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(71) Applicant: **Pierburg S.p.A.**
66034 Lanciano (IT)

(72) Inventors:
- **Pachetti, Carlo**
  56121 Pisa (IT)
- **Armenio, Giacomo**
  57128 Livorno (IT)
- **Righetti, Daniele**
  57128 Livorno (IT)

(74) Representative: **Franzolin, Luigi et al**
STUDIO TORTA S.r.l.,
Via Viotti, 9
10121 Torino (IT)

(54) **Variable-delivery pump**

(57) A variable-delivery pump (10) for a fluid, having at least one pumping stage (11a, 11b) in turn having at least one rotor (20) rotated by a drive shaft (17) ; the pump (10) being characterized in that a clutch device (25) is interposed between the drive shaft (17) and the rotor (20) to make the rotor (20) integral with or idle with respect to the drive shaft (17) to adapt the physical characteristics of the fluid to the demands of a user device.

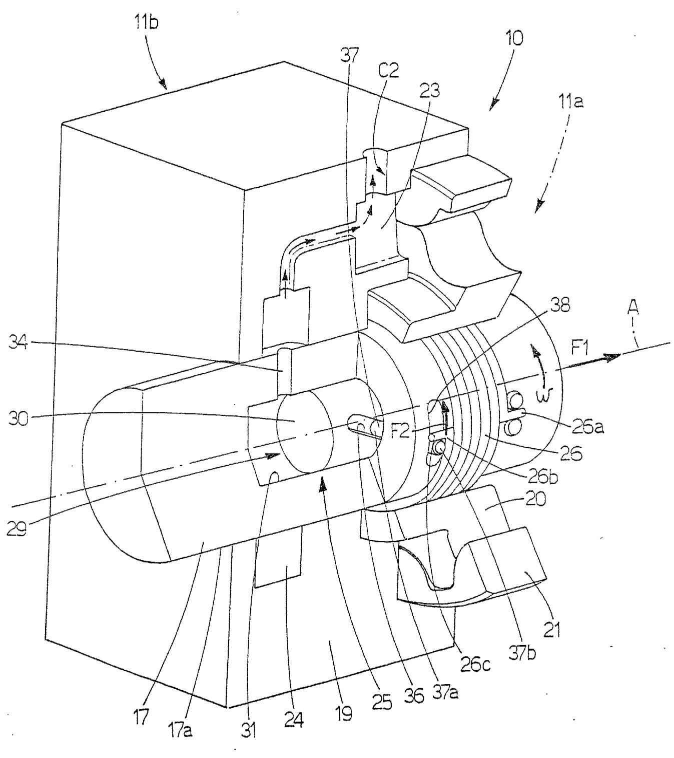

Fig.1

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Description

[0001] The present invention relates to a variable-delivery pump.

[0002] More specifically, the present invention relates to a fixed-displacement, variable-delivery pump.

[0003] In the supply of fluids in general, and automotive drive or lubricating fluids in particular, a need exists for high flow at low operating speeds and, at the same time, low, possibly constant flow at high operating speeds.

[0004] At present, this is achieved using pumps differing in design and operation, and in particular fixed-displacement, variable-delivery rotary pumps, to which the following description refers purely by way of example.

[0005] As is known, in pumps of the above type, flow and supply pressure increase proportionally alongside an increase in the rotation speed of the rotary members, and displacement is selected at the design stage to ensure the required flow at low rotation speeds.

[0006] To reduce flow at high rotation speeds, the pump normally comprises a bypass valve assembly associated with the pump outlet and controlled so that, at low speed, it remains idle and flow from the pump is fed entirely to the user device, whereas, over and above a given engine speed threshold, it is activated to drain off part or even all the flow from the pump.

[0007] Though widely used, pumps of the above type have several drawbacks by failing to provide for a constant degree of efficiency, and by being relatively inefficient, particularly at high speed, i.e. when part of the flow from the pump is drained off by the bypass valve, as opposed to being fed to the user device.

[0008] It is an object of the present invention to provide a variable-delivery pump designed to provide a straightforward solution to the aforementioned drawbacks, and which, in particular, provides for high flow at low operating speeds and, at the same time, a high degree of efficiency over the full operating range of the pump.

[0009] According to the present invention, there is provided a variable-delivery pump for a fluid, the pump comprising at least one pumping stage in turn comprising at least one rotor rotated by a drive shaft; and the pump being characterized in that a clutch device is interposed between the drive shaft and the rotor to make the rotor integral with or idle with respect to the drive shaft to adapt the physical characteristics of the fluid to the demands of a user device.

