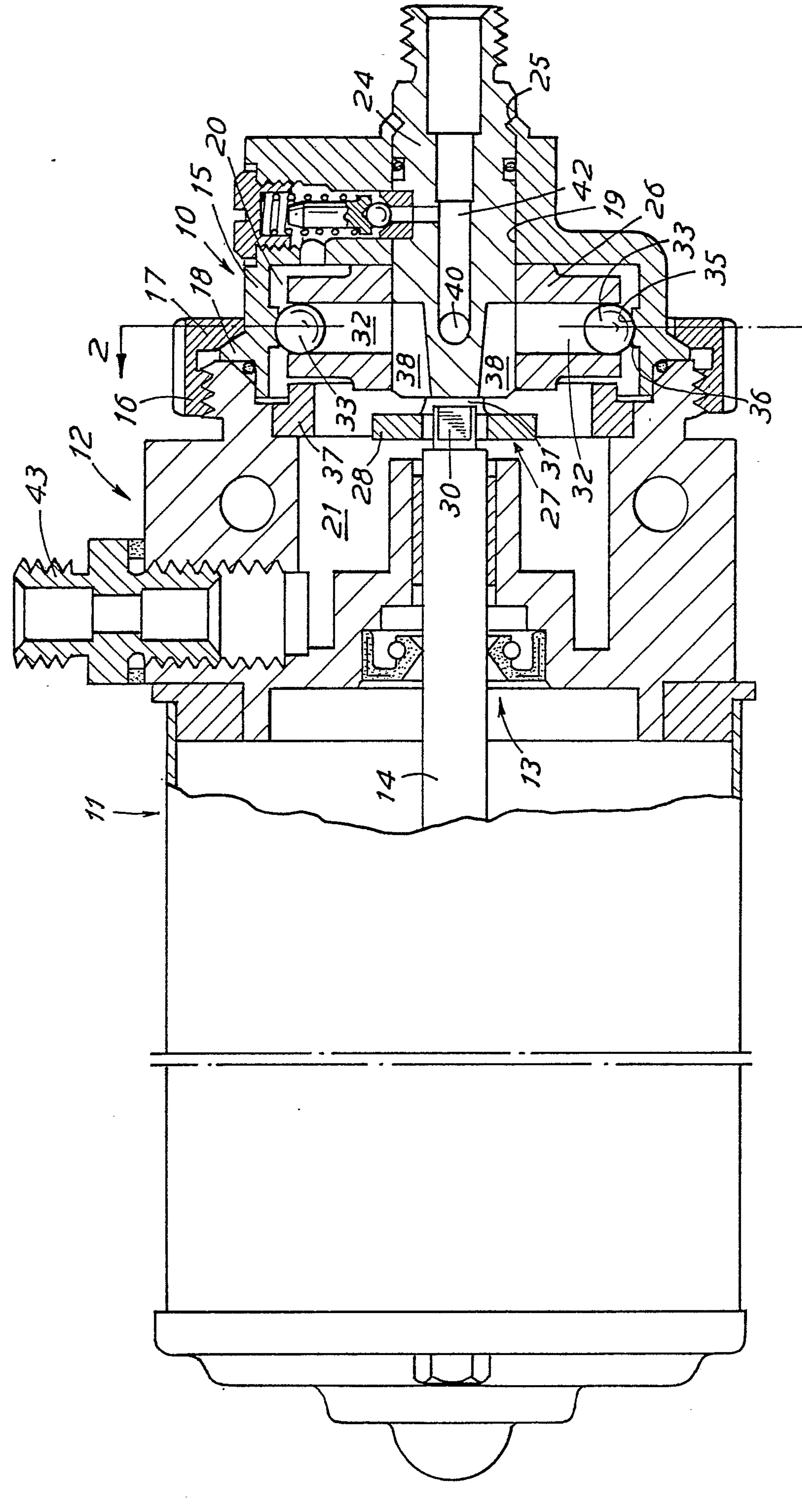
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FIG.1

