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(71) Applicant: **Lindsey, Stephen Francis**
Sunbury-on-Thames, Middlesex TW16 6PD (GB)

(72) Inventor: **Lindsey, Stephen Francis**
Sunbury-on-Thames, Middlesex TW16 6PD (GB)

(74) Representative: **Lomas, Geoffrey Michael et al**
Barker, Brettell & Boutland
Medina Chambers
Town Quay
Southampton, Hampshire SO14 2AQ (GB)

(54) Rotary piston machine

(57) A rotary piston and cylinder device (1) comprising a rotor (11) and a stator (7), the stator (7) at least partially defining an annular cylinder space (9), the rotor (11) comprising a rotor body and at least one piston (13) fixedly depending from the rotor body and which is moved circumferentially through the annular cylinder space (9) on rotation of the rotor (11) relative to the stator (7), the rotor body being sealed relative to the stator (7), and a cylinder space shutter means (3) which is capable of being moved relative to the stator to a closed position in which the shutter means partitions the annular cylinder space (9), and to an open position in which the shutter means (3) permits passage of the at least one piston.

The rotary piston and cylinder device (1) can be arranged to operate as an internal combustion engine, a fluid pump, an hydraulic motor/actuator or a turbine replacement.

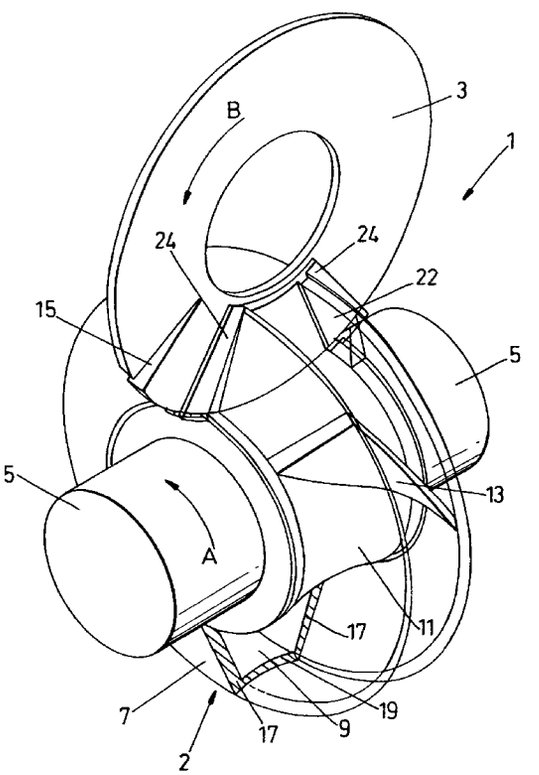

Fig. 1

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Description

[0001] This invention relates to rotary piston and cylinder devices which may be, for example, in the form of an internal combustion engine, or a pump such as a supercharger or fluid pump, or as an expander such as a hydraulic motor or turbine replacement.

[0002] The term 'piston' is used herein in its widest sense to include, where the context admits, a partition capable of moving relative to a cylinder wall, and such partition need not generally be of substantial thickness in the direction of relative movement but can often be in the form of a blade.

[0003] According to one aspect of the invention a rotary piston and cylinder device comprises a rotor and a stator, the stator at least partially defining an annular cylinder space, the rotor comprising a rotor body and at least one piston fixedly depending from the rotor body and which is moved circumferentially through the annular cylinder space on rotation of the rotor relative to the stator, the rotor body being sealed relative to the stator, and a cylinder space shutter means which is capable of being moved relative to the stator to a closed position in which the shutter means partitions the annular cylinder space, and to an open position in which the shutter means permits passage of the at least one piston.

[0004] Preferably the shutter means presents a partition which extends substantially radially of the annular cylinder space.

[0005] Although in theory the shutter means could be reciprocable, it is much preferred to avoid the use of reciprocating components, particularly when high speeds are required, and the shutter means is preferably at least one rotary shutter disc provided with at least one aperture which in the open condition of the shutter means is arranged to be positioned substantially in register with the circumferentially-extending bore of the annular cylinder space to permit passage of the at least one piston through the shutter disc.

[0006] Preferably the at least one aperture is provided radially in the shutter disc.

[0007] Preferably the rotor is adapted to receive the shutter disc.

[0008] Preferably the shutter disc passes through the cylinder space at least once. The shutter disc is preferably driven from the rotor through a suitable transmission means.

[0009] Preferably the axis of rotation of the rotor is not parallel to the axis of rotation of the shutter disc. Most preferably the axis of rotation of the rotor is substantially orthogonal to the axis of rotation of the shutter disc.

[0010] Preferably the piston is so shaped that it will pass through an aperture in the moving shutter means, without balking, as the aperture passes through the annular cylinder space.

[0011] Two particular types of device in accordance with the invention are currently under consideration, one being the inverse of the other, as will now be set forth.

[0012] According to a first type the rotor body comprises a hub, which may be part of a shaft, and the at least one piston extends generally radially outwardly from the hub, the stator extending coaxially around the hub to define the annular cylinder space which extends coaxially about the hub axis.

[0013] According to the second type the rotor is in the form of a ring, and the at least one piston extends from the rotor ring into the annular cylinder space which is defined by the stator positioned internally of the ring (but it should be appreciated that the stator could have portions which extend generally radially outwardly beyond the ring if desired).

[0014] Preferably the at least one piston extends generally radially inwardly from the rotor ring.

[0015] Alternatively the at least one piston may extend out from the rotor in a direction which is substantially parallel to the axis of rotation of the rotor, or at some other angle relative to the axis of rotation of the rotor.

[0016] The rotor body is preferably rotatably supported by the stator rather than relying on co-operation between the pistons and the cylinder walls to relatively position the rotor body and stator. Thus, for a device of the first type the hub is preferably journelled relative to the stator by suitable bearing means.

[0017] It will be appreciated that this is distinct from a conventional reciprocating piston device in which the piston is maintained coaxial with the cylinder by suitable piston rings which give rise to relatively high friction forces.

[0018] Similarly in a device of the second type the rotor ring is preferably rotatably supported by suitable bearing means carried by the stator.

[0019] The annular cylinder space maybe divided into a plurality of annular cylinder spaces. Preferably there is at least one piston in each cylinder space.

[0020] Preferably the communication means is at least one transfer passage.

[0021] The transfer passage or passages may be provided internally or externally of the stator, or internally or externally of the rotor.

[0022] At least one of the transfer passages may be valved by the shutter means.

[0023] Preferably the stator comprises at least one inlet port and at least one outlet port.

[0024] Preferably at least one of the ports is substantially adjacent to the shutter means.

[0025] Preferably at least one of said ports is continuously open. Alternatively at least one of said ports may be valved.

[0026] Said ports maybe valved by the shutter means. Alternatively the ports may be valved by pressure-controlled valving means or other valving means.

[0027] Preferably each piston comprises sealing means.

[0028] Preferably the sealing means comprises at least one sealing strip.

[0029] Preferably each such sealing strip is attached

to the piston by means of at least one resilient member.

[0030] The sealing means may, alternatively, comprise a spring seal.

[0031] Preferably the sealing strip and the piston device define a recess.

[0032] Preferably the piston and the sealing strip comprise angled front portions which encourage the accumulation of pressure in that region of the annular cylinder space which is adjacent to said front angled portions.

[0033] Preferably the profile of the rotor is at least in part that of a diabolo.

[0034] Preferably the ratio of the angular velocity of the rotor to the angular velocity of the shutter disc is 1:1.

[0035] In one preferred configuration the rotary piston and cylinder device is an internal combustion engine.

[0036] In another preferred configuration the rotary piston and cylinder device is a fluid pump.

[0037] In a further preferred configuration the rotary piston and cylinder device is a hydraulic motor/actuator.

[0038] The rotary piston and cylinder device may be a turbine replacement.

[0039] The rotary piston and cylinder device may be a compressor or expander.