[0010] A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a three-dimensional view of a portion of a variable-delivery pump in accordance with the present invention;

Figure 2 shows a first longitudinal section of the variable-delivery pump in Figure 1;

Figure 3 shows a second longitudinal section, with parts not in section for the sake of clarity, of the variable-delivery pump in Figure 1.

[0011] Number 10 in Figure 1 indicates a two-stage pump, in particular for supplying pressurized oil in a lubricating system of an internal combustion engine (not shown).

[0012] As shown in Figures 2 and 3, pump 10 comprises two parallel pumping stages 11a, 11b.

[0013] In known manner, first pumping stage 11a comprises a main body 12 housing two eccentric gear rotors 13 and 14, which mesh to impart to the fluid a given mechanical energy in the form of speed and pressure.

[0014] More specifically, the fluid, in particular lubricating oil, is drawn from a tank (not shown) through an intake chamber 15 and fed by rotors 13, 14 at a higher pressure to a delivery chamber 16. Rotor 14 is fitted in known manner to a drive shaft 17 rotated by an engine (not shown) about a longitudinal axis A of symmetry in a rotation direction defined by a vector *w*; and rotors 13 and 14 mesh to subject the fluid in known manner to the desired pumping action as the fluid is fed from intake chamber 15 to delivery chamber 16.

[0015] The pressurized fluid is fed by known means (not shown) along a conduit C1 from delivery chamber 16 to a delivery passage M shared with second stage 11b (see below) and communicating hydraulically with an outlet S to a user device.

[0016] Second stage 11b, shown in more detail in Figure 1 (in which first stage 11a is not shown for the sake of clarity), comprises a main body 19 housing two eccentric gear rotors 20, 21, which mesh to impart to the fluid a given mechanical energy in the form of speed and pressure.

[0017] Since stages 11a and 11b are parallel, the flow delivered by stage 11b is added at delivery passage M to that of stage 11a.

[0018] As in stage 11a, fluid is fed simultaneously in stage 11b from an intake chamber 18 (which draws the fluid from a tank not shown) to a delivery chamber 23 and to an annular chamber 24, and is fed from delivery chamber 23 along a conduit C2 to delivery passage M, from where it is fed by known means (not shown) to a user device (not shown).

[0019] As shown in the accompanying drawings, a clutch device 25 is interposed between rotors 20, 21 and drive shaft 17 to make rotor 20 integral, or not, with drive shaft 17, depending on the flow of fluid, e.g. lubricating oil, required by the user device downstream from pump 10.

[0020] Clutch device 25 comprises a spring 26 coiled about drive shaft 17 in the same direction as vector *w*, and having a first end 26a fixed (by known means) to drive shaft 17, and a free second end 26b comprising a pawl for the reasons explained in detail later on.

[0021] As shown more clearly in Figures 2 and 3, spring 26 is housed in a gap 27 between the surface 17a of drive shaft 17 and the surface 20a of the mounting hole 28 in rotor 20, and is preloaded and positioned during assembly so as to rest with a given preload on surface 20a of mounting hole 28 and transmit torque from drive shaft 17 to rotors 20, 21 to produce the desired pumping action at second stage 11b.

[0022] At low rotation speed of drive shaft 17, clutch device 25 is therefore engaged to fit rotor 20 to drive shaft 17 as required.

[0023] As shown, particularly in Figure 2, spring 26 is advantageously made of silicon spring steel wire flattened into two surfaces at 180° to each other to increase the contact area between the coils of spring 26 and surface 20a, on one side, and the coils of spring 26 the outer surface 17a of drive shaft 17 on the other.

[0024] To eliminate the drive effect of spring 26 on rotor 20, clutch device 25 comprises actuating means 28 connected to spring 26 by pawl 26c.

[0025] More specifically, actuating means 29 comprise a hydraulic piston 30 housed in a seat 31 formed in drive shaft 17.

[0026] Hydraulic piston 30 ideally divides seat 31 into a first chamber 31a filled with pressurized fluid, and a second chamber 31b housing hydraulic piston 30 itself, which slides inside second chamber 31b to reduce or increase the volume of second chamber 31b at the expense of first chamber 31a, which, as stated, contains a given quantity of pressurized fluid.