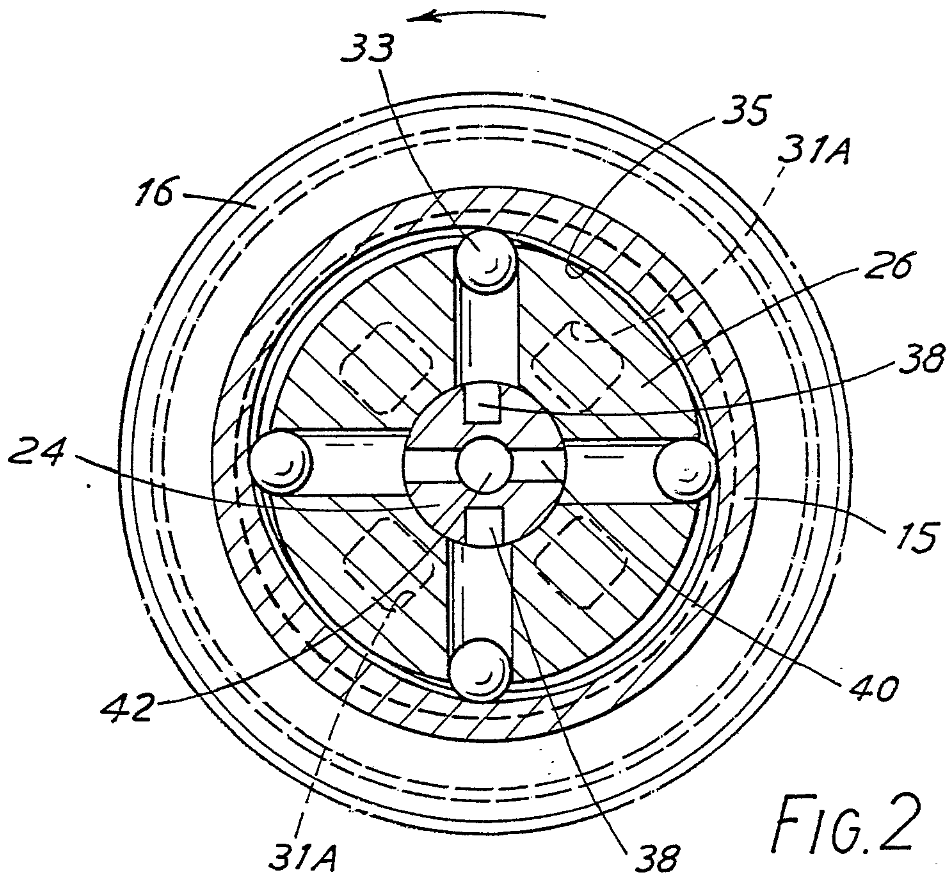

FIG.2

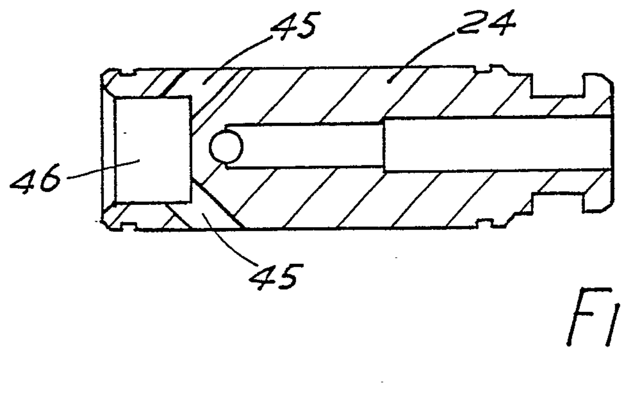

FIG.3

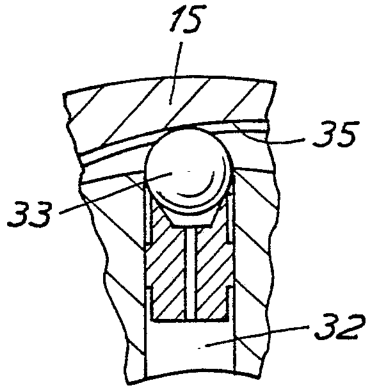

FIG.4

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EUROPEAN SEARCH REPORT

Application Number

EP 89 30 2633

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.4)
X	FR-A-1 456 704 (NATIONAL RESEARCH DEVELOPMENT) * Page 2, right-hand column, last paragraph - page 3, right-hand column, paragraph 5; figures 1-4 *	1	F 04 B 1/10
Y		2-5	
Y	CH-A- 390 689 (HYDREL) * Page 1, line 48 - page 2, line 25; page 3, lines 1-20; figures 1,2,7 *	2-5	
A		1	
Y	DE-A-2 021 651 (TEVES) * Page 4, paragraph 2; page 7, paragraph 3 - page 8, paragraph 2; figures 3,3a *	2	
A		1	
A	FR-A-2 368 619 (AUTOMOTIVE PRODUCT) * Page 3, line 11 - page 9, line 26; figures 1-4c *	1,2,4,5	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DE-A-3 628 769 (TEVES) * Column 4, lines 37-40; figures 1,2 *	1,6	F 04 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12-06-1989	BERTRAND G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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