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(54) Title: WET MULTI-PLATE CLUTCH ARRANGEMENT

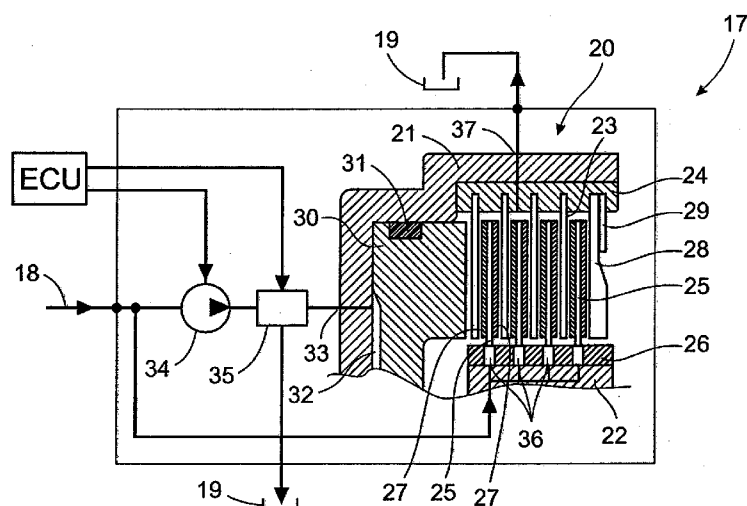


Fig.2

(57) Abstract: The invention relates to a wet multi-plate clutch arrangement, comprising a wet multi-plate clutch (20) having an actuating cylinder (30, 32) controlled by hydraulic pressure; a source of hydraulic pressure for actuating the wet multi-plate clutch (20); a controllable valve for connecting the source of hydraulic pressure (34) to the actuating cylinder (30, 32); and a coolant intake (36) for supplying coolant to the wet multi-plate clutch (20). The source of hydraulic pressure and the coolant intake (36) are connected to a common source (18) of hydraulic fluid. The invention further relates to a transmission and a vehicle provided with such a wet multi-plate clutch arrangement.

WET MULTI-PLATE CLUTCH ARRANGEMENT

TECHNICAL FIELD

5 The invention relates to a wet multi-plate clutch arrangement, comprising a wet multi-plate clutch having an actuating cylinder controlled by hydraulic pressure. The wet multi-plate clutch is supplied with a coolant for cooling a series of stacked clutch plates and friction discs within the clutch.

BACKGROUND OF THE INVENTION

10 A clutch is a mechanical device that provides for the transmission of power from one component (the driving member) to another component (the driven member) when engaged, but can be disengaged. A wet clutch is cooled by a flow of cooling fluid which also keeps the surfaces clean and gives smoother performance and longer life. Wet clutches, however, tend to lose some energy to the liquid. Since the surfaces of a wet clutch can be slippery (as with a motorcycle clutch bathed in engine oil), stacking multiple clutch discs can compensate for
15 the lower coefficient of friction and so eliminate slippage under power when fully engaged.

In a vehicle transmission, a wet clutch is often cooled by the same oil as the transmission. These clutches are usually made up of a stack of alternating plain steel and friction discs, often termed multi-plate clutches. Some of the plates have lugs on their inner diameters locking them to a basket which turns the transmission input shaft, while the intermediate
20 plates have lugs on their outer diameters that lock them to the engine crankshaft. In this way, the plates can slide axially, but are locked against rotation to their respective shaft. The plates are forced together by a clutch piston against a set of coil springs or a diaphragm spring plate when the clutch is engaged.

Wet multi-plate clutches are actuated by hydraulic pressure to drive the gears in a
25 transmission or gearbox. The fluid acts on a clutch piston located within the clutch housing at one end of the stack of plates. When the clutch is engaged, hydraulic pressure act on the piston, which pushes a series of stacked clutch plates and friction discs against a fixed pressure plate. When the clutch is engaged, torque can be transferred from the driving shaft to the driven shaft. To disengage the clutch, fluid pressure inside the piston is reduced. This
30 allows the piston springs to return the piston to its original position, which eases pressure on the clutch pack and pressure plate.