[0027] Hydraulic piston 30 is angularly fixed and slides axially in a direction defined by axis A. And to prevent any rotation of hydraulic piston 30 (Figure 2) about axis A, a key 32 is inserted inside a through hole 32a connecting surface 17a of drive shaft 17 to seat 31; and one end of key 32 projects inside a groove 33 formed on the surface of hydraulic piston 30 to prevent it rotating about axis A.

[0028] First chamber 31a communicates hydraulically with annular chamber 24 of second stage 11b via a through hole 34.

[0029] Delivery chamber 23 and annular chamber 24 are connected hydraulically by a conduit 35 formed in main body 19.

[0030] Though the embodiment shown in the accompanying drawings comprises one through hole 34, a second through hole (not shown) may be formed at 180° to the first for better balance.

[0031] The fluid pressure in chamber 31a is obviously the same as in annular chamber 24.

[0032] In addition to groove 33 for preventing rotation about axis A, the surface of hydraulic piston 30 also has a slot 36 sloping with respect to axis A.

[0033] Slot 36 is engaged by a first end 37a (Figure 1) of a pin 37, a second end 37b of which projects from surface 17a through an opening 38 connecting surface 17a to second chamber 31b.

[0034] Pin 37 is forced to travel along a path along which it is perpendicular at all times to axis A.

[0035] The longitudinal axis of symmetry of through opening 38, which is arc-shaped, therefore extends in a plane substantially perpendicular to axis A; and pawl 26c of spring 26 rests on second end 37b of pin 37.

[0036] In other words, connection of slot 36 and through opening 38 by pin 37 forms a cam mechanism whereby, for example, displacement of hydraulic piston 30 in the direction indicated by arrow F1 is converted into displacement of pin 37 in the direction indicated by arrow F2, and vice versa.

[0037] Since, as stated, pawl 26c, integral with second end 26b of spring 26, rests on second end 37b of pin 37, displacement in the direction of arrow F2 tightens the coils of spring 26 about surface 17a, thus detaching them from surface 20a of mounting hole 28 in rotor 20, so that rotor 20 becomes idle with respect to spring 26, which therefore acts as a bearing. Obviously, a fall in pressure in annular chamber 24 also reduces the hydraulic pressure in chamber 31a of seat 31 to allow hydraulic piston 30 to move in the opposite direction to arrow F1; and the movement of hydraulic piston 30 is also assisted by spring 26, one end 26b of which, as stated, acts elastically on pin 37 via pawl 26c.

[0038] Pump 10 according to the present invention operates as follows:

- when drive shaft 17 rotates at low speed, both parallel stages 11a and 11b are active and pump the fluid so as to increase its pressure and flow;
- in this case, rotor 20 of second stage 11b is made integral with drive shaft 17 by spring 26, the outer surface of which - preferably, though not necessarily, flattened - rests on surface 20a of mounting hole 28, so that the torque induced by shaft 17, rotating in the direction of vector *w*, is transmitted to rotor 20 made integral with shaft 17 by spring 26 of clutch device 25;
- when the speed of the engine, and therefore of drive shaft 17 connected mechanically to it, increases, the pressure of the fluid in annular chamber 24 also increases, thus accordingly increasing the pressure in chamber 31a;
- the increase in pressure in chamber 31a moves hydraulic piston 30 in the direction of arrow F1;
- displacement of hydraulic piston 30 in the direction of arrow F1 is converted by the cam mechanism into displacement of pin 37 in the direction of arrow F2, thus detaching the outer surface of spring 26 from surface 20a of mounting hole 28, by the coils of spring 26 being tightened about surface 17a of drive shaft 17;
- as a result, rotor 20 becomes idle with respect to shaft 17, thus deactivating second stage 11b;
- a fall in fluid pressure in chamber 31a moves hydraulic piston 30 in the opposite direction to arrow F1, thus resulting in a corresponding movement of pin 37 in the opposite direction to arrow F2; which

return movement is assisted by the elastic action of spring 26 on pin 37 and therefore on hydraulic piston 30.

[0039] The advantages of the present invention will be clear from the foregoing description.

[0040] In particular, pump 10 according to the present invention enables the bypass valve assembly associated with the outlet of the pump to be dispensed with. Using a valve assembly results in irregular and, in particular, relatively poor efficiency, especially at high rotation speeds of the drive shaft, at which, as opposed to being fed to the user device, part of the flow delivered by the pump is drained directly, thus impairing the overall efficiency of the pump.

