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(54) **Fluid pumping apparatus with Helmholtz-resonator**

(57) A pumping apparatus for fluids, in particular oil. The pumping apparatus includes a pump (10), a hydraulic circuit connected hydraulically to the pump (10), and a device (100) for damping vibration of the pumping apparatus. The device is a Helmholtz resonator (100) which

is integrated in a cover (23) of the pump (10). The resonator (100) is in direct fluid communication with the pressurized side of the pump (10) through a channel formed inbetween a bearing (20) and a bearing seat (13a, 13b) of the pump (10).

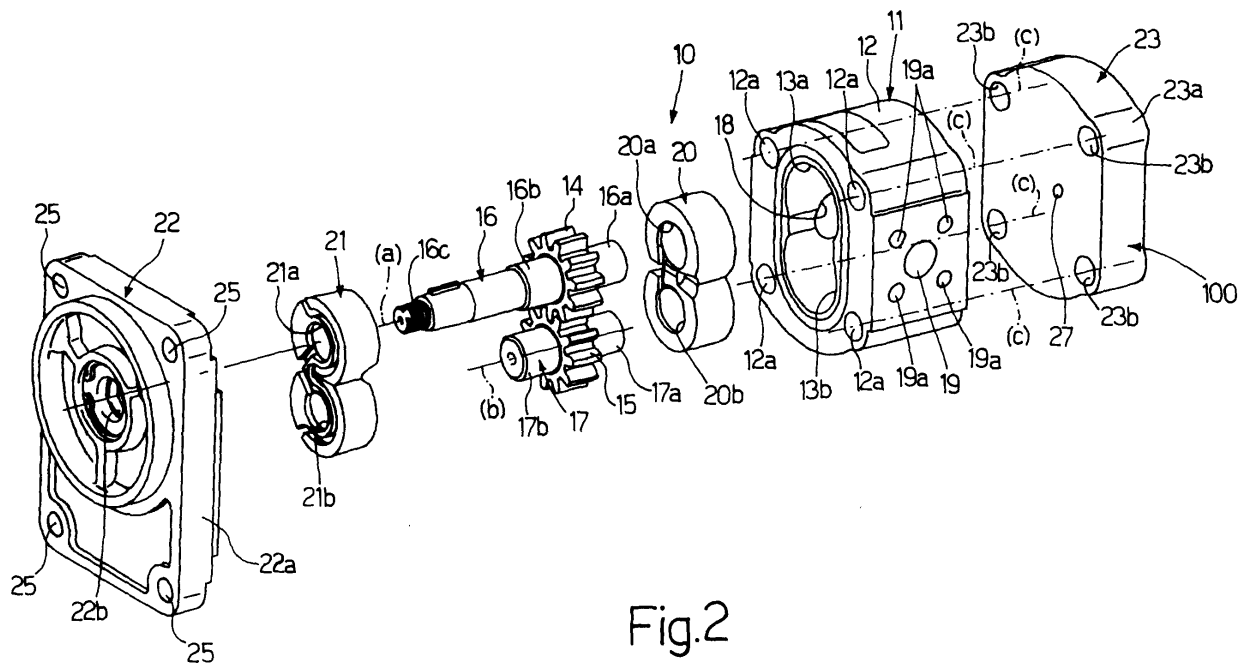


Fig.2

## Description

**[0001]** The present invention relates to a pumping apparatus for fluids, in particular oil.

**[0002]** As is known, a common problem in automotive oil pumping equipment is noise, mainly caused by irregular pressure generated by the pumps in the hydraulic circuits. To eliminate the drawbacks caused by noise-generating variations in pressure in the hydraulic circuits, external cascade filters (e.g. "reactive type" filters such as a Helmholtz resonator, which uses a gas damper, or "passive type" filters as throttles, section variations etc.) are normally installed separately from the pump along the oil line.

**[0003]** If the user device calls for e.g. 10 bar pressure, in addition to the 10 bars generated by the pump, a pressure oscillation or so-called "ripple" is also produced, caused by the successive meshing of the gear teeth, in case the pump is a gear type pump. This "ripple" produces vibrations along the oil line and, hence, noise.