A problem with known wet multi-plate clutches is that for energy efficient operation they require one circulation pump for the supply of cooling oil and a separate high pressure pump for the supply of pressurized hydraulic oil to the clutch piston. This requires separate circuits
35 and pumps for cooling oil and hydraulic oil, which adds weight, quality risks and cost to the wet clutch arrangement.

A further problem is that oil used for cooling the clutch must itself be cooled before being returned to a common oil pan or similar in the transmission. This requires a separate oil heat exchanger which must be mounted within or adjacent the transmission casing, which
40 contributes additional weight and cost to the wet clutch arrangement.

The object of the invention is to provide an improved wet multi-plate clutch arrangement that solves the above problems.

INVENTION

The above problems have been solved by an arrangement as claimed in the appended claims.

In the subsequent text, the term "water-based fluid" is intended to describe fluid having water as a main constituent and being suitable for the purpose of both cooling and pressurizing a transmission component such as a wet multi-plate clutch.

According to a preferred embodiment, the invention relates to a wet multi-plate clutch arrangement. The arrangement comprises a wet multi-plate clutch having an actuating cylinder controlled by hydraulic pressure. Hydraulic pressure is supplied by a source of hydraulic pressure for the purpose of actuating the wet multi-plate clutch. The source of hydraulic pressure can be a pump suitable for supplying a pressure sufficiently high for actuating the wet multi-plate clutch. Such a high pressure pump can be mechanically, electrically or hydraulically operated. A controllable valve is used for connecting the source of hydraulic pressure to the actuating cylinder. A coolant intake is provided for supplying coolant to a series of stacked clutch plates and friction discs within the wet multi-plate clutch.

According to the invention, the source of hydraulic pressure and the coolant intake are connected to a common source of hydraulic fluid via a supply conduit. The fluid supplied from the common source is suitable for both cooling and pressurizing the wet multi-plate clutch. Subsequently, used hydraulic fluid is returned to the source via a common return conduit.

The hydraulic fluid preferably comprises water or a water based fluid. According to one example, the water based fluid comprises water and an anti-freeze fluid. The anti-freeze fluid can be ethylene glycol.

According to a further example, the hydraulic fluid described above is an engine coolant. A typical engine coolant can contain 50-55% by weight water (de-ionized), 45-55% by weight anti-freeze (ethylene glycol, also termed ethane-1,2-diol) and 1-3% by weight additives, such as corrosion inhibitors. The ratio of water and ethylene glycol is usually dependent on ambient conditions; for instance, a mixture of 60% ethylene glycol and 40% water freezes at -45 °C. Ethylene glycol disrupts hydrogen bonding when dissolved in water. Pure ethylene glycol freezes at about -12 °C, but when mixed with water, neither can readily forms a solid crystal structure, and therefore the freezing point of the mixture is depressed significantly. The minimum freezing point is observed when the ethylene glycol percent in water is about 70% (-51 °C).

The common source of hydraulic fluid can be an engine coolant circuit, wherein both the source of hydraulic pressure and the coolant intake are supplied by the coolant circuit. The coolant from the coolant circuit is supplied to the clutch arrangement at a predetermined pressure generated by a pump or a similar device in the coolant circuit. Used coolant and fluid drained from the source of hydraulic pressure and the actuating cylinder is returned to the engine coolant circuit.

The source of hydraulic pressure can be a high pressure pump, for instance a variable displacement pump, being operated continuously. Alternatively the pump can be controlled by an electronic control unit (ECU) to be operated on demand, that is, when the transmission requires the clutch to be actuated. The pump can also be connected to a pressure accumulator (not shown) to ensure that pressure for actuating the clutch is available at all times. This allows the pump to be operated intermittently, on demand from the transmission or for charging the accumulator. A controllable valve, connected to the ECU, is controlled to supply pressure to the actuating cylinder.

