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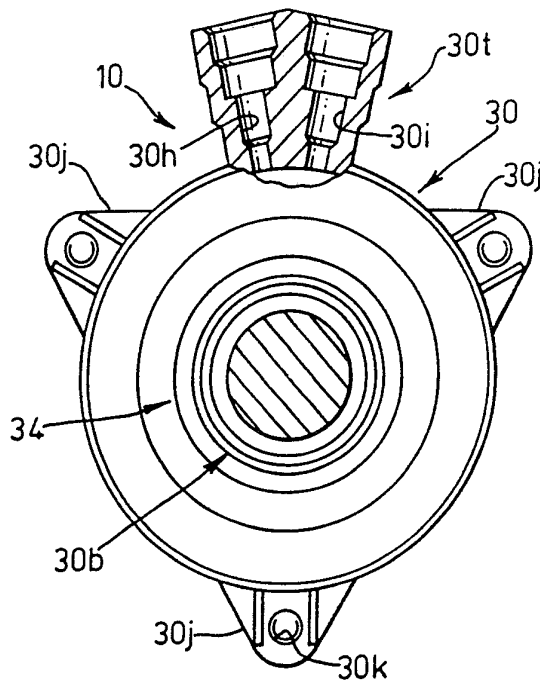
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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| <p>(51) International Patent Classification 4 :<br/><b>F16D 25/08</b></p>   | <p><b>A1</b></p> | <p>(11) International Publication Number: <b>WO 89/12762</b><br/>(43) International Publication Date: 28 December 1989 (28.12.89)</p>   |
| <p>(21) International Application Number: PCT/GB89/00556<br/>(22) International Filing Date: 22 May 1989 (22.05.89)<br/>(30) Priority data: 206,657 15 June 1988 (15.06.88) US<br/>(71) Applicant: AUTOMOTIVE PRODUCTS PLC [GB/GB];<br/>Tachbrook Road, Leamington Spa, Warwickshire CV31<br/>3ER (GB).<br/>(72) Inventors: WROBLESKI, David, Lee ; 6550 33 Mile Road,<br/>Romeo, MI 48065 (US). LEIGH-MONSTEVENS,<br/>Keith, Vernon ; 5622 Larkins Drive, Troy, MI 48098<br/>(US).<br/>(74) Agent: ADKINS, Michael; Withers and Rogers, 4 Dyer's<br/>Buildings, Holborn, London EC1R 2JT (GB).</p> |                  | <p>(81) Designated States: AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), FR (European patent), GB, GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent).<br/><br/><b>Published</b><br/><i>With international search report.</i></p> |

(54) Title: A HYDRAULIC ACTUATOR



(57) Abstract

A non-rotatable hydraulic actuator (10) for a clutch (11) has a housing (30) with an annular piston bore (30e) axially overlapping a cavity (30p) for the clutch release bearing (34). A piston (32) slidable in the bore (30e) abuts the transmission housing (18) in a bore (18c) of which is fixed a quill shaft (22) along which the housing (30) can slide.

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A HYDRAULIC ACTUATOR

This invention relates to a hydraulic actuator particularly, but not exclusively, for use with motor vehicles having manual transmissions.

A clutch actuator for a manual transmission motor vehicle normally comprises a selectively displaceable element which is connected to the release element of the clutch assembly to separate two rotatable elements of the clutch, which elements are normally frictionally coupled to transfer energy from the engine crank shaft to the transmission input shaft. In the case of a hydraulic actuator, the actuator comprises the slave portion of a hydraulic master cylinder/slave cylinder assembly wherein the master cylinder is mounted to be directly operated by the clutch pedal.

As is well known, the release element of the clutch rotates at engine speed when the clutch is engaged and slows down and may eventually stop when the clutch is released or disengaged to permit a gear change. The actuator on the other hand is non-rotating, that is, the body of the actuator must be secured against rotation to a structural component such as a transmission housing or the clutch housing. Therefore, the clutch actuator must be connected to

the release element through a bearing commonly called a throw out or release bearing.