**[0004]** The line must therefore be fitted with a device for damping vibration within the frequency range of the pump.

**[0005]** If powered by an internal combustion engine to pump oil to various external user devices (e.g. hydraulic steering, hydraulic actuators, etc.), the pump is also known to vary its speed as a function of engine speed, again causing vibrations.

**[0006]** Laboratory tests show that, in the case of pumps mounted on farm machinery engines, most noise is produced in the 1500-2200 rpm range.

**[0007]** In most applications, vibration is damped using a resonator with a damping peak of around 2000 rpm, but which at the same time also provides for acceptable damping of vibration slightly above or slightly below this value. On average, a good resonator can damp vibrations ranging between 20% above and 20% below its rated design frequency.

**[0008]** The geometry of the resonator can also be altered so that it effectively damps only one frequency or a range of frequencies. In the latter case, however, efficiency is reduced as compared to a resonator which operates best with only one rated design frequency.

**[0009]** In known systems of this sort, a Helmholtz resonator may be formed by a tube coaxial with another tube forming part of the oil circuit. The inner tube, in which the oil flows, has at least one hole connected to the outer tubular resonator to fill the resonator chamber with oil, which remains stationary inside the chamber. The stationary oil in the resonator chamber and the rigidity of the oil in the through hole act as a "mass-spring" system to damp vibration (and noise) produced by the pump.

**[0010]** Given the high pressures (as much as 200 bar) operating in the hydraulic systems in which it is installed, and the extensive surface area of the resonator, considerable forces are produced which the resonator, separate from the pump, must be able to withstand. As such, it must be mechanically strong enough. In addition, the res-

onator furthermore must be rigid enough to prevent its walls from flexing and initiating resonance phenomena which would defeat the purpose of the resonator itself.

**[0011]** To reduce the size of the filter, it is often necessary to adopt a small tube section, thus resulting in load loss along the line.

**[0012]** Since noise can be transmitted through air or structures, it is preferred to integrate a Helmholtz resonator in the pump itself, to eliminate or at least reduce structural noise transmission as well. Since a normal gear pump, for example, has two covers "sandwiching" the component parts of the pump, integrating the Helmholtz resonator in one of the pump covers is a valid solution. Such an integrated resonator is described in GB-B-2.319.564. In this arrangement, the resonator chamber is connected to the outlet port of the pump and thus is not immediately effective in the area where the vibrations are generated. Moreover, substantive modifications of the pump body itself are required to adapt it to the cover in which the resonator chamber is incorporated. More specifically, apart from a supply channel inbetween the outlet port and the resonator chamber, additional seals around the supply channel are required to avoid leakage of oil inbetween the pump body and the cover holding the resonator chamber.

**[0013]** It is therefore an object of the present invention to provide a pumping apparatus for fluids, in particular oil, designed to eliminate the aforementioned drawbacks.

**[0014]** According to the present invention, there is provided a pumping apparatus for fluids, in particular oil, as defined in Claim 1.

**[0015]** 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 an assembly drawing of a pump forming part of the fluid pumping apparatus (shown only partly) which is the main object of the present invention;

Figure 2 shows an exploded view of the Figure 1 pump; and

Figure 3 shows a cover of the Figure 1-2 pump, in which a Helmholtz resonator is integrated according to the invention.

**[0016]** Number 10 in Figure 1 indicates a pump forming part of a pumping apparatus (shown only partly) which is the main object of the present invention. In the non-limiting embodiment shown purely by way of example in the accompanying drawings, pump 10 is a gear pump for pumping oil.

**[0017]** As will be clear to anyone skilled in the art, however, what is said in the following disclosure also applies to other types of pumps (e.g. variable-eccentricity vane pumps) and to any type of fluid, provided the geometry of the filter-resonator is designed accordingly.

**[0018]** As shown in detail in the exploded view in Figure 2, pump 10 comprises a one-piece pump body 11 ad-

vantageously, though not necessarily, extruded from metal, in particular aluminium. Pump body 11 comprises a casing 12 defining two communicating inner cavities 13a, 13b (Figure 2). Casing 12 has four longitudinal through holes 12a for the purpose explained in detail below. Cavities 13a, 13b house respective rotors 14, 15 meshing with each other.