[0040] The invention will now be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of one embodiment according to the first type of rotary piston and cylinder device set forth, in which part of the stator has been removed,

Figure 2 is a plan view of the embodiment illustrated in Figure 1 with all of the stator shown,

Figure 3 is a side elevation of the embodiment shown in Figure 1,

Figures 4 to 7 are plan view snapshots of the embodiment shown in the preceding figures to illustrate the device in operation, in which the stator has been removed,

Figure 8 is a plan view of a second embodiment according to the first type of rotary piston and cylinder device set forth in which a chordal section therefrom has been removed,

Figures 9 to 11 are plan view snapshots of the embodiment illustrated in Figure 8 in operation,

Figure 12 is a cross-sectional view of a sealing arrangement for use in rotary piston and cylinder devices,

Figure 13 is a perspective view of a modified shutter disc for a rotary piston and cylinder device,

Figure 14 is a perspective view of an embodiment of the second type of rotary piston and cylinder device in which the stator has been omitted for clarity,

Figure 15 is a front elevation of the embodiment illustrated in Figure 14 in which the stator is shown,

Figure 16 is a cross-sectional view of the embodiment illustrated in Figure 14 in which the piston has been omitted for clarity,

Figure 17 is a front elevation of the outer ring and piston for the embodiment illustrated in Figures 14 to 16, and

Figure 18 is a perspective view of another embodiment of the second type of rotary piston and cylinder device in which the piston and stator have been omitted for clarity.

[0041] Figure 1 shows a perspective view of a rotary piston and cylinder device 1 of the first type set forth. The device 1 comprises a rotor (11), a stator (7) and shutter means.

[0042] The stator is of substantially circular outline and comprises a chamber casing 2. However, the stator need not necessarily be of circular outline.

[0043] The chamber casing 2 is formed from two side walls 17 and a roof 19 which extend coaxially about the hub axis. Said walls and said roof partially define an annular cylinder space 9. Each of said side walls has formed therein a port, 20 and 22. A gap in the chamber casing 2 allows for the insertion and subsequent rotation of the shutter means.

[0044] The shutter means comprises a shutter disc 3 in which there is provided an aperture 15.

[0045] The rotor comprises a piston 13, a hub 11 and two shafts 5. The arcuate profile of the hub 11 is of a radius which is substantially that of the shutter disc 3 so as to receive said shutter disc.

[0046] The rotor is rotatably attached to the stator by means of suitable bearing means (not shown).

[0047] Both of said side walls 17 are inclined substantially radially, with respect to the shutter disc 3. The stator 7 further comprises a rim 24 which assists in sealing. The rim extends outwardly at a direction of 90° to the side walls 17 and 19 thereof. The shutter disc 3 may, however, be entirely encased by the stator.

[0048] The piston 13 extends across the annular cylinder space 9 so as to create a division therein. The piston 13 is rigidly attached to the hub 11. The piston is so shaped that when both the hub and the shutter disc rotate at (substantially) the same angular speed the piston is able to pass through the aperture 15 without prohibiting interference. The effective size of the aperture 15 is dependent on the thickness of the piston 13. To effect the correct ratio of angular velocities between the shutter disc 3 and the hub 11 suitable transmission means

(not shown) is used. However, the ratio of the angular velocities of the rotor to that of the shutter disc may be 1:2 if two diametrically opposed pistons were provided.

[0049] The piston 13 is sealed with the walls of the annular cylinder space 17 and 19, around the edge portions 26, 28 and 30.

[0050] In use the assembly shown in Figures 1 to 3 may be used as a pump. For this application port 20 acts as an inlet port and port 22 acts as an outlet port. The shafts 5 would be powered by a motor (not shown). The arrows A and B show the senses of rotation of the hub 11 and the shutter disc 3 respectively. Fluid is drawn into the inlet port 20.

[0051] Figures 4 to 7 show snapshots of the device (with the walls 17 and the roof 19 removed) as the piston 13 passes through the aperture 15 in shutter disc 3.

[0052] Once the piston 13 has passed through the aperture 15, the piston 13 forces the fluid through the outlet port 22.

[0053] The piston blade 13 is angled relative to the shutter disc 3 so as to allow a smaller aperture 15.

[0054] The lack of reciprocating motions means that acceleration forces impose less of an rpm limit on the device.

[0055] The fact that there are only two moving parts may reduce frictional losses (increasing efficiency) and wear (increasing working life).

[0056] The lack of valving (the inlet and outlet ports are continuously open) means not only that would there be a reduction in pumping losses compared to a valved system but also that the output would essentially be continuous.

[0057] However, both the inlet and outlet ports need not necessarily be continuously open. The output may be valved for increased efficiency at larger input/output pressure ratios. This may be achieved by the arrangement shown in Figure 13 and a suitably sized and positioned outlet port in the roof 19. Line A-A is the axis of rotation of the shutter disc 3.

[0058] An axially extending wall 42 is provided on the shutter disc 3 with an opening 82 such that as the shutter disc 3 rotates, the opening 82 periodically comes in to register with the outlet port thus opening the outlet port at the correct time. Alternatively, a suitably located port could be provided in the rotor which would periodically come in to register with a suitably located static opening. Yet a further alternative would be to provide the outlet port with a pressure controlled valve, other rotary valving means or other valving means.

[0059] Using such a single cylinder design as a pump is of course only one application. Such a design could also be used as an expander (hydraulic motor, turbine replacement).

[0060] Figures 8 to 11 show a second embodiment of the first type of rotary piston and cylinder device set forth.

[0061] This embodiment has been adapted to be used as a combustion engine and it is this particular application which is described below. Corresponding reference numerals apply where appropriate.

[0062] In this embodiment the annular space 9 has been divided into two annular cylinder spaces 32, 34 by the inclusion of a circumferentially extending central wall 35 in the stator 7.

[0063] The hub 11 now comprises two pistons 36 and 38. The pistons 36 and 38 correspond to end sections of the piston 13 so that the pistons are able to pass through the aperture 15 as the aperture passes through each of the annular cylinder spaces 32 and 34.

[0064] The annular cylinder space 32 defines an induction/compression space, and the cylinder space 34 defines a combustion/exhaust space.

[0065] The central wall 35 has formed therein a transfer passage 40. The transfer passage 40 provides a communication means between annular cylinder space 32 on one side of the shutter disc 3 and annular cylinder space 34 on the other side of the shutter disc 3. In this embodiment the transfer passage 40 is shaped so that as the aperture 15 passes through the transfer passage 40, the aperture 15 acts as a valve therein. In this case the transfer passage is opened when the aperture 15 is central to the passage 40.

[0066] In use the device operates as follows.

[0067] As the hub 11 revolves, air/fuel mixture is drawn into the induction/ compression space 32 through the inlet port 20. Simultaneously the mixture induced on the previous revolution is compressed in front of the piston 38. When the aperture 15 opens the transfer passage 40, compressed air/fuel mixture is allowed to pass into the combustion/ exhaust space 34 behind the piston 36. Said compressed mixture is then ignited (by suitable ignition means, not shown) so that the piston 36 drives the hub 11 and hence the shafts 5. Simultaneously the gases from the previous revolution are forced out through the outlet port 22.

[0068] One possible way of sealing the pistons with the walls 17, 35 and the roof 19 is shown in Figure 12. Figure 12 shows a sealing arrangement for piston 36 which is on the combustion/exhaust side. A recess is formed in the piston 36 to accommodate a sealing strip 44.

[0069] There is provided between the base of the recess and the sealing strip 44 a resilient member 46. The sealing strip 44 is positioned in the recess so that there is a gap 50 on one of said sealing strip. The piston 36 and sealing strip 44 comprise angled front portions 48 and 49 respectively.

[0070] In use, the angled front portion 48 encourages a build up of pressure in the region of the cylinder space which is adjacent to said angled front portions, resulting in a so-called 'ram' effect. On the other side of the sealing strip 44 the gap 50 allows pressure to act on the bottom of the sealing strip. The build up of pressure at the front of the sealing strip partially balances the combustion pressure.