The actuator can be mounted off axis or externally relative to the transmission input shaft or it can be mounted concentrically. The off axis or external arrangement involves the use of a lever arm connected between the actuator output element and the clutch release member. The typical concentric arrangement requires no such lever arm. Instead, the cylinder body of the actuator is fixed to the clutch bell housing or to the face of the transmission housing and the axially translatable piston is connected to the outer race of the throw out bearing. The inner race is in turn connected to the clutch release element. Examples of concentric actuator arrangements are shown for example in our United States Patents Nos. US-A-4,585,106; US-A-4,585,107; US-A-4,585,108; US-A-4,585,109; US-A-4,609,087; US-A-4,264,290; US-A-4,660,694; US-A-4,684,003; US-A-4,687,087 and US-A-4,708,228.

Whereas these prior art concentric actuators are satisfactory in most applications, there are certain applications where the size and/or profile of the prior art actuators present problems with respect to installation and/or operation.

A further example can be seen in US-A-2,717,680 which describes a hydraulic actuator for use with a clutch comprising a housing which, in use, is concentric with a drive input shaft for transmitting driven between the clutch and a transmission, the housing defining piston bore housing a piston, and including a section for carrying a clutch release bearing, and means for enabling hydraulic fluid to be delivered to said piston bore to move the actuator housing axially whereby clutch release force will be transmitted through the clutch release bearing to the clutch. In US-A-2,717,680 the release bearing is placed in front of the piston bore which makes the actuator of undesirable length. The present invention is intended to reduce that problem and is directed to the provision of a concentric actuator which can be easily located and mounted in concentric relationship to the input shaft of the transmission and which offers both increased axial compactness and easier installation as advantages over the prior art.

According to one aspect of the invention there is provided a hydraulic actuator for use with a clutch comprising a housing which, in use, is concentric with a drive input shaft for transmitting driven between the clutch and a transmission, the housing

defining a piston bore housing a piston, and including a section for carrying a clutch release bearing, and means for enabling hydraulic fluid to be delivered to said piston bore to move the actuator housing axially whereby clutch release force will be transmitted through the clutch release bearing to the clutch, the section for carrying the release bearing and the piston bore overlapping axially.

This arrangement provides a more axially compact arrangement than those disclosed in the prior art.

Preferably the section for carrying the release bearing includes a radially extending portion connected at its outer periphery to an inner wall defining a wall of the piston bore which is annular in the embodiments described below. The radially extending portion provides a convenient means through which clutch release forces can be transmitted to the clutch release bearing.

The housing may include a hub portion and, in such a case, the aforesaid section for carrying the release bearing may include part of said hub portion.

The hub portion is preferably slidable on a guide for guiding the actuator during movement thereof. The

guide may be a quill tube extending from the transmission and through which the drive input shaft passes. Preferably a portion of the quill tube is located with a bore formed in a casing of the transmission. The said portion of the quill tube may form a race for a journal bearing for the drive input shaft.

The aforesaid radially extending portion may take the form of a web extending between the hub portion and the inner piston bore wall. The said hub portion may conveniently extend axially each side of the web portion. That arrangement helps to maximise the guiding inner face between the hub portion and the guide and thereby provide positive sliding guidance for the actuator housing.

Preferably the section carrying the bearing comprises a bore which, in use, faces the clutch.

The hub portion may be arranged to extend towards the clutch so as to extend axially beyond the inner piston bore wall.

The inner piston bore wall may be arranged to extend towards the transmission so as to extend axially beyond the hub portion.

Preferably means is provided to inhibit rotation of a race of the release be a ring relative to the actuator housing. The means may comprise an axially extending projection such as a pin for projecting into an axial recess formed, for example, in a race of said release bearing. The means preferably permits self-alignment of the release bearing. Where the aforesaid radially extending portion is provided the means for inhibiting rotation may be provided thereon.