Alternatively, the pump can be replaced by a pressure intensifier located between the controllable valve and the clutch. This allows the pressure of the coolant supplied from the coolant circuit to be multiplied, to generate a pressure sufficient to actuate the clutch when the controllable valve is opened by the ECU.

As described in the above examples, coolant for the wet multi-plate clutch arrangement is supplied by a coolant circuit, such as an engine coolant circuit. The coolant from the coolant circuit can be supplied to the clutch arrangement at a predetermined pressure generated by a coolant pump or a similar device (not shown) in the coolant circuit. This coolant pump can be driven continuously by the engine, for instance via a fan belt, or be driven independently, for instance by an electric motor. In the latter case, the coolant pump can be operated on demand, dependent on the cooling requirements of the engine and/or the cooling requirements of the clutch arrangement. If the coolant pump is operated on demand from the coolant circuit only, an additional pump can be required for supplying coolant to the clutch arrangement. An advantage of driving the pump on demand, as opposed to continuously is that it saves energy and cost.

Alternatively, if the pressure in the cooling circuit is insufficient, coolant can be supplied to the clutch arrangement by the high pressure pump, via a pressure reducing throttle valve or similar (not shown), or by a separate, additional pump (not shown). Such an additional pump can be a low pressure pump for circulating coolant from the supply conduit, past the friction plates and adjacent clutch plates, to the return conduit. The additional pump can be driven continuously, or be operated intermittently on demand by the ECU. In the latter case, the pump can be operated when the clutch arrangement requires cooling and/or when a controllable coolant pump is not being operated.

As indicated above, the wet multi-plate clutch comprises a series of stacked, alternate clutch plates and friction discs. Each friction disc making up the multi-plate clutch can be provided with a coating of a friction material comprising carbon fibres. Alternatively, each friction disc can be provided with a coating of a friction material comprising sintered bronze. According to a further alternative, each friction disc can be provided with a coating of a friction material comprising an organic material, such as a paper-based material.

The invention further relates to a vehicle transmission having at least one wet multi-plate clutch. The wet multi-plate clutch comprising an actuating cylinder controlled by hydraulic pressure; a source of hydraulic pressure for actuating the wet multi-plate clutch; a controllable valve for connecting the source of hydraulic pressure to the actuating cylinder; and a coolant intake for supplying coolant to the wet multi-plate clutch, as described above. According to the invention, the source of hydraulic pressure and the coolant intake are connected to a common source of hydraulic fluid.

The invention further relates to a vehicle comprising an internal combustion engine, or any other type of prime mover, connected to a transmission, wherein the transmission comprises at least one wet multi-plate clutch as described above.

5 FIGURES

In the following text, the invention will be described in detail with reference to the attached drawings. These schematic drawings are used for illustration only and do not in any way limit the scope of the invention. In the drawings:

- 10 Figure 1 shows a schematically indicated vehicle provided with a clutch arrangement according to the invention;
- Figure 2 shows a schematic diagram of a wet multi-plate clutch arrangement suitable for use in a vehicle as indicated in Figure 1
- Figure 3 shows a schematic diagram of an alternative wet multi-plate clutch arrangement suitable for use in a vehicle as indicated in Figure 1

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DETAILED DESCRIPTION

Figure 1 shows a schematically indicated vehicle 11 provided with a clutch arrangement according to the invention. The vehicle 11 is provided with an internal combustion engine (ICE) 12 connected to a transmission 13, comprising a gearbox, for transmitting torque to a vehicle drive axle (not shown). The ICE 12 comprises an engine cooling circuit 10 (indicated by dashed lines) that is connected to a radiator 14 that receives engine coolant from the ICE 12 through a first conduit 15 and supplies coolant to the ICE 12 through a second conduit 16. The coolant is circulated through the cooling circuit 10 by a water pump (not shown). The transmission 13 comprises at least one wet multi-plate clutch 17. Hydraulic fluid for actuating and cooling the wet multi-plate clutch 17 is supplied from a supply conduit 18 through a supply conduit 18 and is returned to the ICE 12 through a return conduit 19.