[0071] There are many advantages to such an engine

design. The lack of a complex valve train and the fact that it has only two moving parts should reduce frictional losses. Since the induction/compression and combustion/exhaust stages are physically separated it is possible that the former could be cooled to a greater extent, and energy would be returned to the gas from the walls of the combustion side once the compressed gas had been transferred between the cylinder spaces.

[0072] Primarily this would increase the efficiency of the cycle, but it would also assist with combustion side cooling. The relatively narrow transfer passage may act as a venturi, allowing direct injection of fuel into the compressed gas (from an injector on the combustion side of the transfer passage) at a lower pressure than would otherwise be necessary. Direct injection may allow a higher compression ratio to be used (and hence increase the engine efficiency). The energy expended in fuel pressurisation may be reduced by having a split injection system in which part of the fuel is injected into the inlet port (in which the gas that is injected into is around atmospheric pressure) and the rest of the fuel needed to form a combustible mixture is injected into the compressed gas in the transfer passage. This may improve fuel mixing and would still allow a high compression ratio to be used without the risk of pre-ignition that would occur if all of the fuel was added to the inlet port.

[0073] The circular geometry of the engine may cause fuel to be centrifuged outwards. In the combustion side, this could possibly be controlled with an injector design, or an aerodynamic device by the injector to control amount of mixing. This would allow variable charge stratification (and hence allow power output to be varied without throttling).

[0074] There are of course many modifications which could be introduced without deviating from the scope of the invention. For example, we may also provide one or more transfer passages extending externally of the stator. Such transfer passages could be valved by the shutter disc by an adaptation of the arrangement shown in Figure 13. Such a transfer passage could be valved alternatively by, or in combination with, a suitable opening in the shutter disc 3. Yet a further possibility is that of providing a transfer passage in the rotor which would periodically come in to register with two static ports, the static ports providing communication between the different cylinder spaces.

[0075] Another possible modification would be the introduction of a second port on the induction/compression side to allow part of the induced air to be rejected. Control of the amount of air rejected would allow throttling of the device without the pumping losses associated with conventional throttles. Using this form of throttling, the compression ratio is effectively reduced, but the expansion ratio remains the same.

[0076] An embodiment 31 according to the second type of rotary piston and cylinder device set forth is shown in Figures 14 to 17. The device 31 illustrated comprises an outer ring 56, a shutter disc 58 and stator 60.

[0077] The stator 60 comprises a roof 62 and walls 64a and 64b. Said roof and said walls extend circumferentially around an axis of rotation Y-Y. The walls 64a and 64b comprise two ports 80 and 81, respectively, which are located adjacent to the shutter disc 58. The inlet port and the outlet port may equally be provided in the roof 62.

[0078] The outer ring 56 is rotatably mounted to said stator 60 by suitable bearing means. The outer ring 56 is provided with an inner surface 68 which is substantially arcuate in outline so as to accommodate the shutter disc 58. The inner surface 68 and stator 60 define an annular cylinder space 70. Said annular cylinder space is sealed by means of sealing rings (not shown). Said outer ring further comprises a piston 72 which extends generally inwardly of the outer ring 56.

[0079] The piston 72 is provided with inner surface portion 72a and is shaped so as to allow for the movement of said inner surface portion on the roof 62.

[0080] The shutter disc 58 is provided with an aperture 76 and the shutter disc is mounted within the outer ring 56 so that the shutter disc passes once through the annular cylinder space 70 as illustrated. The shutter disc has an axis of rotation X-X.

[0081] The sealing of the pistons with the stator may take the form previously described.

[0082] Suitable transmission means are provided (not illustrated) between the outer ring 56 and the shutter disc 58 so that they both rotate at the same angular velocity.

[0083] The embodiment described may be used as a pump with an inlet port 80 and an outlet port 81. In this case, the outer ring 56 would be driven by suitable driving means (not shown). During operation the outer ring 56 and the shutter disc 58 would rotate and the stator 60 would remain stationary.

[0084] As an alternative embodiment (not shown) of the second type of rotary piston and cylinder device, the inlet and outlet ports may be provided in outer ring 56 and may be valved by openings provided in a static outer housing.

[0085] As a further alternative one or more of the inlet or outlet ports may be valved by a modification to the shutter disc 58. However other suitable valving means may be used.

[0086] As yet a further alternative the inlet and outlet ports may be provided in the outer ring 56 so that more conventionally the outer ring 56 remains stationary and the rotating shutter disc 58 and the stator 60 rotate inside the outer ring 56.

[0087] One advantage of this second type of rotary piston and cylinder device with respect to the first type is that of reduced external dimensions.

[0088] This second type of rotary piston and cylinder device could be adapted to be used as an hydraulic motor. Alternatively, if appropriate communication means

were provided between different parts of the annular cylinder space 70, the device could be used as a combustion engine.

[0089] A further embodiment according to the second type of rotary piston and cylinder device is shown in Figure 18. In this case the angle between the axis Y-Y of rotation of the rotor ring and the axis B-B of rotation of the shutter disc is 45°. One advantage of this is that the piston attached to the outer ring is less angled with respect of the axis of rotation of the outer ring which reduces the side thrust on the outer ring. Another advantage of the embodiment shown in Figure 18 is that the external dimensions are further reduced compared to the rotary piston and cylinder device 31.

[0090] As with the first type of rotary piston and cylinder device, the second type of rotary piston and cylinder device could be used as a pump or hydraulic motor/actuator or as a compressor or expander with the addition of valving means.

[0091] As a further alternative, a number of the devices set forth could be combined, or the cylinder space divided to form multi-stage machines. These could take the form of a combustion engine, if appropriate valving and communication means were provided, or other machines such as multi-stage compressors.

Claims

1. A rotary piston and cylinder device (1) comprising a rotor (11) and a stator (7), the stator (7) at least partially defining an annular cylinder space (9), the rotor (11) comprising a rotor body and at least one piston (13) fixedly depending from the rotor body and which is moved circumferentially through the annular cylinder space (9) on rotation of the rotor (11) relative to the stator (7), the rotor body being sealed relative to the stator (7), and a cylinder space shutter means (3) which is capable of being moved relative to the stator to a closed position in which the shutter means partitions the annular cylinder space (9), and to an open position in which the shutter means (3) permits passage of the at least one piston.

2. A rotary piston and cylinder device (1) according to claim 1 in which the shutter means (3) presents a partition which extends substantially radially of the annular cylinder space (9).

3. A rotary piston and cylinder device (1) according to any preceding claim in which the shutter means (3) comprises a rotary shutter disc (3) provided with at least one aperture (15) which in the open condition of the shutter means (3) is arranged to be positioned substantially in register with the circumferentially extending bore of the annular cylinder space (9) to permit passage of the at least one piston (13) through the shutter disc (3).

4. A rotary piston and cylinder device (1) according to claim 3 in which the at least one aperture (15) is provided radially in the shutter disc (3).

5. A rotary piston and cylinder device (1) according to claim 4 in which the axis of rotation of the rotor (11) is not parallel to the axis of rotation of the shutter disc (3).

6. A rotary piston and cylinder device (1) according to claim 5 in which the axis of rotation of the rotor (11) is substantially orthogonal to the axis of rotation of the shutter disc (3).

7. A rotary piston and cylinder device (1) according to any preceding claim in which the annular cylinder space (9) is divided into a plurality of annular cylinder spaces (32, 34).

8. A rotary piston and cylinder device (1) according to claim 7 in which there is at least one piston (36, 38) in each cylinder space (32, 34).

9. A rotary piston and cylinder device (1) according to either claim 7 or claim 8 in which communication means (40) is provided between the annular cylinder spaces (32, 34).

10. A rotary piston and cylinder device (1) according to claim 9 in which the communication means comprises at least one transfer passage (40).