[0041] When required, i.e. when the rotation speed of the drive shaft exceeds a given threshold value, the same effect is achieved by disconnecting one stage of a multistage pump easily and reliably as described above with reference to Figures 1-3. In so doing, pumping efficiency is improved considerably by not pumping surplus fluid not required by the user device.

Claims

1. A variable-delivery pump (10) for a fluid, the pump (10) comprising at least one pumping stage (11a, 11b) in turn comprising at least one rotor (20) rotated by a drive shaft (17); and the pump (10) being **characterized in that** a clutch device (25) is interposed between said drive shaft (17) and said at least one rotor (20) to make said at least one rotor (20) integral with or idle with respect to said drive shaft (17) to adapt the physical characteristics of the fluid to the demands of a user device.

2. A pump (10) as claimed in Claim 1, wherein said clutch device (25) comprises a preloaded elastic member (26) coiled about said drive shaft (17); said elastic member (26) acting as a friction member between said drive shaft (17) and said at least one rotor (20).

3. A pump (10) as claimed in Claim 2, wherein one end of said elastic member (26) is fixed to said drive shaft (17).

4. A pump (10) as claimed in Claim 2, wherein the coils of said elastic member (26) are wound in the same direction as rotation (*w*) of said drive shaft (17).

5. A pump (10) as claimed in Claim 2, wherein, when said at least one rotor (20) is integral with said drive shaft (17), the outer surface of said elastic member (26) rests on a surface (20a) of a mounting hole (28) in said at least one rotor (20), so as to act as a friction member between said drive shaft (17) and said at least one rotor (20).

6. A pump (10) as claimed in Claim 5, wherein the outer surface of said elastic member (26) is flattened to maximize the contact area between said elastic member (26) and said surface (20a) of the mounting hole.

7. A pump (10) as claimed in Claim 6, wherein said elastic member (26) is flattened by flattening the wire from which said elastic member (26) is made.

8. A pump (10) as claimed in Claim 2, wherein said clutch device (25) also comprises actuating means (29) connected to said elastic member (26); said actuating means (29) being activated hydraulically by the pressure of the fluid in an annular chamber (24).

9. A pump (10) as claimed in Claim 8, wherein movement of at least one portion of said actuating means (29) in one direction (F1) corresponds to release of said elastic member (26) from said at least one rotor (20); the movement in said direction (F1) tightening the coils of said elastic member (26).

10. A pump (10) as claimed in Claim 9, wherein said actuating means (29) comprise a hydraulic piston (30) housed in a seat (31) formed in said drive shaft (17); at least one portion (31a) of said seat (31) being connected hydraulically to said annular chamber (24).

11. A pump (10) as claimed in Claim 10, wherein said hydraulic piston (30) and a free end (26b) of said elastic member (26) are connected to each other by a cam mechanism.

12. A pump (10) as claimed in Claim 11, wherein said cam mechanism comprises a slot (36) formed in said hydraulic piston (30), and a through opening (38) formed in said drive shaft (17); said slot (36) and said through opening (38) being connected mechanically to each other by a pin (37) substantially perpendicular to a longitudinal axis (A) of symmetry of said drive shaft (17).

13. A pump (10) as claimed in Claim 12, wherein said slot (36) slopes with respect to said axis (A) of the drive shaft.

14. A pump (10) as claimed in Claim 12, wherein the longitudinal axis of symmetry of said through opening (38), which is arc-shaped, extends in a plane substantially perpendicular to said axis (A) of the drive shaft.

15. A pump (10) as claimed in Claims 9-14, wherein movement of at least one portion of said actuating

means (29) in a direction (F1) parallel to said axis (A) of the drive shaft corresponds to translation of said pin (37) in a direction (F2) perpendicular to said axis (A) of the drive shaft, and such as to stress said elastic member (26).