Figure 2 shows a schematic diagram of a wet multi-plate clutch arrangement 17, suitable for use in a vehicle 11 as indicated in Figure 1. The diagram shows a partial axial sectional view of a wet-type multi-plate clutch 20 having a stack of alternate friction discs and clutch plates according to the present invention.

The wet-type multi-plate clutch 20 comprises a substantially cylindrical drum or clutch case 21 having an axially opened one end, a hub 22 disposed within the interior of the clutch case 21 and arranged coaxially with the clutch case and rotated relative to the clutch case, a plurality of annular separator or clutch plates 23 disposed in an outer spline member 24 provided on an inner periphery of the clutch case 21 for allowing displacement in an axial direction, and a plurality of annular friction plates 25 disposed in an inner spline member 26 provided on an outer periphery of the hub 22 for allowing displacement in an axial direction. The friction plates 25 are arranged alternately with the separator plates 23 in the axial direction and each having friction materials 27 adhered or stuck to surfaces thereof.

The wet-type multi-plate clutch 20 further comprises a piston 30 for urging the separator plates 23 and the friction plates 25 to engage them together, a packing plate 28 provided in the inner periphery of the clutch case and adapted to hold the separator plates 23 and the friction plates 25 in a fixed condition at axial one end, and a stop ring 29 for fixedly holding the packing plate 28.

As shown in Figure 2, the piston 30 is disposed within a closed end portion of the clutch case 21 for a sliding movement in the axial direction. An O-ring 31 is arranged between an outer peripheral surface of the piston 30 and an inner surface of the clutch case 21. Further, a seal member (not shown) is also arranged between an inner peripheral surface of the piston 30 and an outer peripheral surface of a cylindrical portion (not shown) of the clutch case 21. Accordingly, a fluid-tight hydraulic chamber 32 is defined between an inner surface of the closed end of the clutch case 21 and the piston 30. The piston 30 and the hydraulic chamber 32 form an actuating cylinder for the clutch. The hydraulic chamber 32 is supplied with pressurized fluid through a pressure port 33. The hydraulic fluid is supplied to the pressure port 33 by a supply conduit 18, which in turn is connected to an engine cooling circuit (not shown) as indicated in Figure 1. A high pressure pump 34 and a controllable valve 35, both controlled by an electronic control unit ECU, are located upstream of the pressure port 33. The high pressure pump 34 draws fluid from the supply conduit 18 and delivers fluid at a pressure sufficient for actuating the piston 30. Hydraulic fluid drained from the pump and/or the hydraulic chamber 32 is discharged from the controllable valve 35 and is returned to the engine coolant circuit via a return conduit 19.

The high pressure pump 34 can be a variable displacement pump being operated continuously. Alternatively the pump 34 is controlled by the ECU to be operated on demand. The pump can also be connected to a pressure accumulator (not shown) to ensure that pressure for actuating the clutch is available at all times.

Each of the friction plates 25 held by the hub 22 for a sliding movement in the axial direction is provided at its both surfaces with friction materials 27 secured thereto. However, the friction material 27 may be provided on only one surface of the friction plate 27 and an adjacent clutch plate 23. Further, cooling fluid supplying ports 36 for supplying cooling fluid from an inner diameter side to an outer diameter side of the wet-type multi-plate clutch 20 are formed in the hub 22 to extend or pass through the hub in a radial direction. The cooling fluid supplied to the fluid supplying ports 36 is drawn from the supply conduit 18, which in turn is connected to an engine cooling circuit (not shown) as indicated in Figure 1. After cooling the friction plates 27 and adjacent clutch plates 23, the cooling fluid flows radially outwards through the clutch case 21 to a cooling fluid outlet port 37. The cooling fluid drained from the clutch case 21 is discharged from the outlet port 37 and is returned to the engine coolant circuit via the return conduit 19.

