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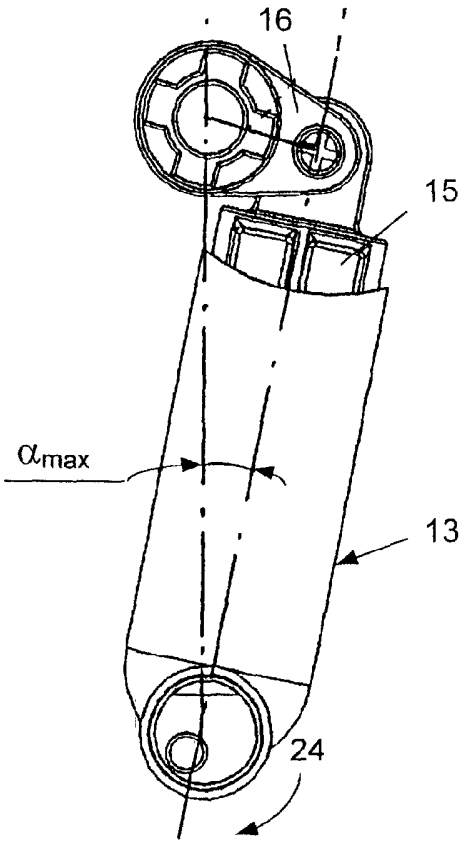

(57) Abstract: The subject of the invention is an engine that is actuated by a fluid under pressure, preferably water, and comprises one or more oscillating, connecting-rod assemblies (13), including a cylinder (14) and a piston (15), and at least one or more cranks (16) driven by the connecting-rod assemblies (13). For each connecting-rod assembly (13), a preferably stationary valve (20) controls the feed and the discharge of the pressure fluid to and from it, synchronically with the angular position of the corresponding crank (10), and acts as the pivot about which connecting-rod assembly (13) oscillates. The engine can be applied for producing mechanical work in any apparatus, for example in sprinklers, concrete mixers, apparatus for winding cables or garden hose reels, and so on, or for the production of electrical energy. The actuating fluid can be used, after its discharge from the engine, for purposes for which high pressure is not required.

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METHOD AND APPARATUS FOR THE PRODUCTION OF MECHANICAL POWER FROM HYDRAULIC ENERGY

Field of the Invention

This invention relates to the production of mechanical power from hydraulic energy; in particular, it relates to an engine that is actuated by a fluid, preferably water, or gas, preferably air, under pressure. It further relates to a mechanism for actuating a shaft by means of a pressure fluid which comprises an oscillating, connecting-rod assembly and at least a crank driven by said connecting-rod assembly, as hereinafter defined. The invention further relates to the use of such a mechanism for actuating various mechanical apparatus. The invention further relates to a valve for controlling the feed and the discharge of pressure fluid to and from a connecting-rod assembly, synchronically with the angular position of the crank driven by said assembly.

Background of the Invention

Fluid-actuated mechanisms for carrying out mechanical work are known in the art and have been described in a number of patents. USP 2,518,990 describes a fluid-actuated hose reel in a lawn sprinkler. USP 2,989,605 describes a water-powered retractable shower head. More recently, USP 5,741,188 discloses a ride-on toy or a garden tool which includes a stationary element, a movable element connected thereto, water pressure operating means for moving the movable element with respect to the stationary element, a water inlet and a water outlet, and a valve for controlling the flow of the water through the device.

European Application 136414 A2 discloses a water flow operated device for winding and/or unwinding a layer of flexible material, which comprises a

stationary element, a spool having a central axis, said spool being rotatable about a central axis when engaged with the stationary element; and a water flow-operated mechanism engaged by said stationary element for controllably rotating said spool.

The provision of a generally or widely applicable motor operated by a fluid under pressure (herein "a pressure fluid" or "an actuating fluid"), in particular water, that is effective, simple in construction and economical, is extremely desirable. It is therefore a purpose of this invention to provide such a motor.

It is another purpose of this invention to provide such a motor which is self-controlled, in the sense that it contains all the components necessary for assuring its operation without the provision of separate, central control mechanisms.

It is a further purpose of this invention to provide such a motor which comprises a shaft, or a plurality of shafts, or a crankshaft, driven into rotation by one or a plurality of oscillating-rod-crank couplings, which incorporates a control mechanism for actuating the oscillating motion of the rod in synchronism with the rotary impulses required by the rotating elements.

It is a still further purpose of this invention to provide a fluid-actuated motor, in particular a water motor, for use in a variety of apparatus requiring mechanical energy for various purposes.

It is a still further purpose of this invention to provide a mechanism which is actuated by a pressure fluid, in particular water, which imparts

rotational impulses to a crank or a crankshaft at a plurality of angular positions of said crank or crankshaft.

It is a still further purpose of the invention to provide means for feeding pressure fluid, in particular, water, to a cylinder, to actuate a piston and synchronize its alternating motion to the angular motion of a rotating element, that is simple, self-contained and economical to build.

Other purposes and advantages of the invention will appear as the description proceeds.

Summary of the Invention

In a first aspect thereof, the invention provides a mechanism for actuating a rotatable shaft from actuating or pressure fluid, which comprises a crank connected to the shaft for mutually dependent swinging motion of the crank and rotation of the shaft; an angularly oscillating connecting-rod assembly comprising a cylinder and a piston, said piston being pivotally connected to said crank for mutually dependent oscillation of said assembly and swinging motion of said crank; and a valve, preferably stationary valve, for permitting feed of actuating fluid to said cylinder and permitting discharge of said fluid from said cylinder, depending on the angular position of said connecting-rod assembly.

It is preferred that the stationary valve should acts as the pivot about which the connecting-rod assembly angularly oscillates. However, it would be possible to provide a separate pivot and a separate stationary valve, as long as the valve permitted feed of actuating fluid to the connecting-rod assembly cylinder and discharge of the fluid from said cylinder, depending on the angular position of the connecting-rod assembly. This could be

achieved, e.g., by placing a valve at an intermediate position of the connecting-rod assembly cylinder, viz. closer to the crank than the pivot; or by providing the connecting-rod assembly cylinder with an extension and placing the valve beyond the pivot, in such a position as to cooperate with that extension. Other solutions could be devised by expert persons, by the application of mechanical and kinematic know-how, and all such solutions are embodiments of the invention. The invention therefore comprises any mechanical solutions whereby the operation of the valve is synchronized with the oscillating motion of the connecting-rod assembly.

Preferably, the stationary valve and the connecting-rod assembly are pivotally connected through respective pivot surfaces, said pivot surfaces being provided with apertures for the passage of actuating fluid. Said apertures become more or less juxtaposed depending on the angular position of said connecting-rod assembly, whereby said feed and discharge of said fluid to and from the connecting-rod assembly are automatically synchronized with the crank swinging motion.