**[0019]** As shown in Figure 2, rotor 14 is fitted to a drive shaft 16 driven around a longitudinal axis (a), and rotor 15 is driven, in use, by rotor 14. Rotor 15 is connected to a shaft 17, having a longitudinal axis (b) parallel to axis (a).

**[0020]** Pump body 11 has an intake opening 18 (Figure 2) and an opposite delivery opening 19. The wall of casing 12, in which opening 19 is formed, has a number of holes 19a (Figure 2) for screwing on a delivery conduit (not shown) using known means, the conduit being connected to the hydraulic circuit. Opening 18 has similar holes (not shown in Figure 2) for connecting an intake conduit (equally not shown).

**[0021]** The fluid being pumped, in particular oil, is therefore drawn in, by rotation of rotors 14, 15, through intake opening 18 in known manner not described herein, and is pumped into the hydraulic circuit connected to delivery opening 19.

**[0022]** Cavities 13a and 13b in pump body 11 house a first bearing 20 and a second bearing 21. First bearing 20 has two seats 20a, 20b for housing, in use, a portion 16a of shaft 16 and a portion 17a of shaft 17 respectively. Similarly, second bearing 21 (on the opposite side of rotors 14, 15) has two seats 21a, 21b for housing, in use, a portion 16b of shaft 16 and a portion 17b of shaft 17 respectively.

**[0023]** As shown in Figure 2, in use, rotors 14, 15, shafts 16, 17, and bearings 20, 21 are "sandwiched" inside cavities 13a, 13b of pump body 11 by two covers 22 and 23.

**[0024]** Cover 22 is of conventional design, and comprises a main body 22a, in which an opening 22b is formed through which an end 16c of shaft 16 protrudes (as best seen in Figure 1). End 16c is connected mechanically to drive means (not shown) for rotating rotor 14 (and therefore also rotor 15 meshing with rotor 14) to pump the fluid as required. Four holes 25 are formed at the four corners of cover 22 to fix pump 10 to a support (not shown). Cover 22 also has four dead holes (not shown) for a purpose explained in detail below.

**[0025]** As schematically shown on the front face of the pump body 11, a conventional elliptical seal is provided around the cavities 13a, 13b for sealing against a flat face of cover 22. An identically shaped seal is provided on the rear face of pump body 11, to seal against cover 23.

**[0026]** The innovative cover 23 is located on the opposite side of pump body 11 and is shown in more detail in Figure 3. As will be seen, cover 23 houses a Helmholtz resonator 100 for damping at the outset any annoying vibration and relative noise produced in pump 10 by the

fluid-pumping action of rotors 14 and 15.

**[0027]** Cover 23 comprises a main body 23a, in turn comprising four longitudinal through holes 23b, and a chamber 26 communicating with the outside solely through a hole 27 (see also Figure 2). Chamber 26 and hole 27 substantially define Helmholtz resonator 100. The oil for filling chamber 26 flows through hole 27, which, in use, communicates hydraulically with cavities 13a, 13b and is located on the delivery opening 19 side of pump 10. The location of hole 27 is chosen such that it is directed to the pressurized area of the pump 10, in the vicinity of the point where the teeth of rotors 14 and 15 mesh. Hydraulic communication between this area and the hole 27 is guaranteed between the nip of the side surface of bearing 20 and its associated seat in the pump body 11. It indeed will be observed that bearing 20 is formed by two semi-circular parts which are placed onto each other, thereby adopting a figure eight configuration. Seats 13a and 13b for their larger part obviously are also semi-circular but in contrast with bearing 20 have a transition area which is somewhat truncated, thereby forming a flat surface connection, as best seen in figure 2. The small channel formed inbetween this flat surface and the outer surface of bearing 20 is advantageously employed to hydraulically connect resonator 100 to the pressurized side of pump 10, thus eliminating the need for drilling any additional connecting channels in the pump body 11.