Preferably the housing includes means for co-operation with further means on the transmission to inhibit rotation of the housing. The means and further means may be a bore and co-operable pin arrangement. For example the means of the housing preferably comprises a bore for slidably receiving means in the form of a pin on the transmission. A plurality of said bores may respectively be defined in a plurality of circumferentially spaced lugs on the housing.

According to another aspect of the invention, the actuator includes a quill shaft fixedly positioned relative to a front face of a transmission housing and extending forwardly from the front face in

concentrically surrounding but radially spaced relation to a transmission input shaft; an actuator housing adapted to be positioned within a clutch housing in concentric relation to the transmission input shaft and including an annular bearing carrier section having an axially extending annular hub portion slidably mounted on the quill shaft and an annular main body section defining a rearwardly opening annular piston bore spaced radially outwardly from the bearing carrier section hub portion to define an annular area concentrically therebetween; a release bearing mounted on the bearing carrier proximate the annular area between the piston bore and the hub portion of the bearing carrier section; an annular piston sized to fit at its forward end in the piston bore and bearing at its rearward end against the front face of the transmission housing; and means for delivering hydraulic pressure fluid to the piston bore so as to move the actuator housing axially forwardly relative to the transmission input shaft with the axial movement guided by the sliding engagement of the bearing carrier section hub portion on the quill shaft so as to move the clutch release element to a clutch disengaged position by the intermediary of the release bearing. This arrangement also provides an axially compact actuator construction.

The annular area between the piston bore and the hub portion of the carrier section may be defined by a forwardly opening annular bearing bore between the hub portion of the bearing carrier and the piston bore, and the release bearing is mounted in the bearing bore. This arrangement provides a convenient and compact mounting structure for the release bearing.

In the disclosed embodiments of the invention, the actuator housing includes radially spaced concentric inner and outer annular piston bore wall portions defining the piston bore therebetween; the bearing carrier section includes the axially extending hub portion and a radially extending web portion connected at its outer periphery to the inner periphery of the inner piston bore wall portion at a location thereon spaced axially rearwardly from the forward end of the inner wall portion and connected at its inner periphery to the outer periphery of the hub portion at a location thereon spaced axially rearwardly from the forward end of the hub portion so as to define a forwardly opening bearing cavity defined by the inner periphery of the piston inner wall portion, the front annular face of the web portion, and the outer periphery of the hub portion;

and the release bearing is mounted in the bearing cavity. This specific housing construction provides an inexpensive, axially compact and effective hydraulic actuator construction.

Hydraulic actuators in accordance with the invention will now be described by way of example with reference to the accompanying drawings in which:-

Fig.1 is a cross-sectional, somewhat schematic view of an invention actuator in accordance with the invention;

Fig.2 is a view looking in the direction of the arrow 2 in Fig.1 with certain elements eliminated for purposes of clarity;

Fig.3 is a schematic view of a prefilled assembly including the invention actuator; and

Fig.4 is a cross-sectional view of a second embodiment of an actuator in accordance with the invention.

In Fig.1 a hydraulic actuator 10 is seen in association with a manual transmission motor vehicle of the type including a clutch 11 having a bell

housing 12 and a plurality of diaphragm spring fingers 14; a transmission 16 including a transmission housing having a front plate 18 defining a front face 18a; and a transmission input shaft 20 drivingly interconnecting the clutch and the transmission in known manner in response to selective engagement and disengagement of the clutch through the intermediary of the diaphragm spring fingers 14 acting as a release element for the clutch.

Transmission front plate 18 includes a central forwardly extending hub portion 18b defining a central bore 18c. A quill shaft 22 is press fit within the bore 18c of the front transmission plate 18.