The mechanism of the invention acts in combination with a source of actuating fluid under pressure and with a discharge, communicating with the stationary valve through fluid channels.

The actuating fluid is preferably water, but it may be another liquid, or may be gaseous - gas or vapor - particularly steam.

Traditional connecting-rod-crank mechanisms must be provided with control means for admitting pressure fluid, in many cases compressed air or steam, to the cylinder and discharging said pressure fluid from it. If more than one connecting-rod were provided, a plurality of control means

would have to be provided and synchronized, as required, to impart a rotational impulse to the crank at appropriate stages of its swinging motion. In the mechanism of the invention, the admission and discharge of the pressure fluid are controlled in each connecting-rod assembly by a valve, preferably a stationary valve which also operates as a pivot, and therefore are automatically synchronized with the stages of the crank rotation.

In more detail, the preferred form of the mechanism of the invention comprises a crank rotatably connected to a shaft either because it is solid with it, or is keyed to it, or is a part of a crankshaft. The connecting-rod assembly comprises a cylinder, which has a pivotal connection to the crank, preferably wherein the cylinder is provided with a pivot seat, such as an annular one, while the crank is provided with a pivot pin or is part of a crankshaft which engages the pivot seat, the opposite being equally possible. The cylinder is provided with a pivot seat or surface, preferably being cylindrical or a segment of a cylinder, which has an aperture providing a communication with the inside of the cylinder. The aperture may be a single, preferably an elongated, one, or may be constituted by a plurality of openings, e.g., circular openings arranged one after the other along a line, in which cases it will be called herein "composite aperture". In a preferred embodiment of the invention the aperture, whether single or composite, is arranged on a transverse axial line or is symmetric with respect of said line. "Transverse axial line" means herein the intersection of the pivot seat of the connecting-rod assembly cylinder with the plane of symmetry of the cylinder that passes through the axis of symmetry of the pivot pin of the crank and the pivot seat of the connecting-rod assembly. It is preferred that said aperture of said pivot seat, whether single or composite, be symmetric to said transverse axial line, but it is possible

that it be not so symmetric but arranged on a line that is symmetric with respect to said transverse axial line, as will be better explained later on.

The mechanism, in its preferred form, further comprises a stationary valve, the body of which is partly hollow, and which comprises an outer pivot surface slidingly engaged by the pivot seat of the connecting-rod assembly cylinder. Said pivot surface is a part of a cylinder or consists of parts of a cylinder, while the remaining part of the outer surface of the valve body may have a different shape. The valve body has a first and a second aperture communicating with its inner hollow, and which are preferably longitudinal, viz. symmetric with respect to an axial plane of the valve body, but in general are so shaped that they may be juxtaposed to said aperture of the pivot seat of the connecting-rod assembly cylinder. Each of the valve body apertures communicates, through inner channels of the valve body, with a respective port. One of the two ports is in communication with a source of pressure fluid and the other one with or a fluid discharge respectively, and thus communication is established between the respective apertures of the valve body and said pressure fluid source or fluid discharge, respectively. In some applications, as will be explained hereinafter, the functions of the two ports are periodically switched, viz. each communicates alternatively with said source of pressure fluid and with said fluid discharge. In other applications, one of the ports communicates always with said source of pressure fluid and the other communicates always with said fluid discharge.

As the connecting-rod assembly oscillates, its angular position shifts from one extreme end to another extreme end. The first and second apertures of the valve body are angularly spaced by the same angle as the two extreme positions of the connecting-rod assembly. At a given angular position of

said assembly, generally at the center or near the center of its oscillation, the aperture (whether single or composite, viz. consisting of several openings close to one another) of said pivot seat or surface of the cylinder of the connecting-rod assembly is juxtaposed to an unapertured portion of the valve body. As said assembly oscillates, said aperture of said pivot seat or surface becomes gradually juxtaposed to one (first juxtaposition) or to the other (second juxtaposition) of the apertures of the valve body. In the first juxtaposition, the inside of the cylinder is placed in gradually increasing communication with a source of pressure fluid which is fed to the inside of the cylinder, and therefore the piston is subjected to an axial force which it transmits to the crank or crankshaft as a rotational impulse. In the second juxtaposition, the inside of the cylinder is placed in gradually increasing communication with the discharge, there is gradually decreasing resistance to the motion of the piston, and the fluid is gradually discharged from the cylinder. At one of the extremes of the oscillation of the connecting-rod assembly, said first juxtaposition is complete or at least at a maximum, and said piston is subjected to a maximum axial force; at the opposite extreme, and the discharge of the fluid from said cylinder is complete or at least as complete as it will be. Said operative phases will be further described hereinafter, with reference to Fig. 18.

For the sake of clarity, the outwardly or projecting motion of the piston, with respect to the cylinder, from its innermost or most retreated position to its outermost or most extended position, during which it transmits to the crank a rotational impulse, will be called the positive or active stroke, and the inwardly or retreating motion of the piston from said outermost to said innermost position, during which it discharges the fluid from the cylinder, will be called the negative or passive stroke. As will be explained in detail hereafter, the choice of which port communicates with a source of

pressure fluid and which communicates with a discharge depends on the phases of the swinging motion of the crank, and is established so as to impart to the crank a rotational impulse when this is desired and allow it to continue freely in its swinging motion when no further impulse is to be transmitted from the respective connecting-rod. It will be understood that, if the shaft connected to the crank always rotates in the same direction, one port will always be in communication with the source of pressure fluid and the other port will always be in communication with the discharge. However, if the shaft is to rotate alternatively in opposite directions, the ports will periodically switch their aforesaid communications.

In one of the preferred embodiments of the invention, the crank is associated with a plurality of connecting-rod assemblies, which are angularly spaced, preferably by the same angle. Each connecting-rod assembly has an angular position that can be called the "null" or "zero angle position", which is the position at which the axis of the piston of the connecting-rod assembly and the radius of the crank are aligned. Actually, there are two such positions, in one of which the piston is at its greatest retraction, while in the other it is in its greatest extension. When it is said herein that various connecting-rod assemblies are angularly spaced from one another, what is meant is that the null angle positions thereof are angularly spaced from one another. Preferably, the angular spacing is uniform, but this is not necessary and dynamic considerations may suggest a different angular spacing. Since in a preferred embodiment of the invention three connecting-rod assemblies are provided, any two of them are adjacent to one another and are spaced from one another by 120° or by any other chosen angle. The connecting-rod assemblies, however, when a plurality of them is present, need not be at an angle to one another but may be linearly spaced, viz. placed one next to the other in such a way that

the axes of their null angle positions are all coplanar, parallel to one another in the common plane, and displaced from one another perpendicularly to their common direction. In this case, each connecting-rod assembly operates on a different crank and all the cranks are part of a crankshaft. An apparatus in which the connecting-rod assemblies are linearly spaced is also a preferred embodiment.