**[0028]** A Helmholtz resonator 100 is thus integrated in pump 10 to damp, at the outset, vibrations produced by the teeth of the two meshing rotors 14 and 15.

**[0029]** In actual use (Figure 1), each through hole 23b and a corresponding through hole 12a (both having a longitudinal axis (c) parallel to axes (a) and (b)) receive a respective bolt 28 (only two shown in Figure 1), the free end of which is screwed inside the corresponding dead hole (not shown) in cover 22.

**[0030]** One-piece pump body 11, the two bearings 20 and 21, and the two rotors 14 and 15 are thus "sandwiched" between covers 22 and 23, the latter having a Helmholtz resonator 100 in accordance with the invention.

**[0031]** A second Helmholtz resonator may obviously also be provided in cover 22, or in any convenient portion of one-piece pump body 11, without departing from the scope of the present invention.

**[0032]** The advantages of the pumping apparatus according to the present invention are as follows:

- integration within the pump structure itself of a device for suppressing vibration- and noise-induced disturbance;
- direct intervention inside the compartment in which fluid flow and pressure are generated, thus attenuating disturbance as of the outset and so preventing structural vibration transmission;
- suppression of load losses in the fluid circuit;
- no need to change the cross section of the tubes downstream from the pump - unlike conventional

- pumping systems, in which the Helmholtz resonator is located along the fluid line - thus also eliminating the need for additional fittings;
- vibration is damped over the full rotation speed range of the pump (from 1000 to 3000 rpm);
  - substantial saving, by not having to provide a resonator separate from the pump;
  - easier installation of the pump inside the vehicle engine compartment, e.g. by eliminating the space required for the resonator; moreover, it is not always possible to install the resonator in the most technically advantageous position; in fact, if the resonator is positioned wrongly, an air pocket forms inside, and this must be expelled through a bleed hole; since, however, operators frequently forget to bleed the resonator, thus leaving air trapped inside which seriously impairs the efficiency of the resonator, designers must devise an assembly position in which the resonator is always full of stationary oil; space and position problems sometimes prevent installation of Helmholtz resonators (as, for example, on small special-purpose tractors), thus impairing silent operation of the system;
  - the solution proposed in the present invention eliminates the need for high-cost machining of gear pump teeth to prevent vibration of the pump as much as possible;
  - no need for any modifications to existing pump bodies, as oil supply channels from the pump outlet conduit towards the resonator chamber are not required; furthermore, since the resonator communicates with the pump body through a channel closely parallel to the outer surface of the rotor bearings (i.e. emerging interiorly of the conventional seal between the pump body and the associated cover), no additional seals or redesign of conventional seals is needed.

**[0033]** All this allows easy retrofitting of new covers incorporating the resonator to existing pump bodies, without having to perform any modifications at all to the pump bodies. Moreover, one cover easily may be substituted by another cover having a different thickness, and therefore a different volume inside the resonator chamber, to adapt the system to a predominant frequency to be damped.

## Claims

1. A pumping apparatus for fluids, in particular oil, the pumping apparatus (10) comprising :
  - a pump body (11);
  - fluid propelling means (14, 15) enclosed in said pump body (11);
  - a hydraulic circuit connected hydraulically to said pump body (11); and
  - a Helmholtz resonator (100) for damping vibra-

tion generated by said fluid propelling means (14, 15); said resonator being integrated in at least one cover (22, 23) of said pumping apparatus (10); and

**characterized in that** the Helmholtz resonator (100) is in direct fluid communication with the pressurized side of the fluid propelling means (14, 15).

2. A pumping apparatus according to claim 1, **characterized in that** said Helmholtz resonator (100) comprises a chamber (26) and a hole (27) connecting said chamber (26) to the pump body (11) ; said fluid propelling means comprising meshing rotors (14, 15) and said hole (27) being oriented towards the area where the rotors (14, 15) mesh.
3. A pumping apparatus according to claim 2, **characterized in that** the rotors (14, 15) are supported by at least one bearing (20, 21) housed in a seat (13a, 13b) of said pump body (11); a gap inbetween said seat (13a, 13b) and said at least one bearing (20, 21) forming a channel for hydraulically connecting said hole (27) of the resonator (100) to the pressurized side of the pumping apparatus (10).
4. A pumping apparatus according to claim 3, **characterized in that** the pump body (11) comprises at least one elliptically shaped seal, provided closely around the confines of said seat (13a, 13b) for cooperation with said at least one cover (22, 23) to hydraulically seal the pumping apparatus (10); said hole (27) in said at least one cover (22, 23), when mounted on the pump body (11), being located within the confines of said seal.