11. A rotary piston and cylinder device (1) according to claim 10 in which the at least one transfer passage (40) is provided internally of the stator (7).

12. A rotary piston and cylinder device (1) according to claim 10 in which the at least one transfer passage (40) is provided externally of the stator (7).

13. A rotary piston and cylinder device (1) according to any one of claims 10 to 12 in which the at least one transfer passage (40) is valved by the shutter means (3).

14. A rotary piston and cylinder device (1) according to any preceding claim in which the rotor body comprises a hub (11), which is part of a shaft (5), and the at least one piston extends generally radially outwardly from the hub (11), the stator extending coaxially about the hub axis.

15. A rotary piston and cylinder device (31) according to any one of claims 1 to 13 in which the rotor is in the form of a ring (56), and the at least one piston extends generally radially inwardly from the rotor

ring (56) into the annular cylinder space (70) which is at least partially defined by the stator (60) which is positioned internally of the ring (56).

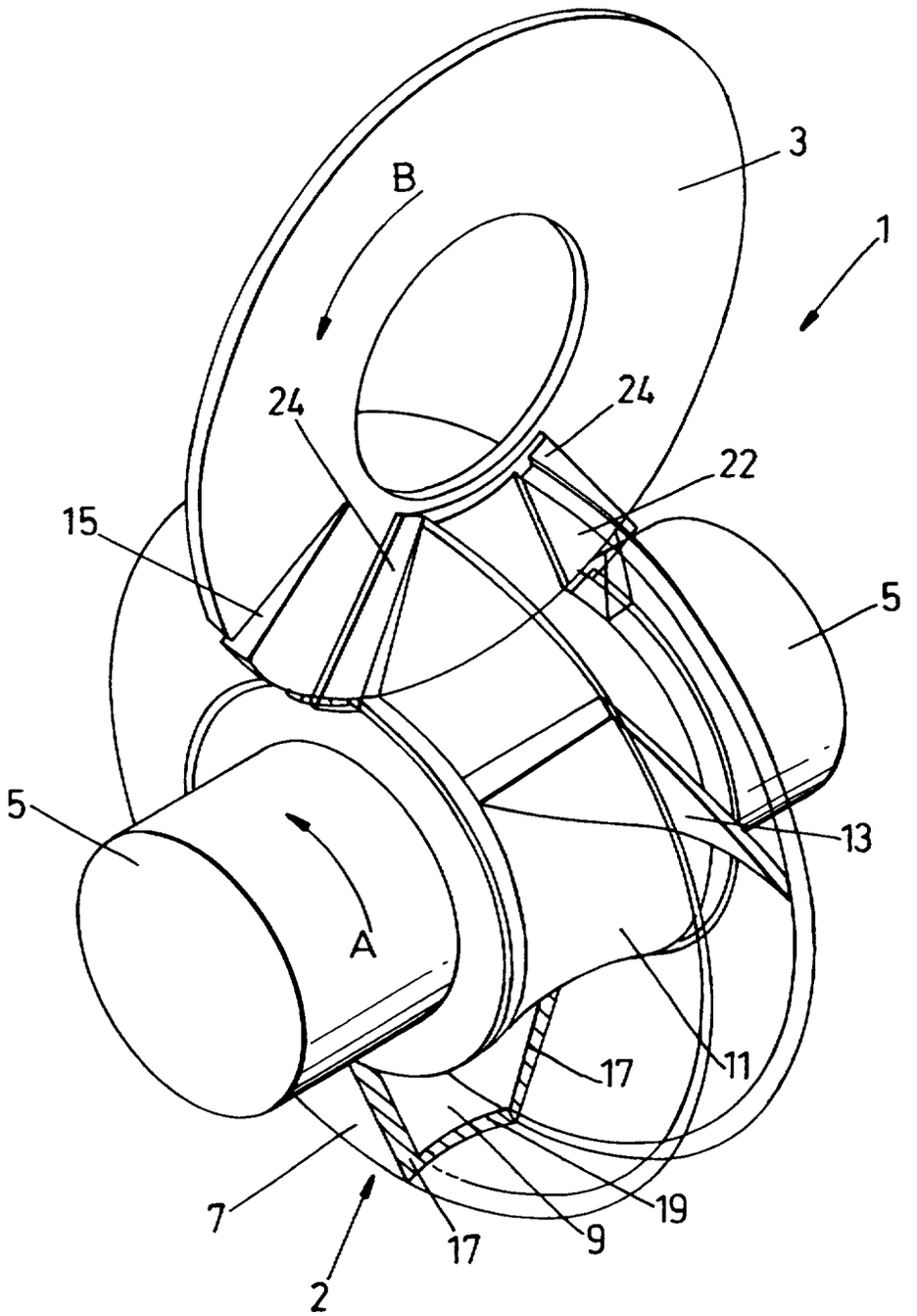

Fig. 1

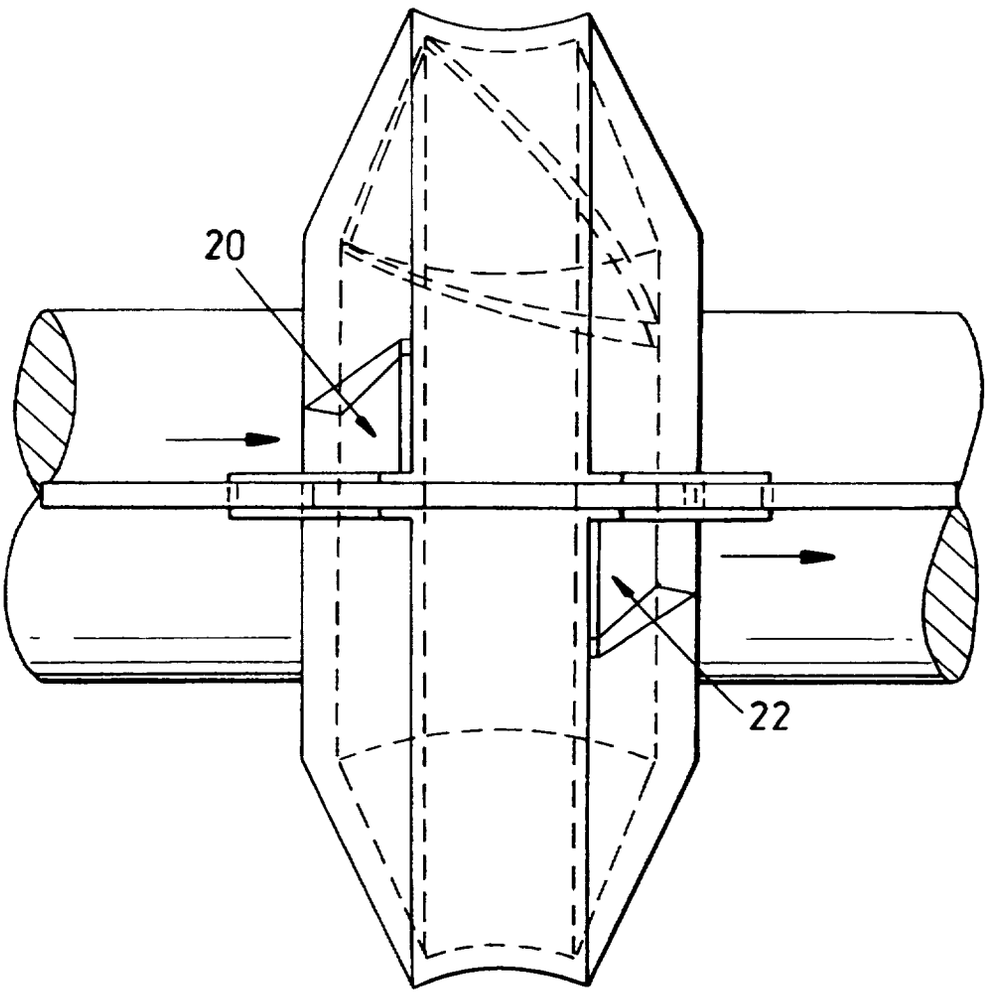

Fig. 2

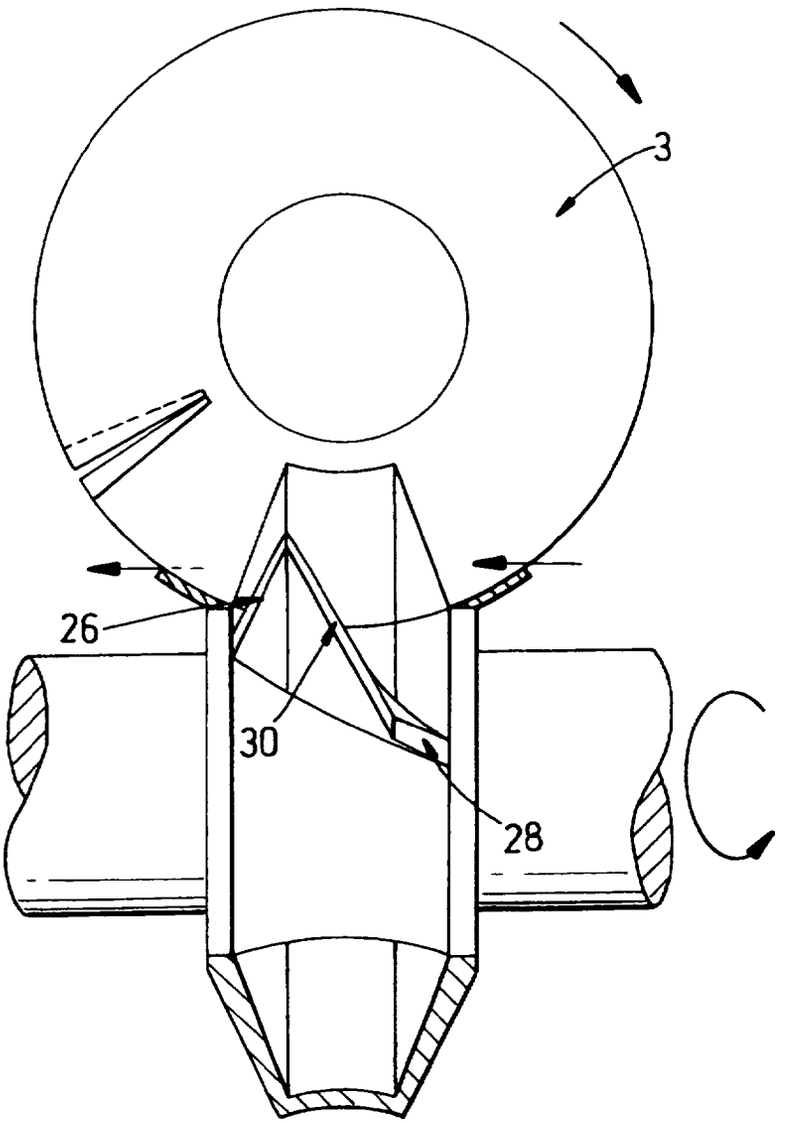

Fig. 3

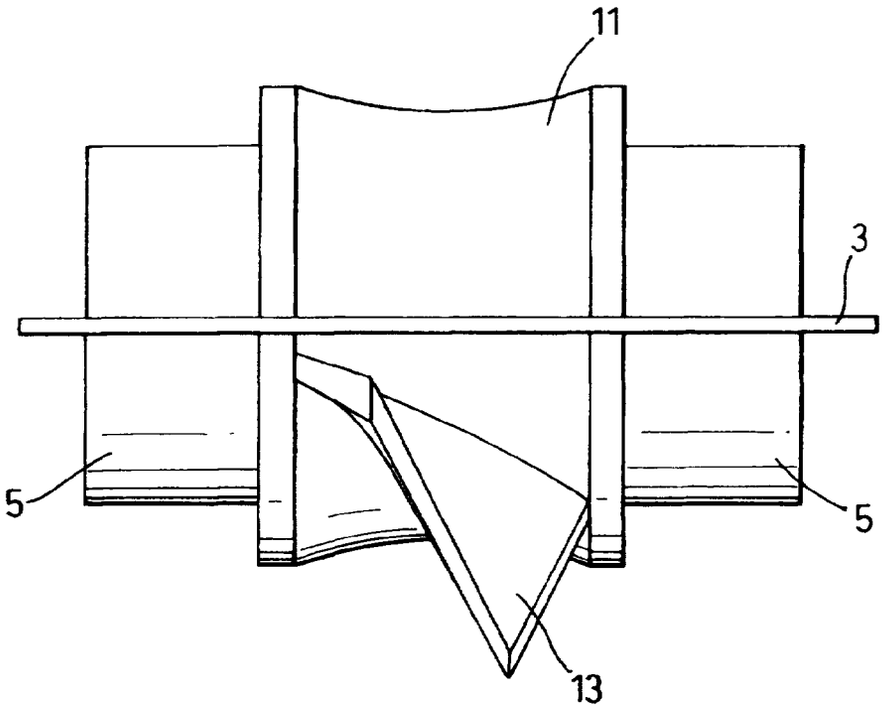

Fig. 4

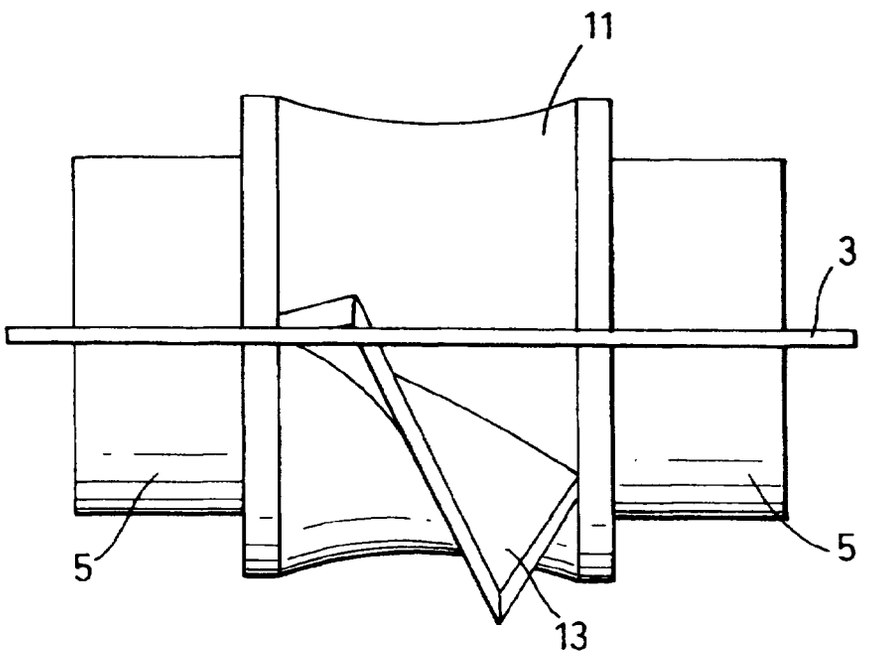

Fig. 5

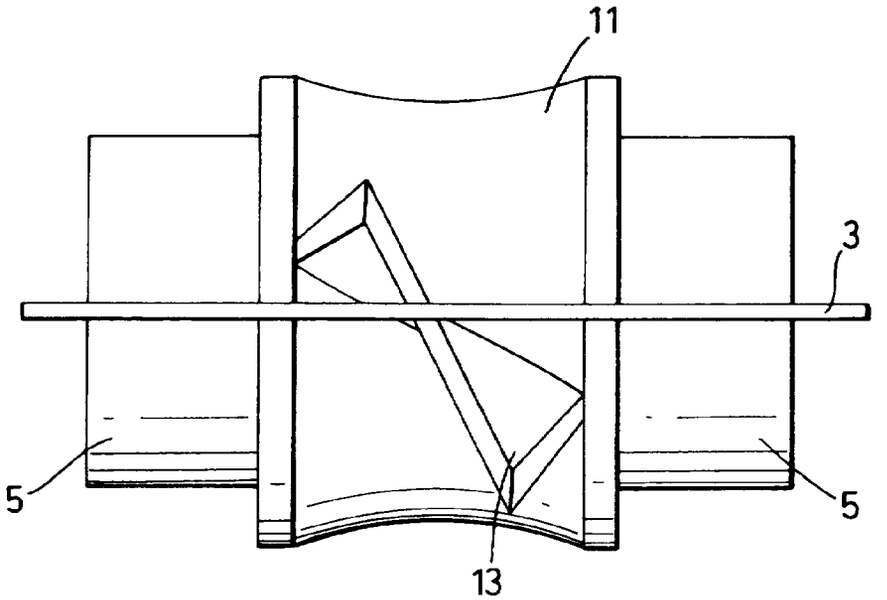

Fig. 6

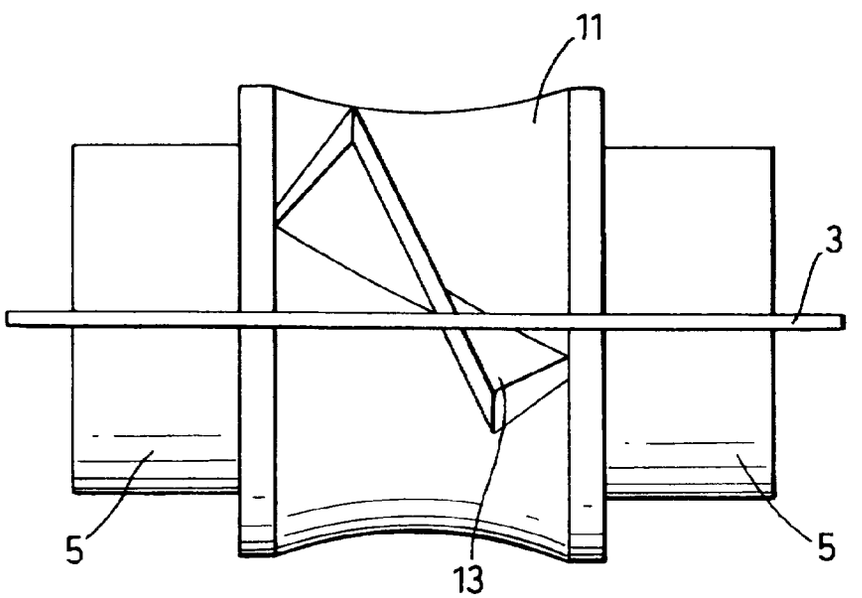

Fig. 7