Another aspect of the invention is the provision of an apparatus for the production of mechanical work from hydraulic energy, which comprises a source of pressure fluid and a mechanism for actuating at least one rotatable shaft from the said pressure fluid, as hereinbefore described.

Preferably, the invention also comprises the use of the mechanism hereinbefore described for producing mechanical work. The mechanism can be applied for producing mechanical work in any apparatus. Among such applications are, for example, sprinklers, mixers, in particular concrete mixers, apparatus for winding cables or garden hose reels, for spreading pool covers, for actuating shading canvases, valve control motors, robots for cleaning swimming pools, ride-on garden toys, cooling fans, rotary watering filters, and the like. The mechanism can also be used for the production of electrical energy, viz. can be coaxial with or otherwise drive an electricity generator. It should be noted that, in some cases of engines according to the invention, the actuating fluid can be used, after its discharge from the engine, for other purposes for which only a low pressure or no pressure at all is required. For instance, if the fluid is water, the discharged water may be used in water sprinklers, drip systems, humidification of cooling fans, supplying water to cement mixers, and the like. Such a further use and the resulting apparatus are also aspects of the invention.

Brief Description of the Drawings

In the drawings:

- Figs. 1A, 1B and 1C illustrate the motion of the connecting-rod assembly during the phase of the rotation of the crank in which a rotational impulse is to be transmitted to said crank, according to an embodiment of the invention;
- Figs, 2A, 2B and 2C illustrate the motion of the connecting-rod assembly during the phase of the rotation of the crank in which no impulse is to be transmitted to said crank, according to the embodiment of Figs. 1;
- Fig. 3 is a schematic cross-section of the connecting-rod assembly and the valve, axial with respect to the assembly and transverse with respect to the valve, according to an embodiment of the invention;
- Fig. 4 illustrates in exploded perspective the relationship between the connecting-rod assembly and the valve, according to an embodiment of the invention;
- Fig. 5 illustrates in perspective view the valve of Fig. 4, which relates to a motor that rotates in one direction;
- Figs. 6 and 7 illustrate an embodiment of the invention in which the connecting-rod assemblies and the valves are spaced linearly;
- Figs. 8 and 9 illustrate an embodiment of the invention which comprises three angularly spaced connecting-rod assemblies;
- Fig. 10 illustrates in perspective view the use of the apparatus of Figs. 8 and 9 in a mixer;
- Figs. 11 and 12 are schematic cross-sections of pistons of the connecting-rod assembly, according to two embodiments of the invention;
- Fig. 13 illustrates in perspective view a variant of the valve of Fig. 5, which relates to a motor that rotates in two directions;

- Fig. 14 is a schematic cross-section analogous to Fig. 3, but embodying the valve of Fig. 13;
- Fig. 15 is an enlarged cross-section of the valve of Fig. 14;
- Fig. 16 illustrates in schematic perspective view a use of the embodiment of Figs. 6 and 7 in a hose reel;
- Fig. 17 illustrates in schematic perspective view a use of the embodiment of Figs. 8 and 9 in a fan;
- Fig. 18 is an enlarged cross-section of the valve body, illustrating the phases of its operation; and
- Fig. 19 is a cross-sectional detail of the valve body, illustrating a device for preventing leakage of fluid under pressure.

Detailed Description of Preferred Embodiments

The operation of a connecting-rod assembly according to an embodiment of the invention will be understood with reference to Figs. 1A, B, C and Fig. 2 A, B, C. Figs. 1 illustrate the motion of the connecting-rod assembly during the phase of the rotation of the crank in which a rotational impulse is to be transmitted to said crank. During said phase, the piston of said assembly moves in its positive or active stroke. Figs. 2 illustrate the motion of the connecting-rod assembly during the phase of the rotation of the crank in which no impulse is to be transmitted to said crank. During said phase, the piston of said assembly moves in its negative or inactive stroke.

As seen in Fig. 1, numeral 10 indicates a shaft, which rotates, together with a crank 16, solid with it or keyed to it, about an axis 11 in the direction indicated by the arrow 12. 13 generally indicates the connecting-rod assembly. 14 is the cylinder of said assembly and 15 is the piston.

Piston 15 is connected to crank 16 by a pivotal connection generally indicated at 17.

The connecting-rod assembly 13 is pivoted to a stationary valve 20, only one end of which is visible in Fig. 1, showing port 21 which communicates either with the source of pressure fluid or with the discharge. Another port communicates with the discharge or with a source of pressure fluid, respectively, and can be provided on the opposite end (not visible in the drawing) of the valve.

In Fig. 1A the connecting-rod assembly 13 is in its first null angle position, which will be called herein the "retracted" null angle position, or briefly, "the retracted position". Line 22, which is the trace on the drawing of the plane of symmetry of cylinder 14 and piston 15, passes through the axis of the shaft 10. The valve axis, the crank axis and the shaft axis are on one plane. Piston 15 is retracted inside cylinder 14 as far as it will go. As crank 16 rotates as shown by arrow 12, connecting-rod assembly 13 rotates in an opposite direction, as shown by arrow 24, about valve 20, which acts as a stationary pivot.

In the position of Fig. 1B, the connecting-rod assembly has rotated by an angle α, which is the maximum one. Piston 15 has accomplished part of its active stroke.

As the motion of the mechanism continues, as shown in Fig. 1C, it reaches its second null angle position, which will be called herein the "extended" null angle position, or briefly, "the extended position". The center of valve 20, the axis of cylinder 14, the axes of piston 15, of shaft 10 and of pivot connection 17 are all on the same plane, the trace of which on the drawing

is indicated at 25. The active or active stroke of piston 15 has come to an end.

Fig. 2 shows the second phase of the operation of the connecting-rod assembly. At the starting point, in Fig. 2A, it is in its extended null angle position, as in Fig. 1C. In Fig. 2B, it is in a position symmetric to that of Fig. 1B. The piston 15 has reentered partly into cylinder 14, and they both have reached the outermost angular deviation of the connecting-rod assembly from its null angle positions, indicated by an angle α symmetric to that of Fig. 1B.

As the motion of the mechanism continues, piston 15 accomplishes its negative or passive stroke and retracts into cylinder 14 as far as it can go. At Fig. 2C, the apparatus has reached the same position as in Fig. 1A, viz. its retracted null angle position.

It is apparent therefore that pressure fluid, particularly water, must be introduced into cylinder 14 while it swings from the position of Fig. 1A to that of Fig. 1C, and must be discharged while it swings from the position of Fig. 2A (the same as that of Fig. 1C) to that of Fig. 2C (the same as that of Fig. 1A).