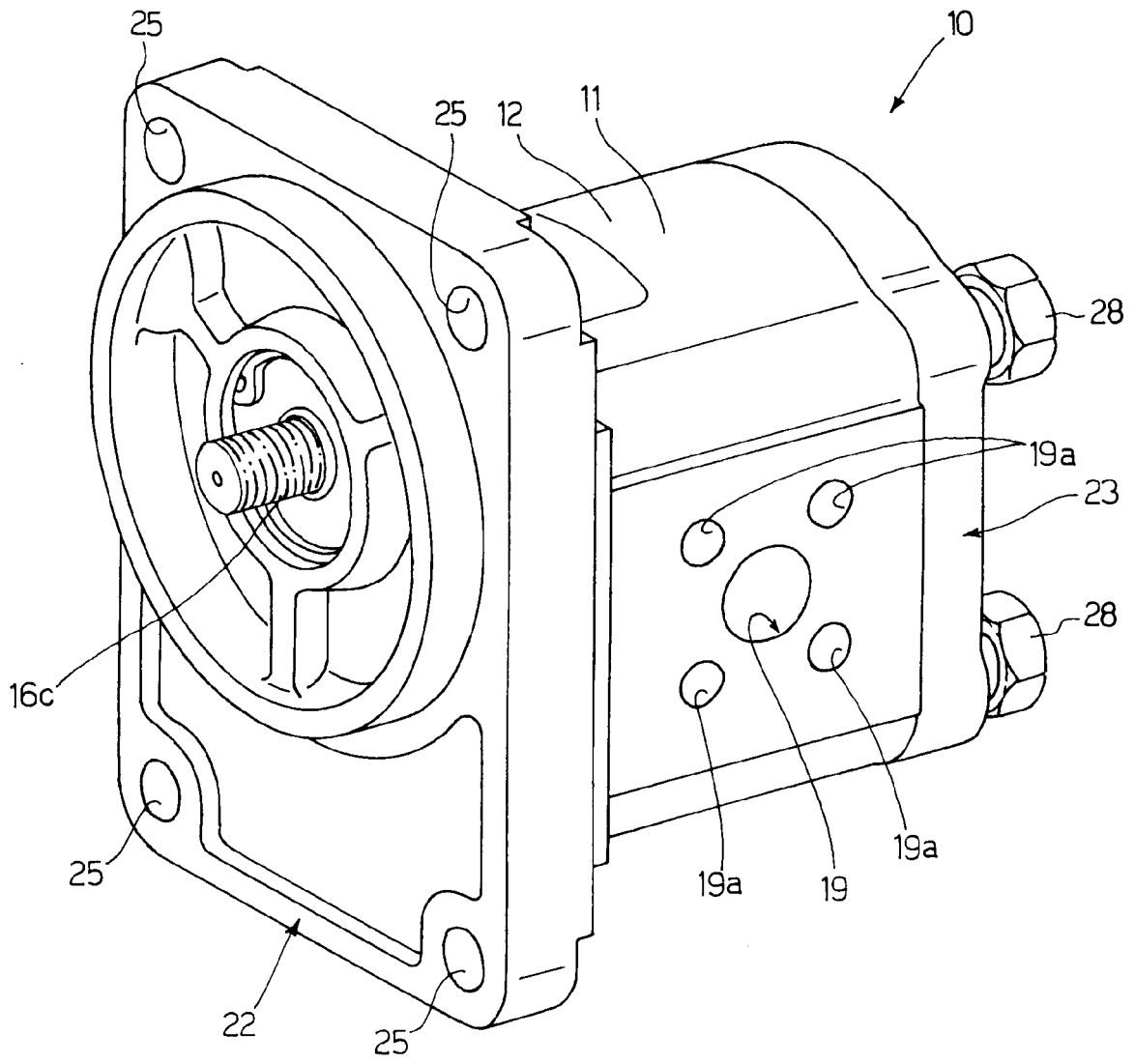


Fig.1