Quill shaft 22 includes an enlarged rearward portion 22a press fit within bore 18c and a forwardly extending guide portion 22b extending forwardly from enlarged portion 22a in concentrically surrounding and radially spaced relation to transmission input shaft 20 and joined to enlarged portion 22a by an annular shoulder 22c. A shaft seal 24 is positioned within enlarged quill shaft portion 22a in sealing engagement with an enlarged portion 20a of the transmission input shaft, and roller bearings 26 are also positioned within enlarged portion 22a of the

quill shaft to provide bearing support for the transmission input shaft. Quill shaft 22 is preferably configured such that annular shoulder 22c is essentially flush with the forward edge of transmission front plate hub portion 18b.

Actuator 10 includes an actuator housing 30, an annular piston 32, and a release bearing 34.

Housing 30 is preferably formed of a plastic material and includes an outer main body portion 30a and a concentrically inner bearing carrier section 30b.

Main body section 30a includes radially spaced inner and outer annular wall portions 30c and 30d defining a rearwardly opening piston bore 30e therebetween closed by a forward annular end wall 30f of the main body section. Main body section 30a further includes a fitting 30t extending radially outwardly from the housing and defining a pair of passages 30h and 30i communicating with piston bore 30e. Passage 30i communicates with a conduit 36 terminating in a vent 37 and passage 30h communicates with a conduit 38 which passes through a suitable opening in clutch bell housing 12 for connection to the discharge port of an associated master cylinder 39 (Fig.3) so that hydraulic fluid discharged from the master cylinder

in response to the operator depression of a associated clutch pedal 40 will be delivered under pressure through conduit 38 and through passage 30h to piston bore 30e. Master cylinder 39, conduit 38 and actuator 10 are prefilled with hydraulic fluid and delivered to the motor vehicle manufacturer as a prefilled assembly for installation on the motor vehicle during the vehicle assembly process.

Housing main body section 30a further includes a plurality of lugs or flanges 30j spaced circumferentially around the housing and each defining a bore 30k for receipt of the forward end of a guide pin 42 threadably received at its rearward end in transmission housing front plate 18 so as to preclude rotation of housing 30 relative to the transmission housing.

Inner bearing carrier section 30b of housing 30 includes an annular axially extending hub portion 30l slidably mounted on quill shaft guide portion 22b and a radially extending annular web portion 30m. Web portion 30m is joined at its outer periphery to the inner periphery of inner annular wall portion 30c at a location thereon spaced axially rearwardly from the forward end of inner wall portion 30c and is joined at its inner periphery to the outer periphery of hub

portion 30l at a location thereon spaced axially rearwardly from the forward end 30n of the hub portion so as to define a forwardly opening annular cavity 30p defined by the inner periphery of the inner wall portion 30d forwardly of web portion 30m, the front annular face of web portion 30m, and the outer periphery of hub portion 30l forwardly of web portion 30m. Hub portion 30l includes a portion 30y extending axially forwardly of the web portion 30m and a portion 30g extending axially rearwardly beyond the rear annular face of web portion 30m to maximise the annular axial guiding interface between the hub portion and the quill shaft guide portion 22b.

Annular piston 32 is preferably formed of a suitable plastic material and is sized to fit at its forward end in piston bore 30e and bear at its rearward end 32a against the transmission housing front face 18a at a location thereon spaced radially outwardly from hub portion 18b and defining an annular space 41 between the piston and hub portion 18b. An annular seal 44 positioned within bore 30e forwardly of the front end of piston 32 precludes leakage of hydraulic fluid out of bore 30e.

Release bearing 34 is mounted in annular bearing cavity 30p and includes a fixed outer race 46 secured

to housing web portion 30m, a rotatable inner race 48 having a radially extending flange portion 48a for engagement with diaphragm spring fingers 14, and a plurality of ball bearings 50. When installed in association with the clutch and transmission of the associated motor vehicle, housing hub portion 30l guides tightly but slidably on quill shaft guide portion 22b, annular piston 32 bears against the front face 18a of the front plate 18 of the transmission housing, and release bearing 34 is maintained in a preloaded condition relative to spring fingers 14 by a coil preload spring 52 encircling outer housing wall 30d and bearing at its opposite ends against the front face 18a of the transmission housing and against lugs 30j and fitting 30t at its forward end so as to function to constantly preload the release bearing. Note that in the installed position of the actuator, the inner housing wall 30c defining the inner periphery of the piston bore 30e is positioned in telescopic relation to transmission housing front plate hub portion 18b in alignment with annular space 41.