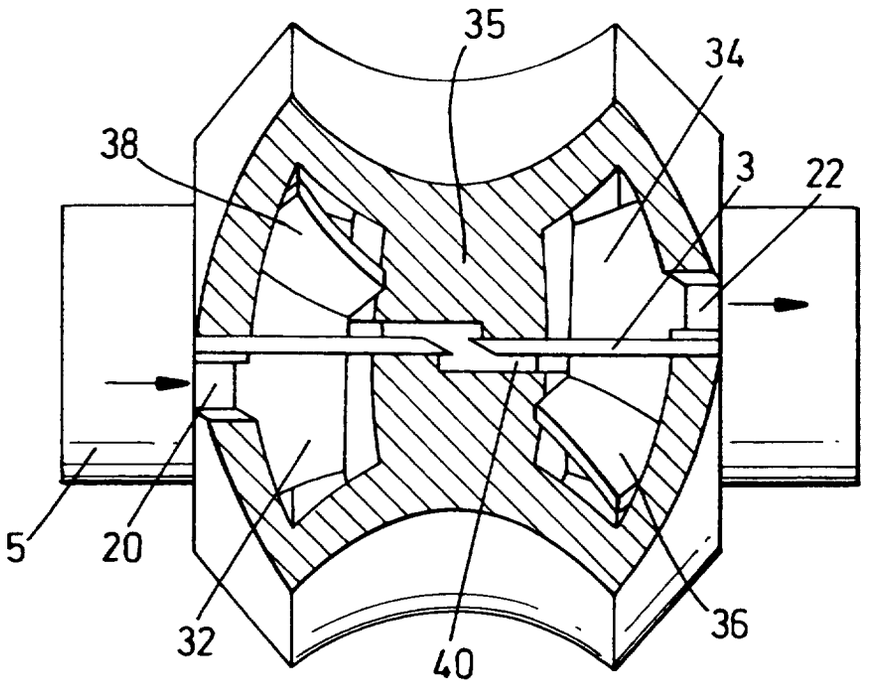

Fig. 8

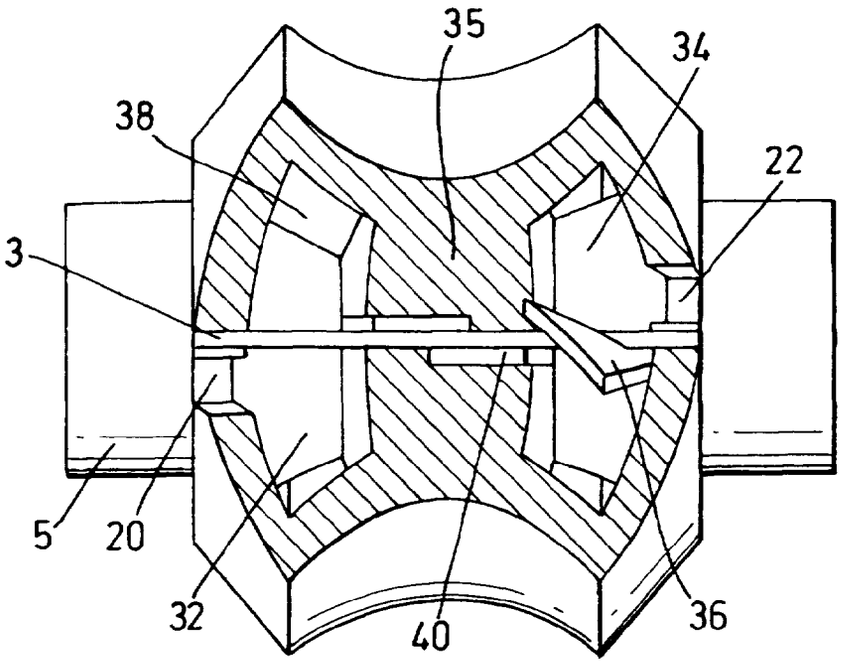

Fig. 9

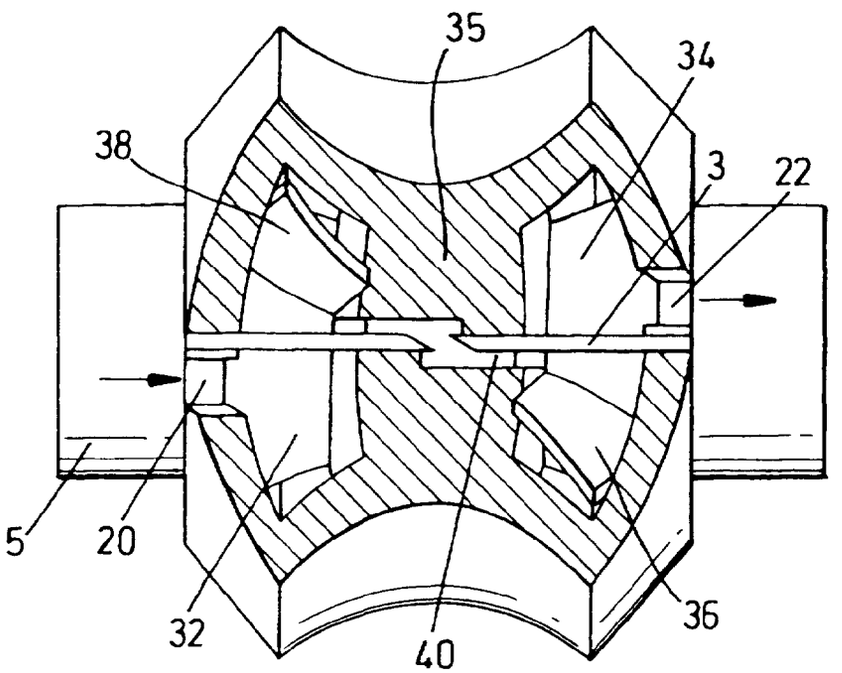

Fig. 10

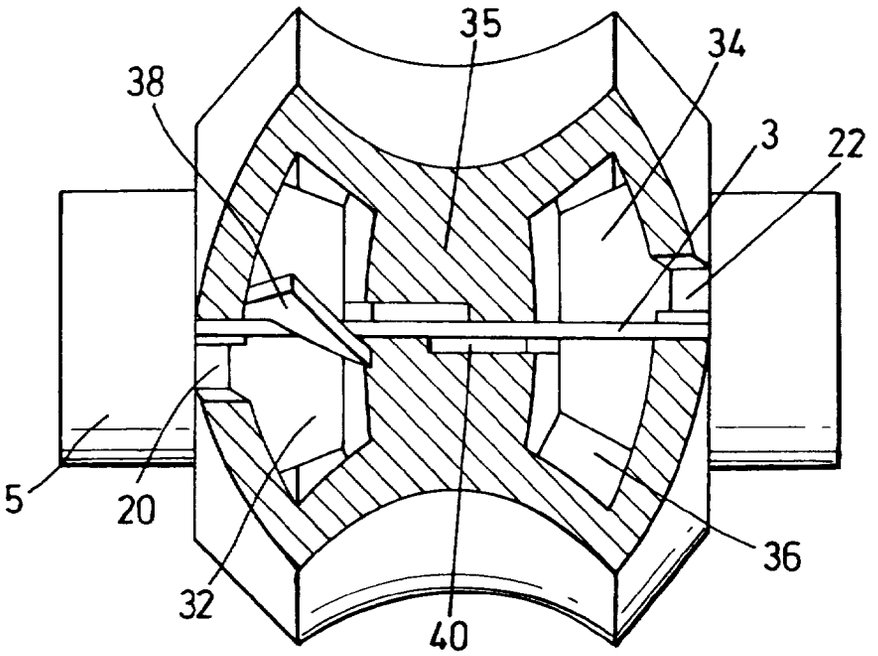

Fig. 11

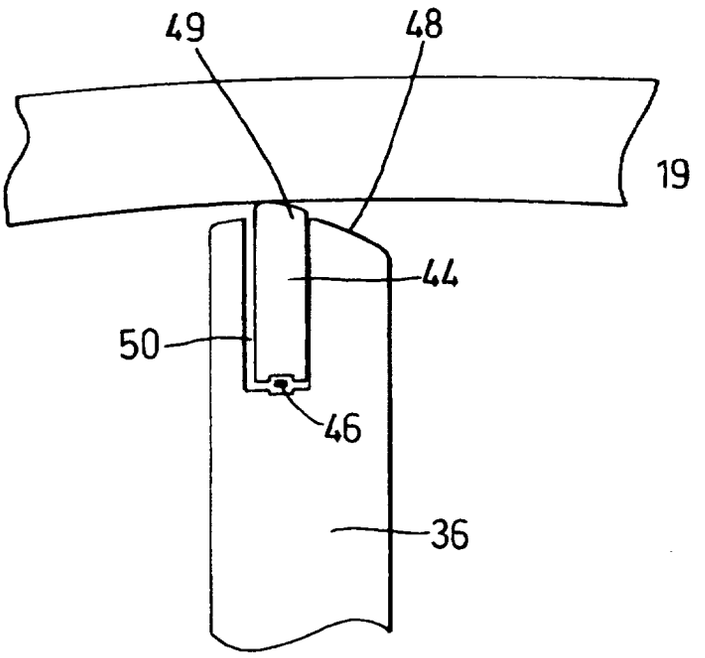

Fig. 12

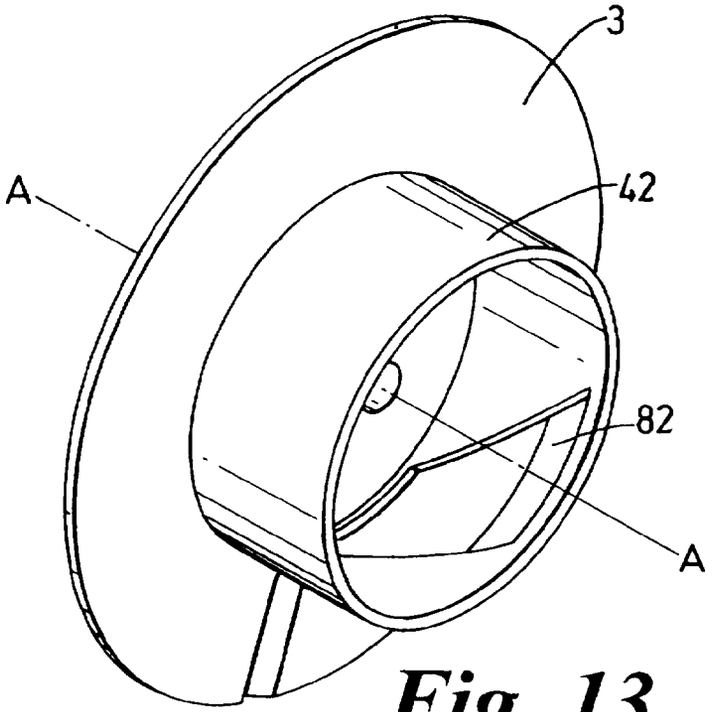

Fig. 13

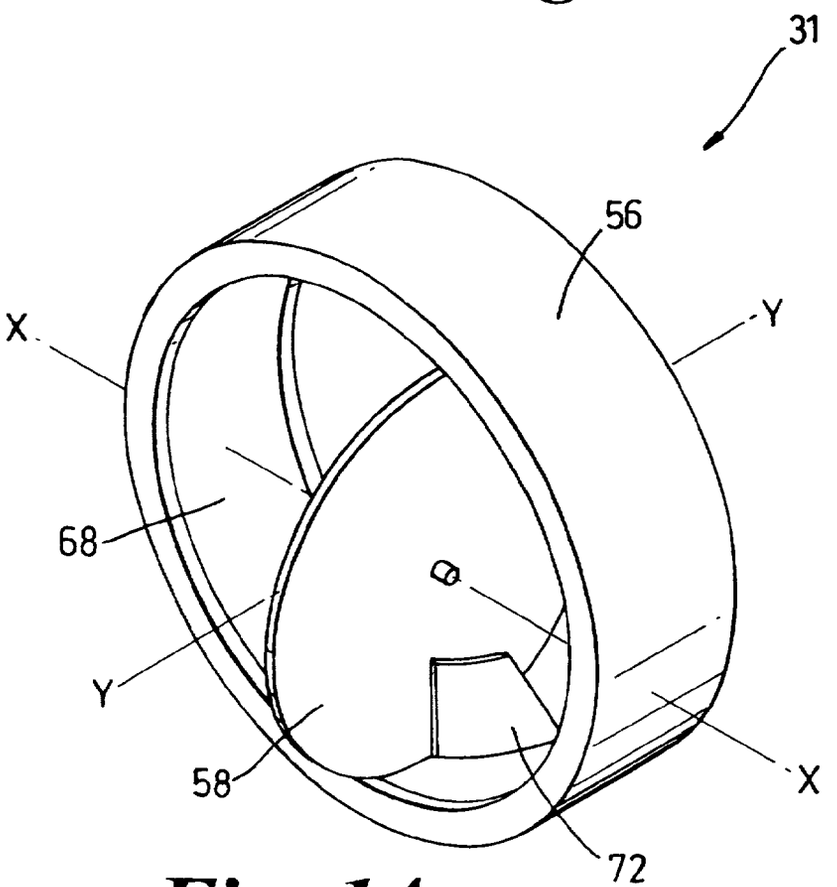

Fig. 14

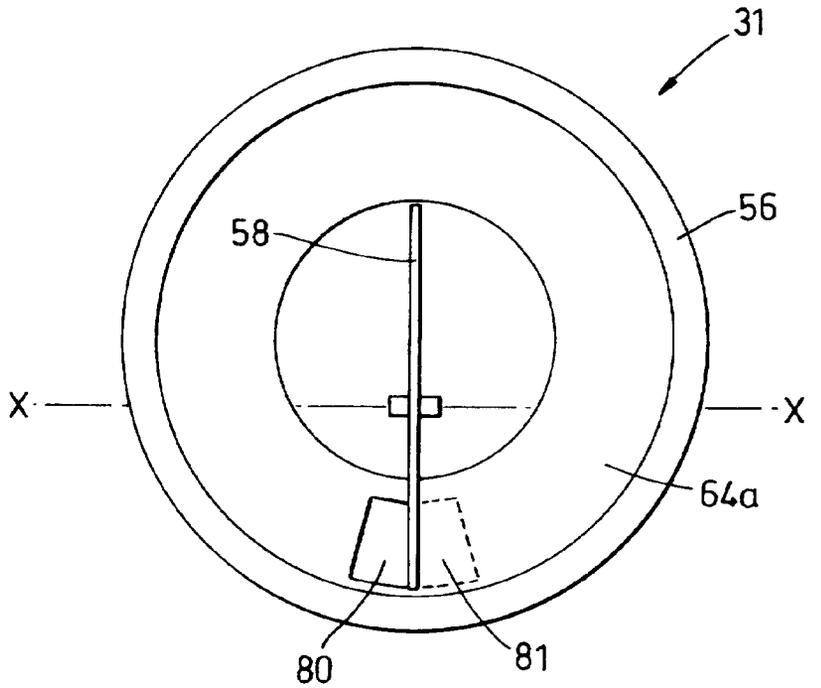

Fig. 15

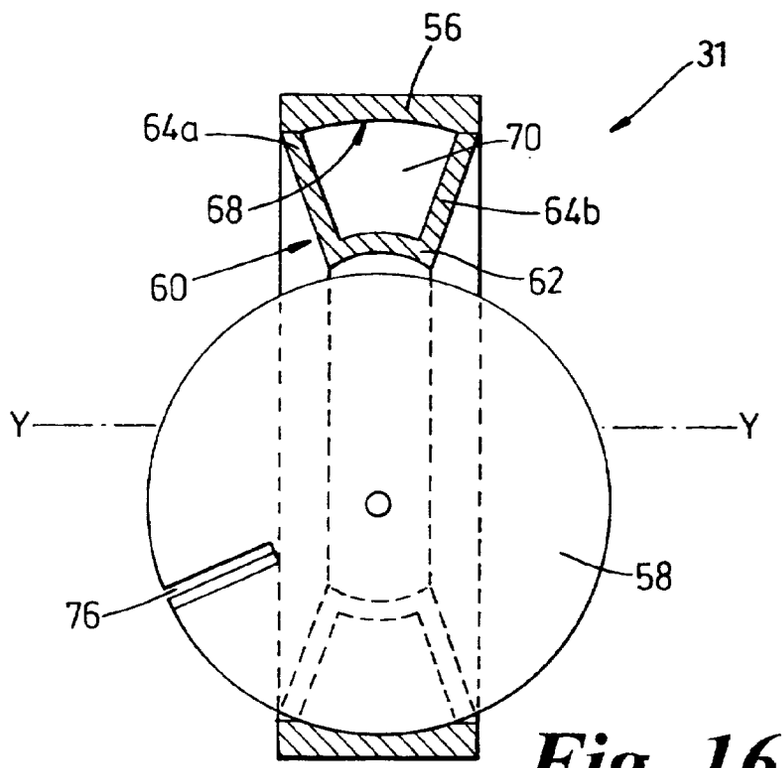

Fig. 16

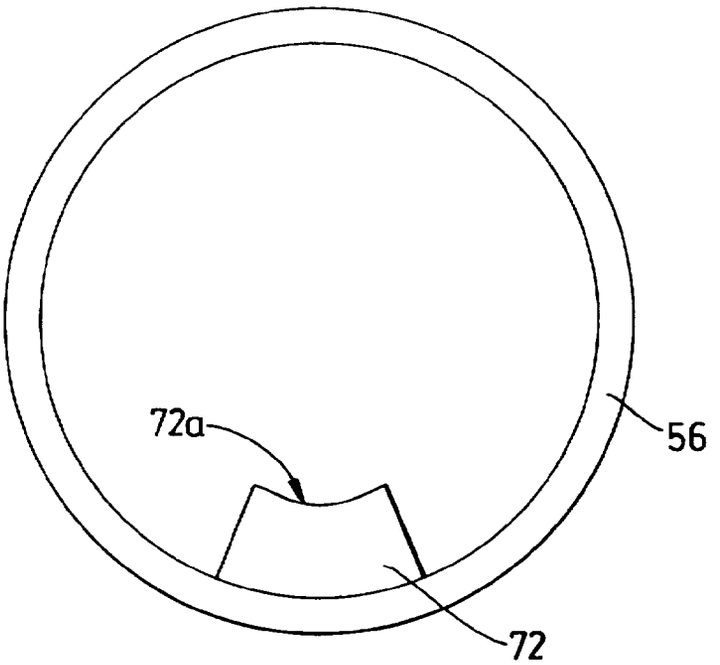

Fig. 17