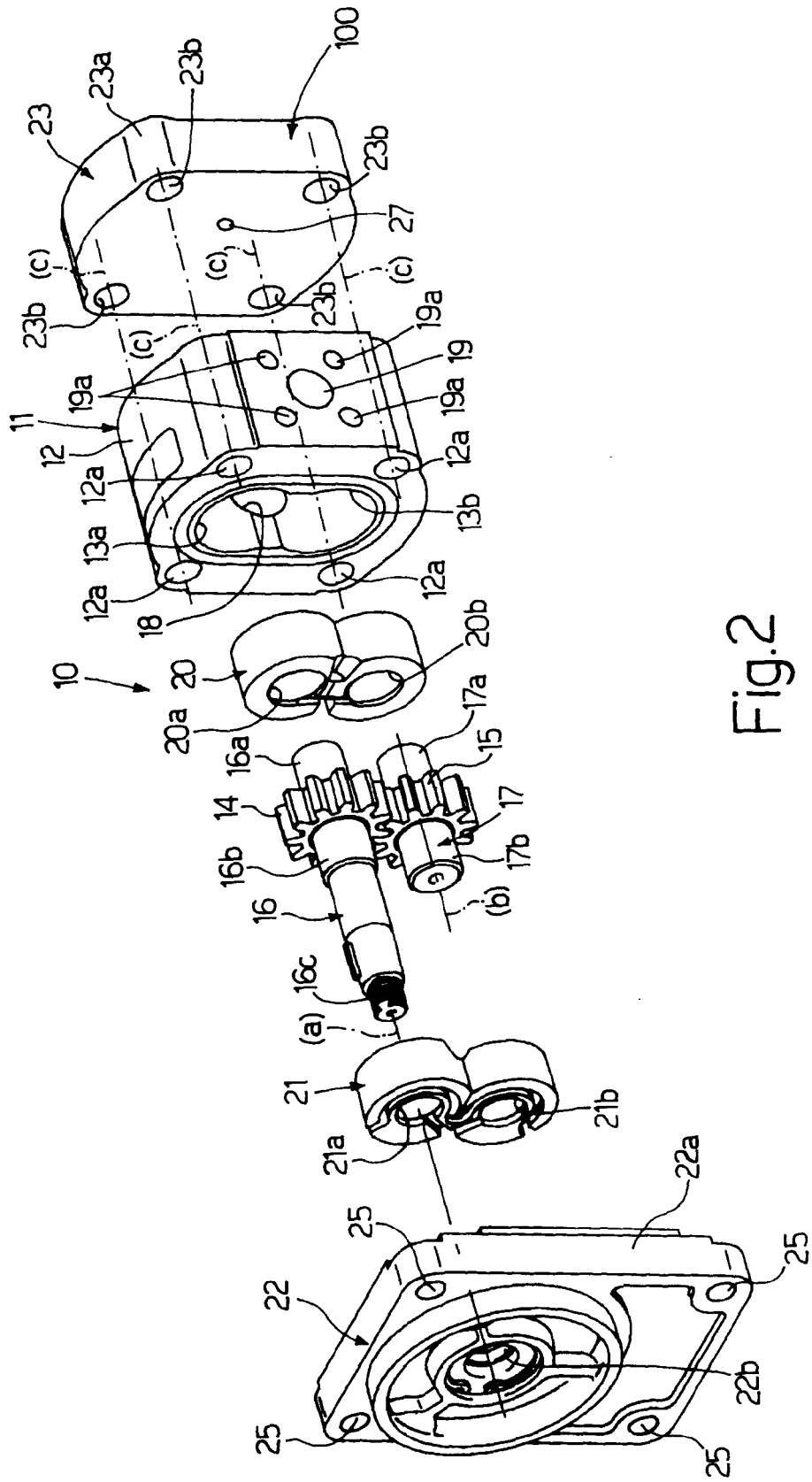


Fig.2