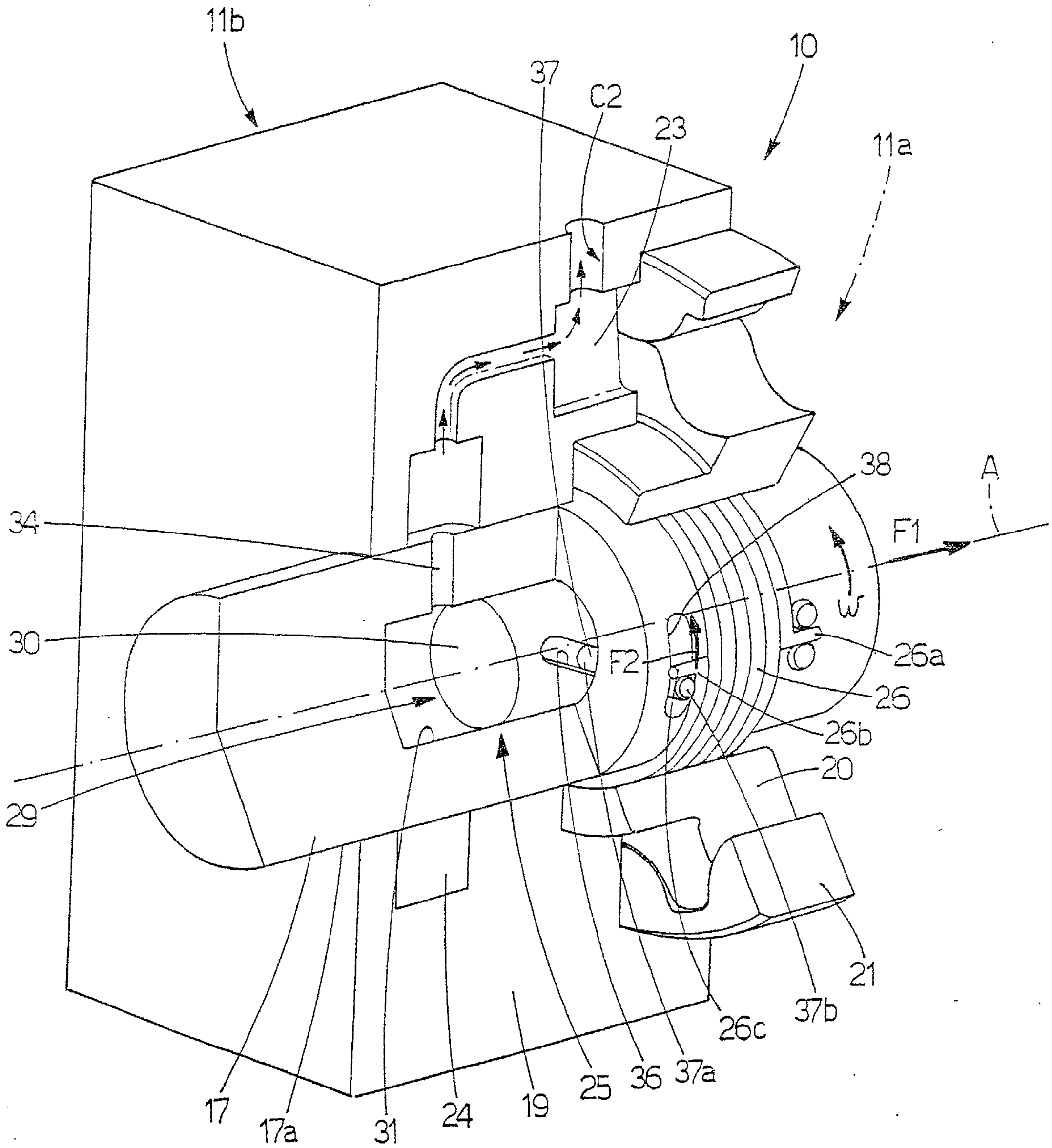
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Fig.1