As indicated above, the common source of hydraulic fluid can be an engine coolant circuit, wherein both the high pressure pump 34 and the cooling fluid supplying ports 36 are supplied by the coolant circuit through the supply conduit 18. Used coolant and fluid drained from the pump 34 and the actuating cylinder, i.e. the piston 30 and the hydraulic chamber 32, is returned to the engine coolant circuit through the return conduit 19.

Figure 3 shows a schematic diagram of an alternative wet multi-plate clutch arrangement. According to this example, the pump 34 used in Figure 2 is replaced by a pressure intensifier

40, located between the controllable valve 35 and the pressure port 33. As indicated in Figure 2, the common source of hydraulic fluid can be an engine coolant circuit, wherein both the pressure intensifier 40 and the cooling fluid supplying ports 36 are supplied by the coolant circuit through the supply conduit 18. Used coolant and fluid drained from the pressure intensifier 40 is returned to the engine coolant circuit through the return conduit 19.

The wet-type multi-plate clutch 20 having the above-mentioned arrangement is actuated (engaged) and released (disengaged) in the following manner. Figures 2 and 3 show a clutch in a disengaged or released condition. In this condition, the clutch plates 23 and the friction plates 25 are separated from each other. In the released condition the piston 30 abuts against the inner surface of the closed end of the clutch case 21. This is achieved by a biasing force of a return spring (not shown).

From this condition, in order to engage the clutch, the valve 35 is controlled to supply fluid pressure into the hydraulic chamber 32 defined between the piston 30 and the clutch case 21. As the fluid pressure is increased, the piston 30 is shifted to the right (Fig. 2) in the axial direction in opposition to the biasing force of the return spring (not shown), thereby closely contacting the clutch plates 23 and the friction plates 27.

After the engagement, in order to release or disengage the clutch again, the fluid pressure in the hydraulic chamber 11 is released through the valve 35. When the fluid pressure is released the piston 30 is shifted to a position where the piston abuts against the closed end of the clutch case 21. This is achieved by the biasing force of the return spring (not shown). In this way, the clutch is released or disengaged.

As described in the above examples, coolant for the wet multi-plate clutch arrangement is supplied by an engine coolant circuit. The coolant from the coolant circuit is supplied to the clutch arrangement at a predetermined pressure generated by a coolant pump or a similar device (not shown) in the coolant circuit. This coolant pump can be driven continuously by the engine, for instance via a fan belt, or be driven independently, for instance by an electric motor. In the latter case, the coolant pump can be operated on demand, dependent on the cooling requirements of the engine and/or the cooling requirements of the clutch arrangement.

Alternatively, if the pressure in the cooling circuit is insufficient, coolant can be supplied to the clutch arrangement by the high pressure pump, via a throttle valve or similar (not shown), or by a separate, additional pump (not shown). Such an additional pump can be a low pressure pump for circulating coolant from the supply conduit 18, past the friction plates and adjacent clutch plates, to the return conduit 19. The additional pump can be driven continuously, or be operated intermittently on demand by the ECU. In the latter case, the pump can be operated when the clutch arrangement requires cooling and/or when a controllable coolant pump is not being operated.

In the above example, the hydraulic fluid used is water or a water based fluid. In the case of engine coolant the water based fluid commonly comprises water and an anti-freeze fluid, such as ethylene glycol.