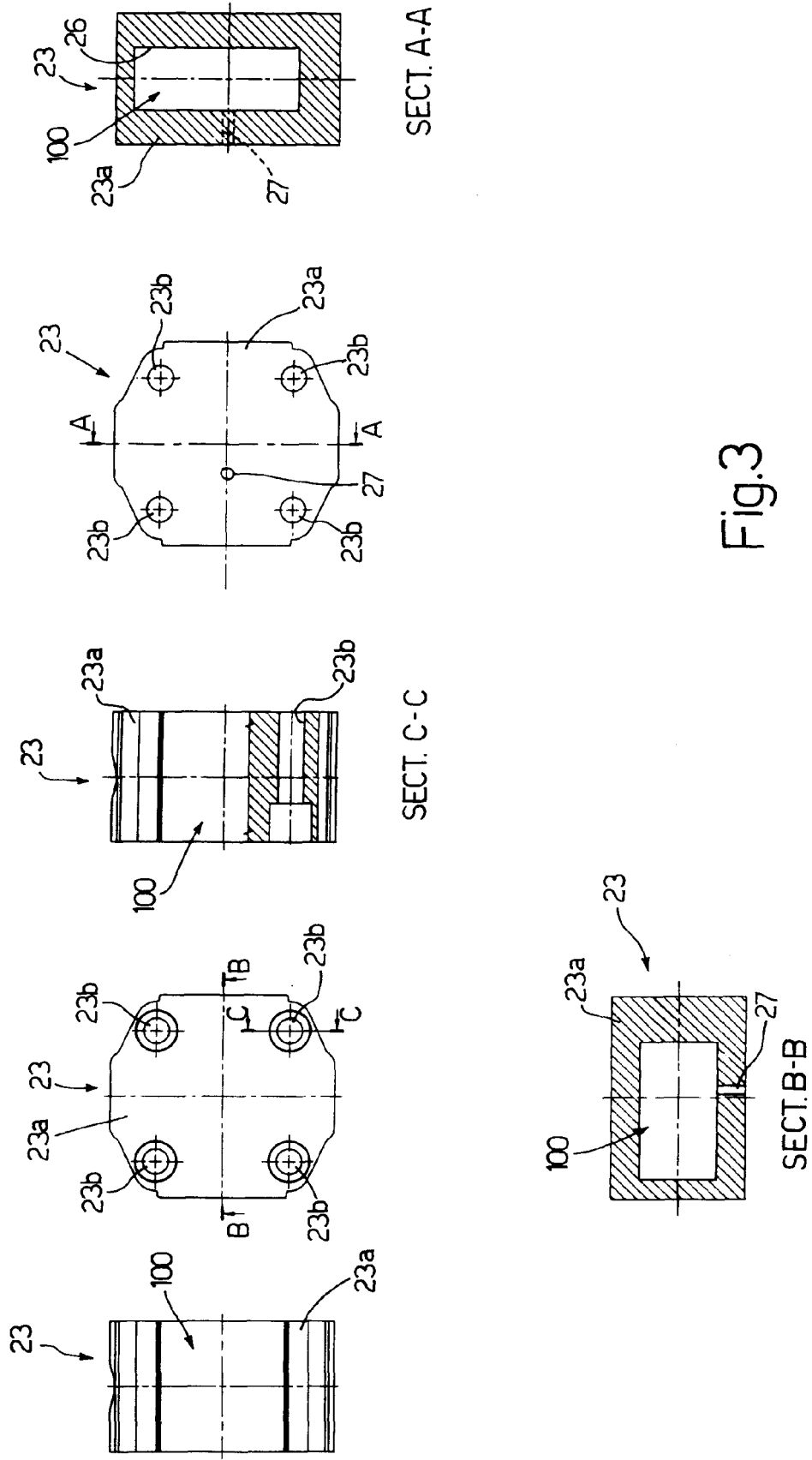


Fig.3