The actuator is seen in Fig.1 in a clutch engaged position in which power is being transmitted from the clutch through the transmission input shaft 20 to the transmission. To disengage the clutch and interrupt

the transmission of power between the clutch and the transmission, pressure fluid is delivered to piston cavity 30e in response to operator depression of clutch pedal 40 to deliver pressure fluid through conduit 38 from master cylinder 39. The pressurized fluid delivered to bore 30e acts on piston 32 and has the effect of moving the housing 30 forwardly or to the left as viewed in Fig.1 so as to move the diaphragm spring fingers 14 to a clutch disengaged position through the intermediary of release bearing 34. Following release of the clutch pedal by the vehicle operator, the invention actuator returns to the position seen in Fig.1. As wear occurs in the clutch over a sustained period of vehicle usage, the position of the clutch actuator corresponding to clutch engagement gradually moves rearwardly relative to the transmission housing with the rear edge of the inner housing wall 30c moving further and further rearwardly into the annular space 41 as wear progressively occurs in the clutch with the limit of wear that the actuator can accommodate being determined by the ultimate abutting engagement of the rear edge of housing annular walls 30c and 30d with the front face 18a of the transmission housing.

The release bearing 34 is able to move radially over the web portion 30m to permit self alignment.

Fig.4 shows a second embodiment and parts which correspond to parts in Figs.1 to 3 carry the same reference numerals. The actuator of Fig.4 is similar in many respects to that in Figs.1 to 3 and only those areas which differ will be described in detail.

The inner and outer walls 30c, 30d of the body 30 carry respective seals 60, 61 at their rear ends. Seal 60 comprises an L-shaped cross-section resilient lip element 62 bonded or moulded on to a rigid ring 63 which is mounted in a recess 64 on wall 30c. The seal 61 is of similar form comprising an L-shaped cross-section resilient lip element 65 bonded or moulded on to a rigid ring 66 mounted in a recess 67 on wall 30d. The lip elements 62, 65 sealingly engage the inner and outer cylindrical surfaces respectively of annular piston 32.

The piston bore 30e houses a stop ring 68 formed of, for example, a plastics material. The stop ring 68 abuts annular end wall 30f and prevents interference between an outer lip 69 of piston seal 44 and orifices leading to passages 30h and 30i (orifice 45 leading to passageway 30i being visible in Fig.4).

The web portion 30m is joined at its inner periphery to hub portion 30i as in Figs.1 to 3. However, the hub portion 30g is omitted in Fig.4 thereby simplifying manufacture of the body 30.

The release bearing 34 has an inner race 69 which fits with clearance 70 around hub portion 30y to permit radial self alignment of the release bearing during use. The rear of the inner race 69 abuts the web portion 30m and is formed with a plurality of recesses 72. A pin 73 is carried in a bore 74 in the web portion 30m and locates with working clearance in one of the recesses 72. The pin 73 inhibits rotation of the inner race 69 whilst permitting the radial movement to facilitate self alignment of the bearing 34. The inner race 69 is normally urged against the web portion 30m by a resilient wavy washer 74 held in compression by a snap ring 75 located in a peripheral groove 76 in the hub portion 30y. An outer race 77 of the release bearing 34 locates on a clutch release ring 78 which engages the diaphragm spring fingers 14. The outer race 77 fits with clearance 78 within the body 30 to facilitate self alignment. As in Figs. 1 to 3, the actuator 30 body is urged normally forwards by springs 52 thereby urging the release ring 78 against the fingers 14.