CLAIMS

1. Wet multi-plate clutch arrangement, comprising a wet multi-plate clutch (20) having an actuating cylinder (30, 32) controlled by hydraulic pressure; a source of hydraulic pressure (34) for actuating the wet multi-plate clutch (20); a controllable valve (35) for connecting the source of hydraulic pressure (34) to the actuating cylinder (30, 32); and a coolant intake (36) for supplying coolant to the wet multi-plate clutch (20), *characterized in* that the source of hydraulic pressure (34) and the coolant intake (36) are connected to a common source (10; 18) of hydraulic fluid, which fluid is water or a water based fluid.
2. Wet multi-plate clutch arrangement according to claim 1, *characterized in* that the water based fluid comprises water and an anti-freeze fluid.
3. Wet multi-plate clutch arrangement according to claim 2, *characterized in* that the anti-freeze fluid is ethylene glycol.
4. Wet multi-plate clutch arrangement according to any one of claims 1-3, *characterized in* that the hydraulic fluid is an engine coolant.
5. Wet multi-plate clutch arrangement according to any one of claims 1-4, *characterized in* that the common source of hydraulic fluid is an engine coolant circuit.
6. Wet multi-plate clutch arrangement according to any one of claims 1-5, *characterized in* that the multi-plate clutch (20) comprises friction discs (25) each provided with a coating of a friction material (27) comprising carbon fibres.
7. Wet multi-plate clutch arrangement according to any one of claims 1-5, *characterized in* that each friction disc (25) making up the multi-plate clutch (20) is provided with a coating of a friction material (27) comprising sintered bronze.
8. Wet multi-plate clutch arrangement according to any one of claims 1-5, *characterized in* that each friction disc (25) making up the multi-plate clutch (20) is provided with a coating of a friction material (27) comprising an organic material, such as a paper-based material.

9. Wet multi-plate clutch arrangement according to any one of claims 1-8, characterized in that a coolant pump is arranged to supply the coolant and where the coolant pump is arranged to be operated on demand.

5 10. Wet multi-plate clutch arrangement according to claim 9, characterized in that the coolant pump is operated dependent on the cooling requirements of an internal combustion engine (12) and/or the cooling requirements of the multi-plate clutch arrangement.

10 11. Vehicle transmission having at least one wet multi-plate clutch (20), the wet multi-plate clutch (20) comprising an actuating cylinder (30, 32) controlled by hydraulic pressure; a source of hydraulic pressure (34) for actuating the wet multi-plate clutch (20); a controllable valve (35) for connecting the source of hydraulic pressure to the actuating cylinder (30, 32); and a coolant intake (36) for supplying coolant to the wet multi-plate clutch (20), characterized in that the source of hydraulic pressure and the coolant intake (36) are connected to a common source (10; 18) of hydraulic fluid, which fluid is water or a water based fluid.

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12. Vehicle comprising an internal combustion engine (12) connected to a transmission (13), wherein the transmission comprises at least one wet multi-plate clutch (20) according to claims 1-11.

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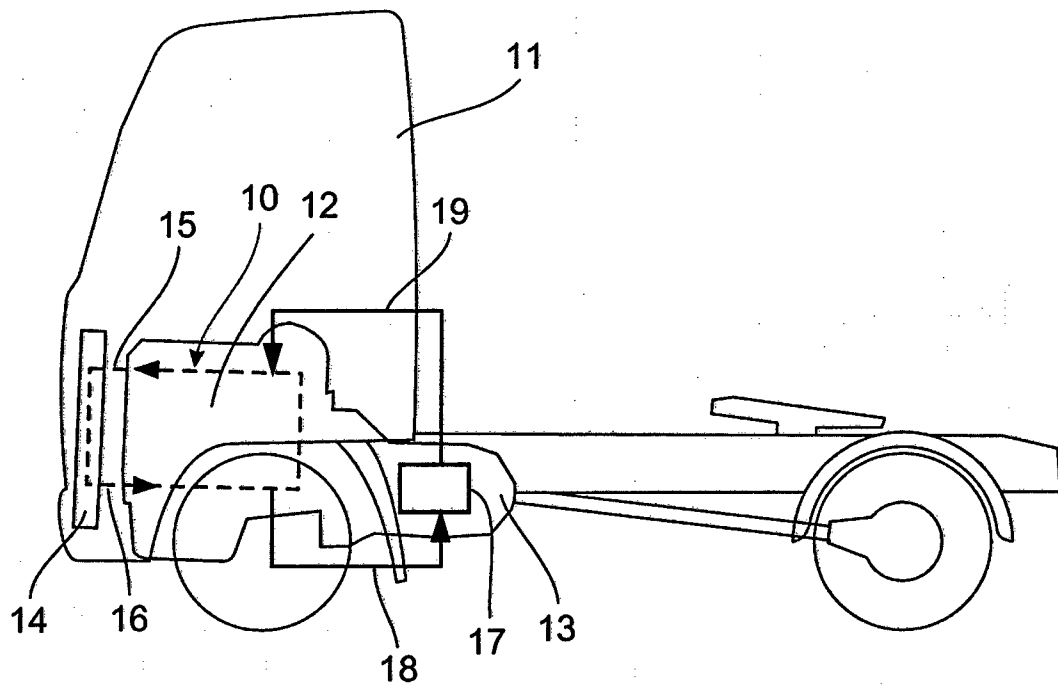