Fig. 3 generally illustrates, in a cross-section that is axial with respect to connecting-rod assembly 13 and the valve 20. The assembly 13 comprises a cylinder 14 and a piston 15, provided with a sealing ring 101 (see also Fig. 11). Numeral 30 indicates a cylindrical surface, spanning an arc of about 240°, which serves as a pivot seat for a pivot pin driven by the crank 16. This embodiment is desirable when the piston is made of plastic matter, because then the pivotal connection between the piston 15 and the crank 16 may be obtained by snapping surface 30 over the pivot pin driven

by the crank 16. In other embodiments, such as that of Fig. 4, the pivot seat is a full ring and must be slid over the pivot pin. The cylinder 14 of the connecting-rod assembly terminates with a transverse cylindrical portion 31. By 'transverse cylindrical portion" is meant herein a portion of a cylinder the axis of which is parallel to the axis about which the connecting-rod assembly oscillates. Within said cylindrical portion 31 is inserted a valve body 32 and said portion 31 is open, at least at one end, to permit the introduction of said valve body. Said cylindrical portion 31 has an aperture 36, through which fluid may be fed into the cylinder 14 or discharged therefrom. Said aperture may be single and preferably symmetric about a central transverse line which is the intersection of said cylindrical portion with a plane of symmetry of the connecting-rod assembly passing through the axis about which the connecting-rod assembly oscillates and the axis of the crank pin. Said aperture may be composite, viz. consisting of a plurality of openings close to one another and centered on said central transverse line. Optionally, however, though less preferably, it could be arranged about a line slanted with respect to said central transverse line, or about a curved line, said slanted or curved line being symmetric with respect to said central transverse line.

In Fig. 3, the cylinder 14 of the connecting-rod assembly, is shown in a position in which aperture 36 of cylindrical sleeve 31 overlaps partially aperture 38 of the valve body and partially a rib 35 of the valve body 32. In either of the null angle positions (only one of them being marked in the drawing) the aperture 36 would be placed on a line 37 which coincides with line 22 of Fig. 1A, and would be stoppered (closed) by said rib 35. As the connecting-rod assembly swings one way or the other from a null angle position, the aperture 36 comes into gradually increasing juxtaposition to one or the other of two apertures 38 and 39 of the valve body. The phases

of said juxtaposition are illustrated in the enlarged cross-section of the valve body 32 in Fig. 18, wherein the cylindrical portion 31 is in its central position and the aperture 36 is closed by rib 35 of valve body 32 (see Fig. 3). As said cylindrical portion 32 swings clockwise (as seen in Fig. 18) in the oscillation of the connecting-rod assembly, aperture 36 gradually overlaps aperture 38 of the valve body, until, after clockwise rotation by an angle α, point A coincides with point C, or is as close as possible to it, and the overlapping of aperture 36 with aperture 38 reaches a maximum. If said cylindrical portion 32 swings counterclockwise (as seen in Fig. 18), said overlapping decreases until it is annulled in the central position shown in the figure, and as the counterclockwise rotation continues, aperture 36 gradually overlaps aperture 39 of the valve body, until, after counterclockwise rotation by an angle α, point D coincides with point F, or is as close as possible to it, and the overlapping of aperture 36 with aperture 39 reaches a maximum.

Apertures 38 and 39 are in communication with inner channels 33 and 34 which lead to opening 21, or to an equivalent opening, not shown in the drawing, and located on the opposite side of the valve. One of these ports is in communication with a source of pressure fluid, while the other port is in communication with the discharge; but, as has been said hereinbefore, in some embodiments said communications may be periodically switched. Switching of communications causes the inversion of the motor direction of rotation. Aperture 36 of the connecting-rod cylinder becomes gradually juxtaposed to one of openings 38 and 39, as has been explained, during the swinging of the connecting-rod assembly between the two maximum angular deviations shown in Fig. 1B and Fig. 2B, and becomes juxtaposed completely or to the maximum degree at either of the said two extreme angular positions which the cylinder 14 may assume. It is seen therefore

that when the mechanism swings towards the position of Fig. 1B, pressure fluid will be gradually admitted through one of the apertures 38 or 39, while, when the mechanism swings towards the position of Fig. 2B, pressure fluid will be gradually discharged through the other of said apertures.

Fig. 4 is a further illustration in exploded perspective of the relationship between the connecting-rod assembly and the valve. Piston 15 is seen as outside of cylinder 14. In this and in other figures, the piston is seen as not as solid as in Fig. 3, but as formed by a number of longitudinal ribs 40, which is desirable for the purpose of lightening the apparatus, particularly in plastic pieces in which thin flat portions are preferred. 42 is the pivot seat, shown herein as ring-shaped. Elastomeric seals, such as seal ring 44, are provided to assure that the fluid should not pass around or through the piston from the bottom of cylinder 14 through which it is admitted or discharged. Figs. 11 and 12 schematically show in cross-section two ways for producing a seal in plastic pistons. The piston body is shown as full in these figures, but this representation is only schematic and the piston will have any desired cross-section. In Fig. 11, the piston generally indicated at 100, is provided with an annular rubber seal 101. In Fig. 12, the piston 102 has a flexible edge 103, which serves as a seal, and is an integral part of the piston. The valve body, generally indicated in Fig. 4 at 45, is illustrated as being outside the cylindrical seat 31, in which it is received during the operation of the device.

The valve body 45 is better illustrated in Fig. 5. It is shown herein as partly cylindrical in order to provide smooth motion of the sleeve 31 about the body 45 of the valve. 109 and 109' are two seal rings. If the valve body is precise in its shape and dimensions, as it may be if it is made of metal, it will closely fit sleeve 31 and there will be no fluid leakages. However, if it

is not precise in its shape, particularly when made of plastic, additional means must be provided to prevent leakage at least about the aperture 38 (or 39) through which passes actuating fluid under pressure, although leakage may not be a serious danger when the fluid flows to the discharge. A means for this purpose is illustrated in Figs. 5 and 19. Fig. 19 is an enlarged cross-section of a single aperture 38' of the valve body, the rest of said valve body being omitted. The cylindrical portion 31 of the connecting-rod assembly cylinder and the valve body 45 do not match precisely and a gap 40 exists between them. The aperture 38' through which passes actuating fluid under pressure, indicated at 104, has an edge 105 spaced from the edge 106 of a broader opening of the valve body (see Fig. 5). An elastomeric sleeve 107 fits tightly over edge 105. A rigid cap 108, e.g. of plastic, having a very thin radial wall 108', fits tightly over elastomeric sleeve 107, but can slide over edge 106. It is provided with an aperture, indicated at 38' because it has the function of the previously described aperture 38 (or 39). The elastomeric sleeve 107 pushes the rigid cap 108 outwardly until the radial wall 108' of the cap is flush with the valve body surface. Sleeve 107, therefore, functions as a spring forcing cap 108 outwardly and as a seal between the cap and the valve body, while the radial wall 108' of the cap functions as a diaphragm urged by the fluid pressure against the inner surface of the cylindrical part 31, whereby to improve sealing.