Each hydraulic actuator in accordance with the invention will be seen to provide an extremely axially compact actuator assembly. Specifically, since the hub portion of the bearing carrier, the bearing itself, and the annular bore receiving the piston are arranged in concentric axially overlapping relationship, the overall axial dimension of the actuator is minimized without detracting from the operational effectiveness of the actuator.

Whereas preferred embodiments of the invention have been illustrated and described in detail, it will be apparent that various changes may be made in the disclosed embodiment without departing from the scope or spirit of the invention.

CLAIMS

1. A hydraulic actuator for use with a clutch comprising a housing (30) which, in use, is concentric with a drive input shaft (20) for transmitting driven between the clutch (11) and a transmission (16), the housing defining piston bore (30e) housing a piston (32), and including a section (30b) for carrying a clutch release bearing (34), hydraulic fluid, in use, being delivered to said piston bore (30e) to move the actuator housing (30) axially whereby clutch release force will be transmitted through the clutch release bearing (34) to the clutch, characterised in that the piston bore (30e) and the section (30b) for carrying the clutch release bearing (34) axially overlap.
2. A hydraulic actuator according to Claim 1 characterised in that the section (30b) for carrying the release bearing (34) includes a radially extending portion (30m) connected at its outer periphery to wall (30c) defining an inner wall of the piston bore (30e).
3. A hydraulic actuator according to Claim 1 or 2 characterised in that the housing (30) includes a hub portion (30l) and the section for carrying the

release bearing (34) includes part of said hub portion (301).

4. A hydraulic actuator according to Claim 3 when appendant to Claim 2 characterised in that the radially extending portion comprises a web (30m) extending between the hub portion (301) and the inner wall (30c) of the piston bore (30e).

5. A hydraulic actuator according to Claim 3 or 4 when appendant to Claim 2 characterised in that said hub portion (301) includes a portion (30y) extending axially to at least one side of the radially extending portion (30m).

6. A hydraulic actuator according to Claim 3, 4 or 5 in which the hub portion (301) is slidable on a member (22) during axial movement thereof.

7. A hydraulic actuator according to Claim 6 characterised in that the member is a quill tube (22) extending from the transmission (16).

8. A hydraulic actuator according to Claim 7 characterised in that a portion (22a) of the quill tube (22) is located within a bore (18c) formed in a casing part (18) of the transmission (16).

9. A hydraulic actuator according to Claim 8 characterised in that the said portion (22a) of the quill tube (22) engages a journal bearing (26) for the drive input shaft (20).
10. A hydraulic actuator according to any of Claims 3 to 9 when appendant to Claim 3 characterised in that the hub portion (301) extends, in use, towards the clutch (11) and extends axially beyond the inner wall (30c) of the piston bore (30e).
11. A hydraulic actuator according to any of Claims 3 to 10 when appendant to Claim 3 characterised in that the inner piston bore wall (30c) extends, in use, towards the transmission (16) and extends axially beyond the hub portion (301).
12. A hydraulic actuator according to any preceding Claim characterised in that the section carrying the release bearing (34) comprises a bore or cavity (30p) which, in use, faces the clutch (11).
13. A hydraulic actuator according to any preceding Claim characterised in that means (72, 73) is provided to inhibit rotation of a race (69) of the release bearing (34) relative to the actuator housing

(30).

14. A hydraulic actuator according to Claim 13 characterised in that the means (72, 73) for inhibiting rotation comprises an axially extending pin (73) for projecting into an axial recess (72) in a race (69) of said release bearing (34).

15. A hydraulic actuator according to Claim 13 or 14 characterised in that where said radially extending portion (30m) is provided, the means (73) for inhibiting rotation is provided in or on said radially extending portion (30m).

16. A hydraulic actuator according to any preceding Claim characterised in that the housing (30) includes means (30k) for co-operation with further means (42) on the transmission (16) to inhibit rotation of the housing (30).

17. A hydraulic actuator according to Claim 16 characterised in that the means on the housing (30) comprises a bore (30k) for slidably receiving means in the form of a pin (42) on the transmission (16).