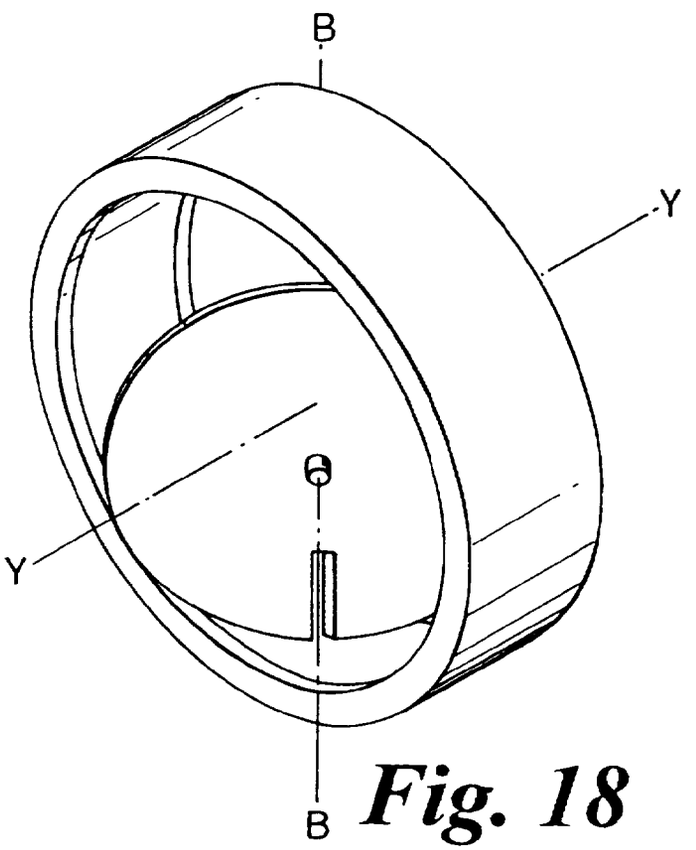

Fig. 18

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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 0703

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE 195 09 913 A (WALTER JUERGEN) 19 September 1996 * claim 1; figures 1,2 *	1-6,14	F01C3/02
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			F01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	4 May 1999	Dimitroulas, P

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