If the shaft driven by the mechanism always rotates in the same direction, fluid and only one seal is required. If the shaft driven by the mechanism alternatively rotates in opposite directions, both valve body ports alternatively communicate with the source of pressure fluid and both must be provided with a seal-cap unit as hereinbefore described. This is illustrated in the exploded perspective of Fig. 13, in the cross-section of

Fig. 14, and in the enlarged partial cross-section of Fig. 15. In Fig. 13, the valve body 45 is provided with two ports 21 and 21' for communication with a fluid source and with a discharge respectively. Two elastomeric seal rings 109 and 109' are mounted on said body. Two openings 110 and 110' of the valve body accommodate two apertures 38 and 39. For aperture 38, are provided elastomeric sleeve 107 and rigid cap 108, having the functions described in connection with Fig. 5. Similar elastomeric sleeve 111 and rigid cap 112 are provided to carry out the same functions for aperture 39. Opening 110 of the valve body can be broad enough to accommodate two apertures 38 and 39. In such configuration, elastomeric sleeves 107 and 111, and rigid caps 108 and 112, could be connected to form a single elastomeric sleeve and/or a single rigid cap. Fig. 14 is an axial cross-section of the connecting rod assembly and a transverse cross-section of the valve. The connecting-rod assembly 13 is the same as in Fig. 11 but the piston 100 is provided with an elastomeric seal 101, as in Fig. 11. The valve body 45 is better seen in Fig. 15, which is an enlarged cross-section thereof, taken across apertures 38 and 39. 113 and 114 are two channels through which said apertures communicate with port 21 and a corresponding port on the other side of the valve body. The two elastomeric sleeves are seen at 107 and 111 and the two rigid caps at 108 and 112.

Figs. 6 and 7 illustrate an embodiment of the invention in which the cranks are part of a crankshaft and the connecting-rod assemblies and the valves are spaced linearly, perpendicularly to their axes in the null angle positions. In Fig. 6, numeral 50 indicates a crankshaft which comprises three cranks 51, 52 and 52'. Corresponding to each of said cranks, the apparatus comprises three connecting-rod assemblies, which comprise pistons 53, 54 and 55, and cylinders 56, 57 and 58. Said assemblies are similar to those of the embodiment previously described. Valves 60, 61 and

62, similar to those hereinbefore described, serve as pivots of the connecting-rod assemblies, being inserted respectively into sleeves 63, 64 and 65. Valves 60, 61 and 62 can be designed as one unit. Numeral 66 indicates a cover element overlapping the apparatus and 67 is a plate attached to one end of cover 66, provided with a projection that serves as a support to engage a stationary frame. 68 is a shaped projection for engaging the crankshaft 50 to any chosen driven apparatus.

Fig. 7 shows in perspective view the assembly of the crankshaft, the connecting-rod assemblies with their terminal sleeves and the valves, not visible because enclosed in the terminal sleeves. This figure also shows at 70, 71 and 72 the pivotal connections between the pistons and the crankshaft. In Fig. 7, the device is shown in different angular positions of the three connecting-rod assemblies. Piston 53 is approximately at the end of its positive stroke and piston 72 is at or near the end of its negative stroke.

Figs. 8 and 9 illustrate in perspective view an embodiment of the device which comprises the three connecting-rod assemblies 80, 81 and 82. They comprise three cylinders 83, 84 and 85 respectively and pistons 86, 87 and 88 respectively. The crank which they drive is identified by numeral 89 and is solid with or keyed to shaft 92. 91 indicates a supporting plate. In Fig. 9 the device is shown in exploded perspective view, in which the crankshaft 90 is clearly visible. The three cylinders 83, 84 and 85 of the connecting-rod assemblies are provided with transverse sleeves 93, 94 and 95, respectively for housing valves 96, 97 and 98 respectively. The valves are supported on a trilateral support 99 attached to a support plate 91.

Fig. 10 illustrates in perspective view an embodiment in which the apparatus of Figs. 8 and 9 is used to drive a cement mixer 100. The

cement mixer is supported on a base 101 by means of legs 102, to which the axis of the cement mixer is pivoted. The device according to the invention, such as illustrated in Figs. 8 and 9, is generally indicated at 103 and is supported on a transverse bar 104. The three connecting-rod assemblies are visible and indicated by the said numerals 80, 81 and 82, as in Fig. 9. A handle 105 permits to rotate the mixer manually, as may be required to place it in an angular position for loading or unloading.

Fig. 16 shows in perspective view a mechanism such as that of Figs. 6 and 7, mounted on a garden hose reel with a stationary stand 120. The mechanism is provided with a cover 121, partly broken off to show part of the connecting-rod assemblies. 122 generally indicates the driven reel of the hose reel. In this configuration, the mechanism/motor according to the invention is located inside the reel.

Fig. 17 illustrates in exploded perspective view the use of a mechanism such as that of Figs. 8 and 9 for driving a fan schematically indicated at 126. Mechanism 125 is supported on a stand 127.

While specific embodiments have been shown by way of illustration, it should be understood that the invention can be carried out with many modifications, variations and adaptations, without departing from its spirit or exceeding the scope of the claims.

CLAIMS

1. Mechanism for actuating a rotatable shaft from actuating fluid, which comprises a crank connected to the shaft for mutually dependent swinging motion of the crank and rotation of the shaft; an angularly oscillating connecting-rod assembly comprising a cylinder and a piston, said piston being pivotally connected to said crank for mutually dependent oscillation of said assembly and swinging motion of said crank; and a valve for permitting feed of actuating fluid to said cylinder and permitting discharge of said fluid from said cylinder, depending on the angular position of said connecting-rod assembly.

2. Mechanism according to claim 1, wherein the valve is a stationary valve.

3. Mechanism according to claim 2, wherein the stationary valve acts as the pivot about which connecting-rod assembly angularly oscillates.

4. Mechanism according to claim 3, wherein the stationary valve and the connecting-rod assembly are pivotally connected through respective pivot surfaces, said pivot surfaces being provided with apertures for the passage of actuating fluid, said apertures becoming variably juxtaposed depending on the angular position of said connecting-rod assembly, whereby the feed and discharge of said fluid are automatically synchronized with the crank swinging motion.

5. Mechanism according to claim 1, further comprising a source of actuating fluid under pressure and a discharge, and fluid communication channels from said source and said discharge to the stationary valve.