Fig.1

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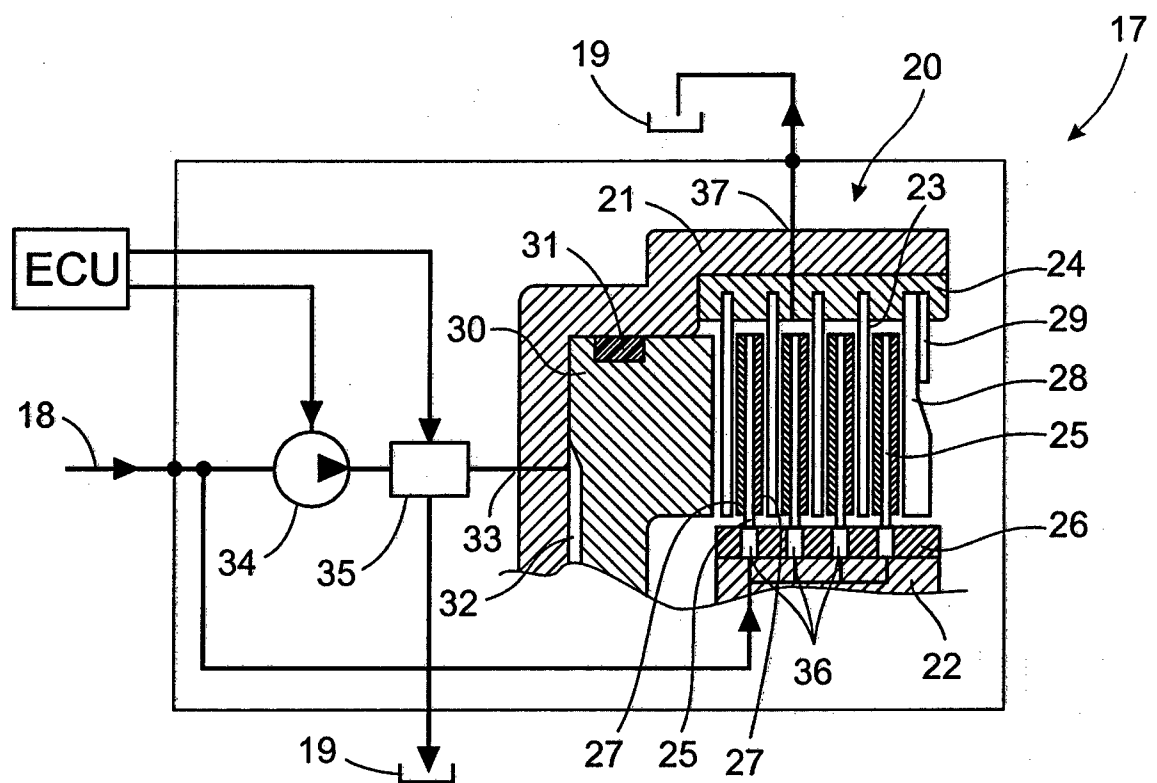