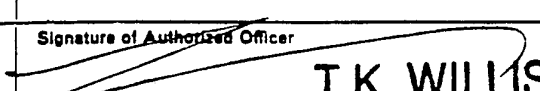
18. A hydraulic actuator according to Claim 17 characterised in that bores (30k) are respectively defined in a plurality of circumferentially spaced lugs (30j) on the housing.





# INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/00556

|   |  |                                     |
|---|--|-------------------------------------|
| <b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>4</sup>   |  |                                     |
| According to international Patent Classification (IPC) or to both National Classification and IPC   |  |                                     |
| IPC <sup>4</sup> : F 16 D 25/08   |  |                                     |
| <b>II. FIELDS SEARCHED</b>  |  |                                     |
| Minimum Documentation Searched <sup>7</sup>   |  |                                     |
| Classification System   | Classification Symbols   |                                     |
| IPC <sup>4</sup>  | F 16 D 25/00   |                                     |
| Documentation Searched other than Minimum Documentation<br>to the extent that such Documents are included in the Fields Searched <sup>8</sup>   |  |                                     |
|   |  |                                     |
| <b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>  |  |                                     |
| Category <sup>9</sup>   | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup> | Relevant to Claim No. <sup>13</sup> |
| X   | US, A, 2550373 (ORTLOFF)<br>24 April 1951<br>see the whole document  | 1, 3, 6, 16,<br>17                  |
| Y   | --   | 7, 8                                |
| X   | GB, A, 1439360 (RANSOME)<br>16 June 1976<br>see the whole document   | 1                                   |
| Y   | --   | 7, 8, 16-18                         |
| Y   | EP, A, 0092823 (FEDERAL-MOGUL)<br>2 November 1983<br>see the whole document                                    | 16-18                               |
| X   | CH, A, 270930 (SELF-CHANGING)<br>16 December 1950<br>see the whole document                                    | 1, 2, 12                            |
| Y   | --   | 3, 16-18                            |
| A   | --   | 7                                   |
|   | ./.  |                                     |
| <p><sup>9</sup> Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> |  |                                     |
| <b>IV. CERTIFICATION</b>  |  |                                     |
| Date of the Actual Completion of the international Search   | Date of Mailing of this International Search Report  |                                     |
| 8th August 1989   | 13. 09. 89   |                                     |
| International Searching Authority   | Signature of Authorized Officer  |                                     |
| EUROPEAN PATENT OFFICE  | <br><b>T.K. WILLIS</b>     |                                     |

| III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET) |  |                      |
|--|--|----------------------|
| Category *   | Citation of Document, with indication, where appropriate, of the relevant passages | Relevant to Claim No |
| Y  | GB, A, 2088010 (FICHTEL & SACHS)<br>3 June 1982<br>see the whole document          | 3                    |
| Y  | GB, A, 599807 (PESCO)<br>22 March 1948<br>see the whole document                   | 16-18                |
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 8900556  
SA 28795

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 07/09/89. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|--|------------------|-------------------------|------------------|
| US-A- 2550373                          |                  | None                    |                  |
| -----                                  |                  |                         |                  |
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|  |                  | US-A- 4456111           | 26-06-84         |
| -----                                  |                  |                         |                  |
| GB-A- 599807                           |                  | None                    |                  |
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| GB-A- 2116283                          | 21-09-83         | DE-A- 3208185           | 08-09-83         |
|  |                  | DE-A- 3210922           | 29-09-83         |
|  |                  | FR-A- 2522755           | 09-09-83         |
|  |                  | FR-A,B 2522756          | 09-09-83         |
|  |                  | JP-A- 58163830          | 28-09-83         |
|  |                  | US-A- 4591039           | 27-05-86         |
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| GB-A- 2143921                          | 20-02-85         | DE-A- 3326107           | 31-01-85         |
|  |                  | FR-A,B 2549554          | 25-01-85         |
|  |                  | US-A- 4633993           | 06-01-87         |
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