6. Mechanism according to claim 4, wherein the stationary valve comprises:

a) a valve body having a pivot portion slidingly engaged by said pivot surface of said connecting-rod cylinder,

b) a first aperture on said valve body pivot portion, said first aperture being engageable by said pivot surface of said connecting-rod cylinder,

c) a second aperture on the valve body pivot portion, said second aperture being engageable by said pivot surface of said connecting-rod cylinder,

d) a first port in said valve body, establishing communication between said first aperture on said valve body pivot portion and a source of pressure fluid;

e) a second port in said valve body, establishing communication between said second aperture on the valve body pivot portion and a fluid discharge;

f) said first and second apertures on said valve body pivot portions being angularly spaced and being so positioned that the first aperture becomes juxtaposed to said aperture of the pivot surface of the connecting-rod assembly cylinder when a rotary impulse is to be given to the crank, and the second aperture becomes juxtaposed to said aperture of the pivot surface of the connecting-rod assembly cylinder when the rotary impulse given to the crank is to cease.

7. Mechanism according to claim 6, comprising a plurality of angularly spaced connecting rod assemblies.

8. Mechanism according to claim 7, wherein the axes of the connecting-rod assemblies are spaced from one another by the same angle when said assemblies are in their null positions.

9. Mechanism according to claim 6, comprising a plurality of linearly spaced connecting -rod assemblies.

10. Mechanism according to claim 6, comprising at least three angularly spaced connecting-rod assemblies.

11. Mechanism according to claim 9, wherein the connecting-rod assemblies are pivoted to linearly spaced cranks.

12. Mechanism according to claim 9, comprising a plurality of linearly spaced cranks forming part of a crankshaft.

13. Mechanism according to claim 6, wherein the crank is keyed to the shaft.

14. Mechanism according to claim 6, wherein the crank is solid with the shaft.

15. Mechanism according to claim 1, wherein the fluid is a liquid.

16. Mechanism according to claim 15, wherein the fluid is water.

17. Mechanism according to claim 1, wherein the fluid is gaseous.

18. Mechanism according to claim 17, wherein the fluid is steam.

19. Mechanism according to claim 17, wherein the fluid is compressed air.

20. Mechanism according to claim 6, wherein the aperture of the pivot surface of the connecting-rod assembly cylinder and the first and second apertures of the valve body pivot portion are longitudinal.

21. Mechanism according to claim 6, wherein the aperture of the pivot surface of the connecting-rod assembly cylinder and the first and second apertures of the valve body pivot portion are slanted.

22. Mechanism according to claim 6, wherein the aperture of the pivot surface of the connecting-rod assembly cylinder is constituted by a plurality of separate, adjacent openings.

23. Mechanism according to claim 6, wherein each of the first and second apertures of the valve body pivot portion is connected to one of the ports of the valve body by a hollow passage within the valve body.

24. Mechanism according to claim 6, comprising, for at least one of the apertures of the valve body, an edge defining said aperture, an elastomeric sleeve tightly fitting over said edge, and rigid cap fitting tightly over said elastomeric sleeve, said cap being slidable with respect to said edge, said elastomeric sleeve forming a seal between said cap and said valve body and being so mounted as to urge said cap outwardly and said cap being provided with a thin radial wall capable of becoming deformed towards the pivot surface of the cylinder of the connecting-rod assembly.

25. Apparatus for the production of mechanical work from hydraulic energy, which comprises a source of pressure fluid, a mechanism according to claim 1 for actuating at least one shaft from said pressure fluid, and means for causing said at least one shaft, when thus actuated, to effect mechanical work.

26. Apparatus according to claim 25, wherein the means for causing the at least one shaft to effect mechanical work is chosen from the group consisting of sprinklers, mixers, apparatus for winding cables or garden hose reels, for spreading pool covers, for actuating shading canvases, valve control motors, robots for cleaning swimming pools, ride-on garden toys,

cooling fans, rotary watering filters, and apparatus for the production of electrical energy.