Fig.2

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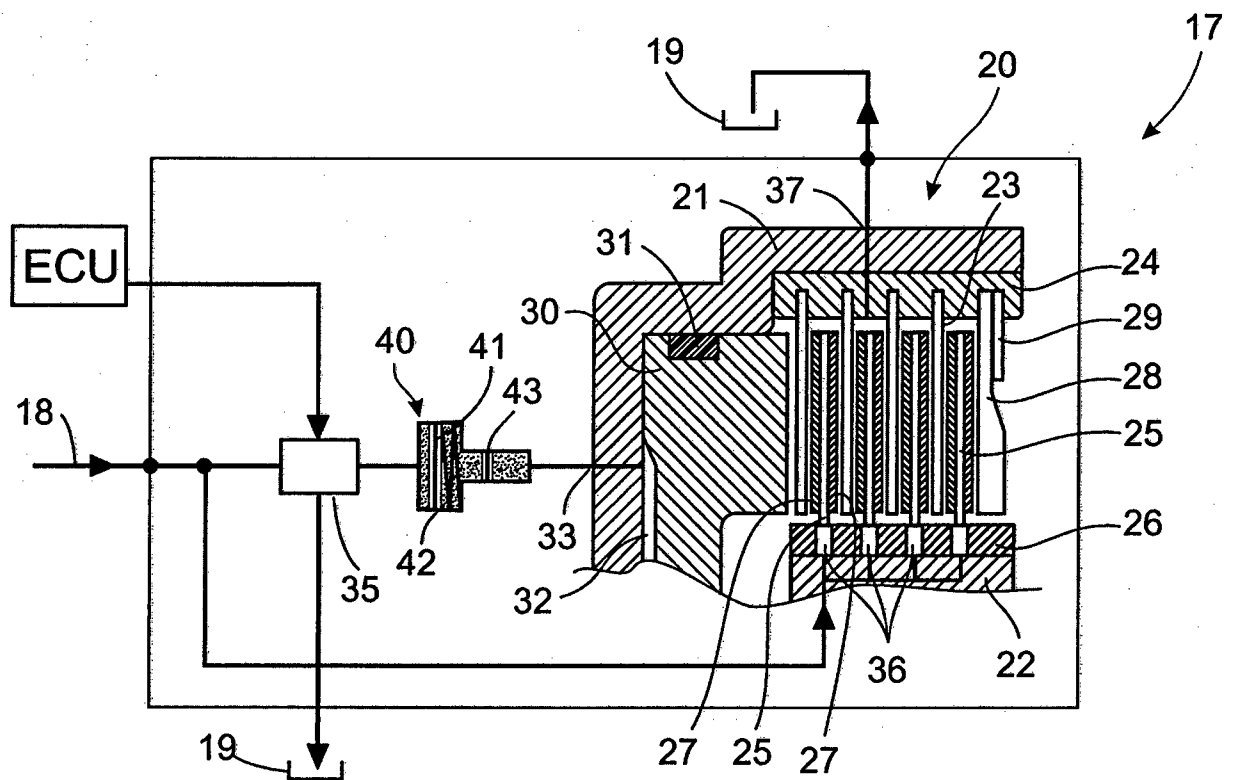


Fig.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/004299

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16D25/0638 F16D25/12 F16D48/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 821 273 A (SANFORD ROY S ET AL) 28 January 1958 (1958-01-28) column 9, line 1 - line 7 column 13, line 49 - line 60; figure 2a -----	1-12
A	US 4 061 079 A (ORTH HAROLD R ET AL) 6 December 1977 (1977-12-06) column 7, line 55 - line 59; figures -----	1,11
A	US 4 828 089 A (COLLINS MARCUS H [US] ET AL) 9 May 1989 (1989-05-09) figure 1 -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/004299

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2821273	A	28-01-1958	NONE	
US 4061079	A	06-12-1977	NONE	
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