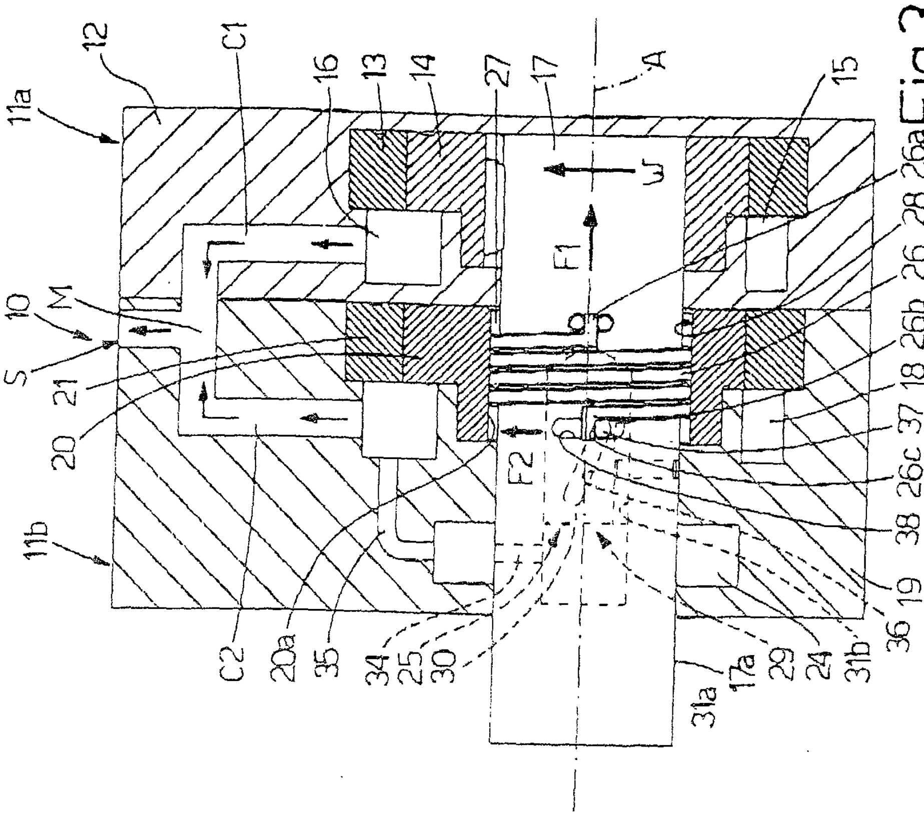
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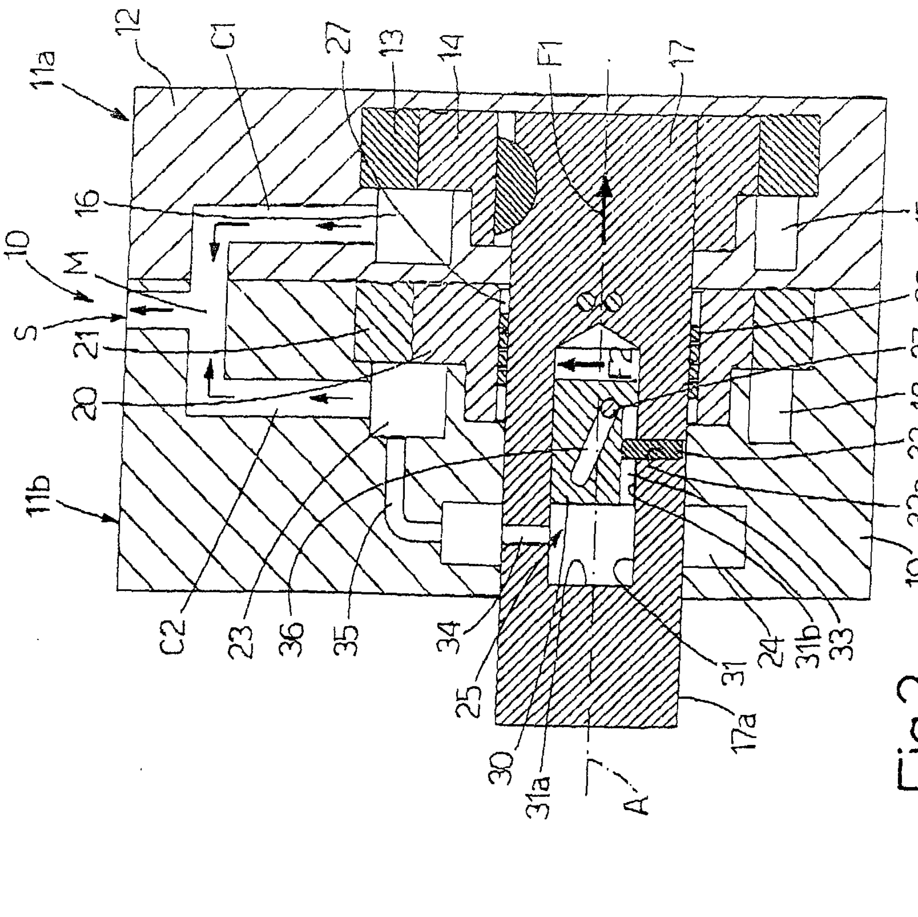
Fig.3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11b
C2
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31a
A
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24
31b
33
17a
F2

Fig.2