27. Apparatus according to claim 25, wherein the source of pressure fluid is a pipe delivering water under pressure.

28. Apparatus according to claim 25, wherein the source of pressure fluid is a compressor for compressing water.

29. Use of a mechanism according to any one of claims 1 to 24, for driving a shaft by means of a pressure fluid.

30. Use according to claim 29, wherein the pressure fluid is water.

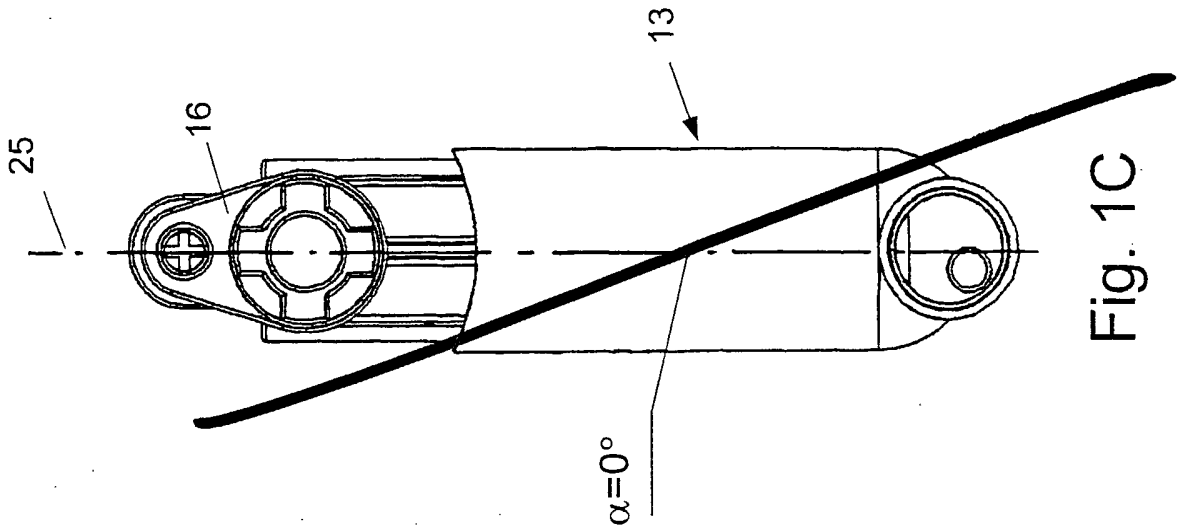

Fig. 1C

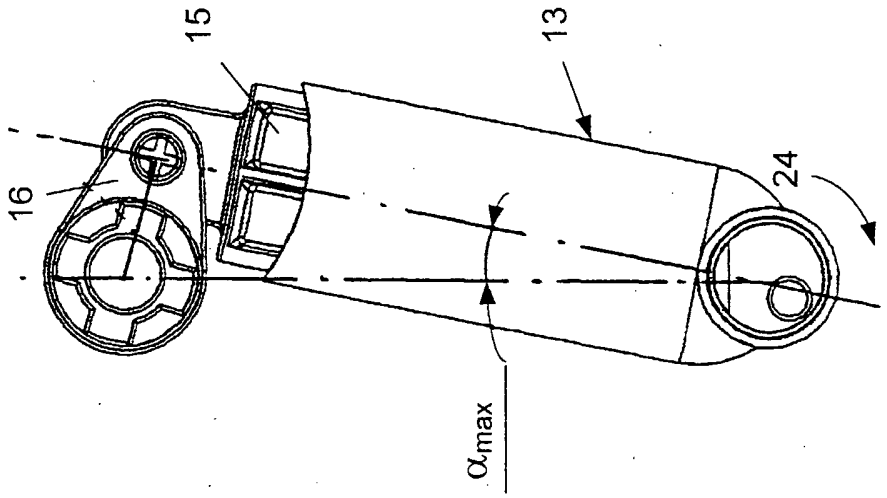

Fig. 1B

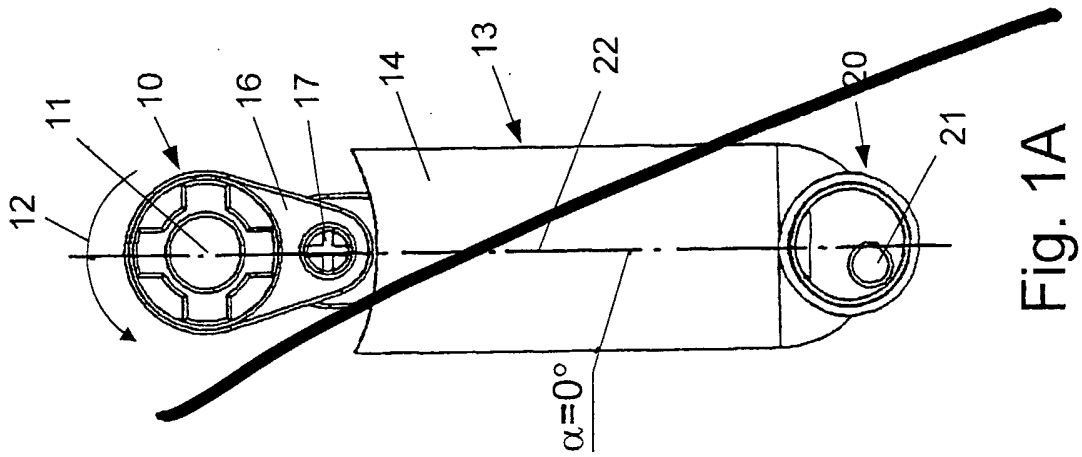

Fig. 1A

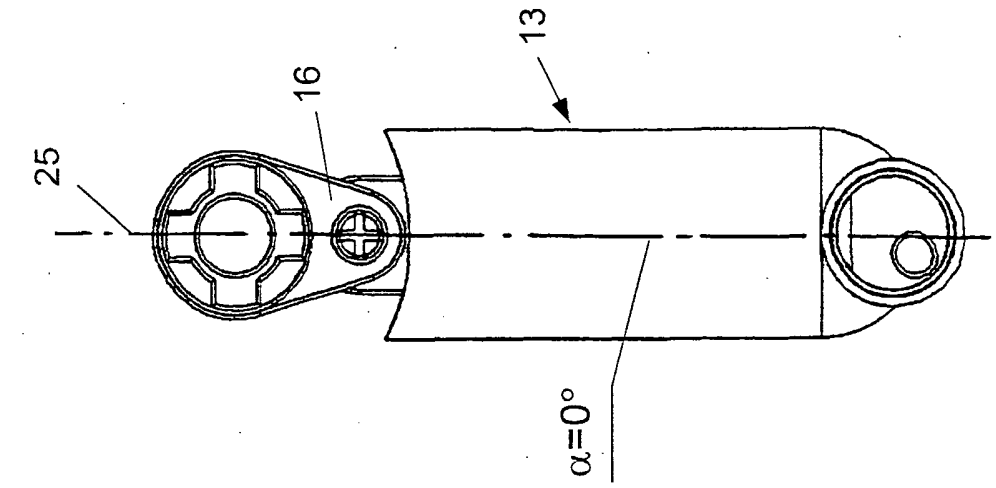

Fig. 2C

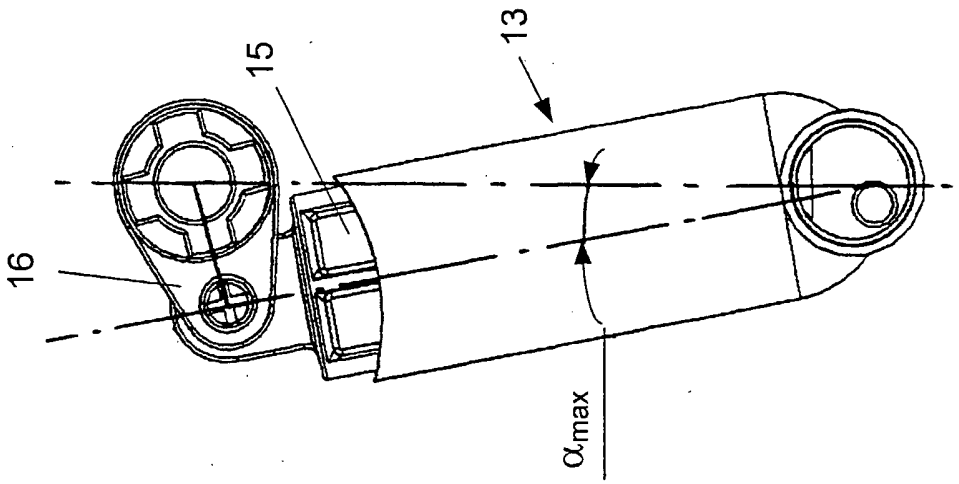

Fig. 2B

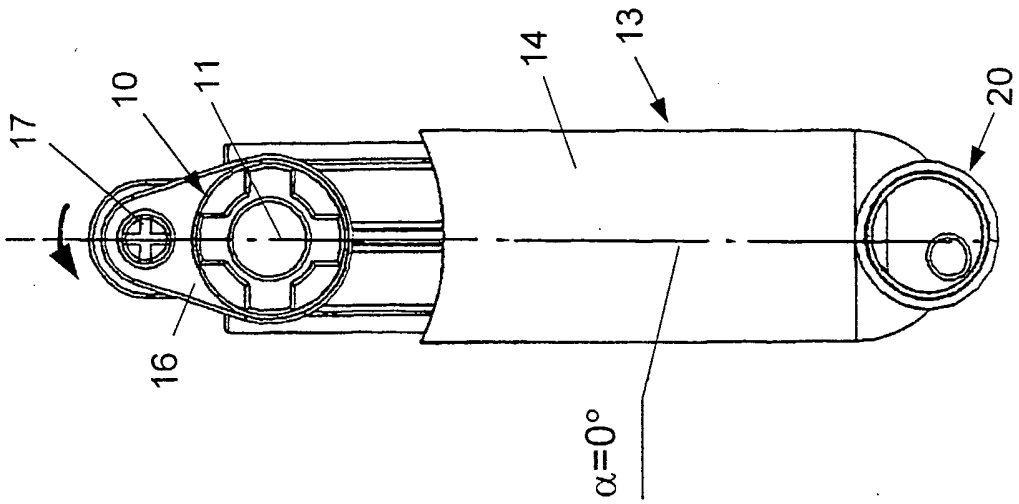

Fig. 2A

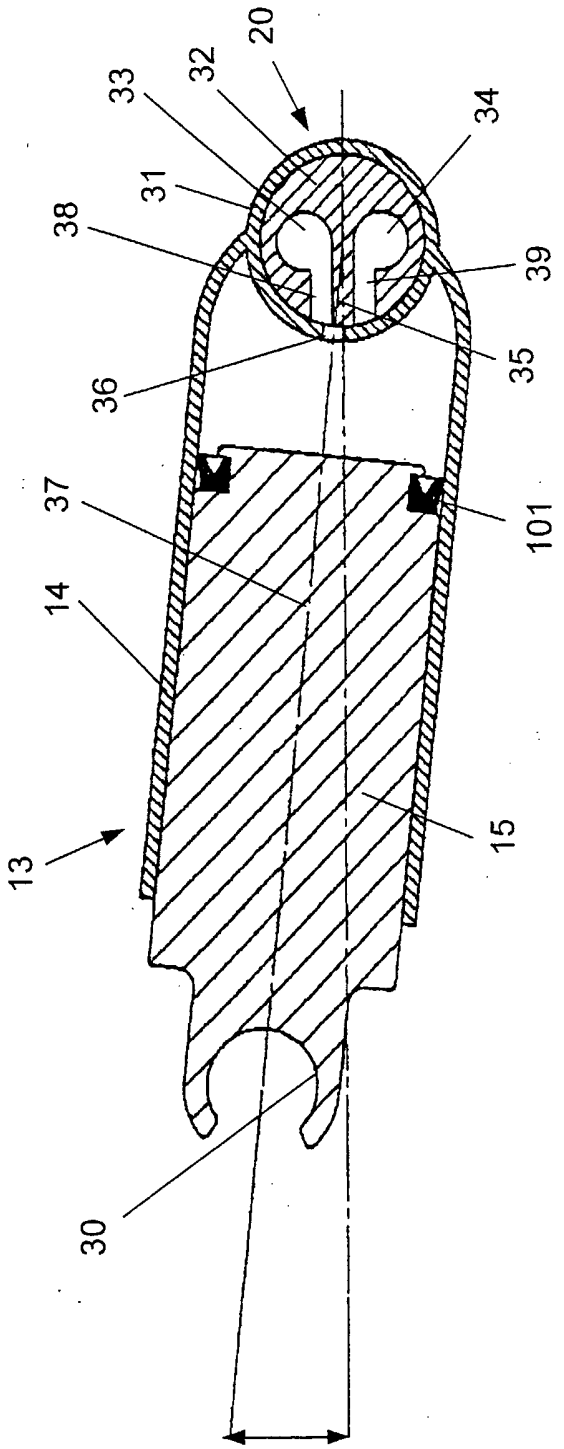

Fig. 3

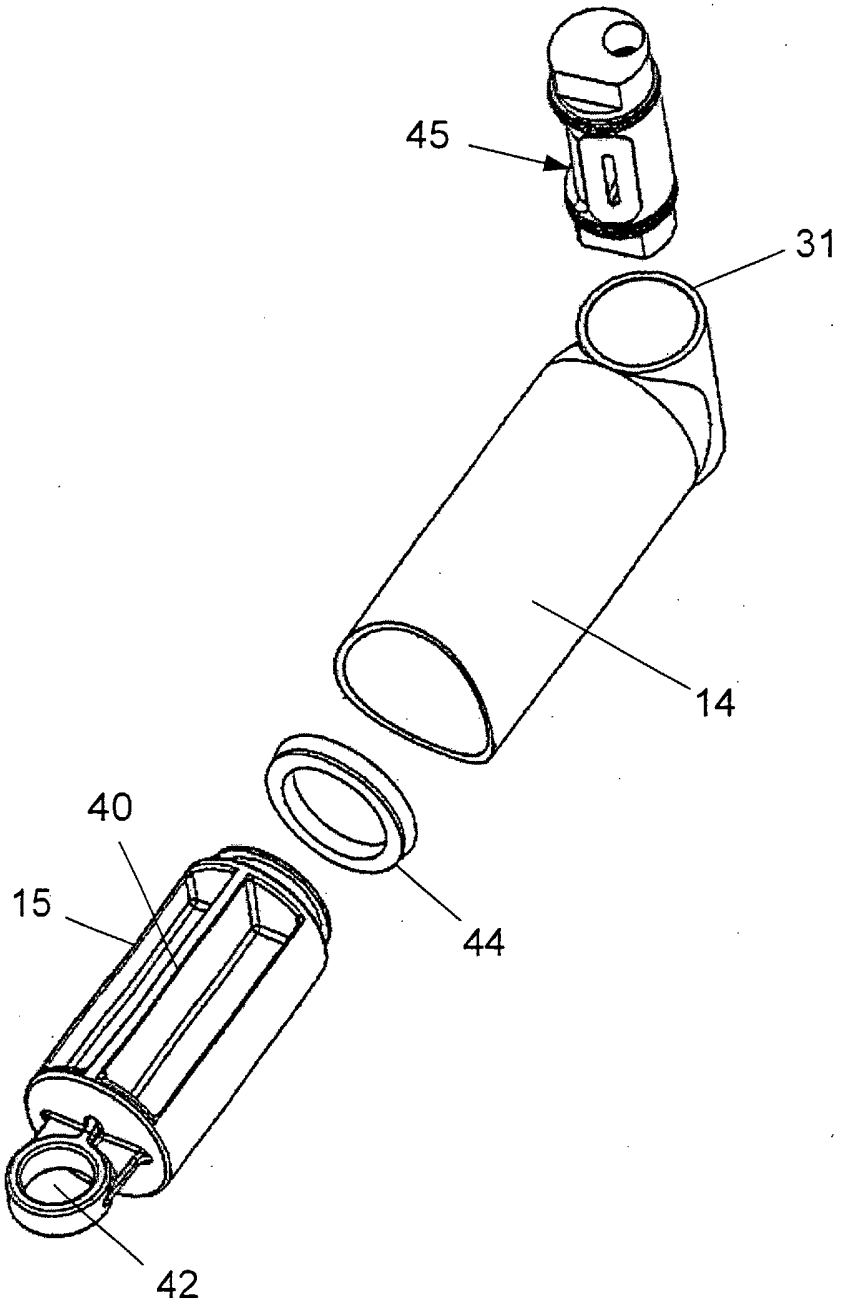

Fig. 4

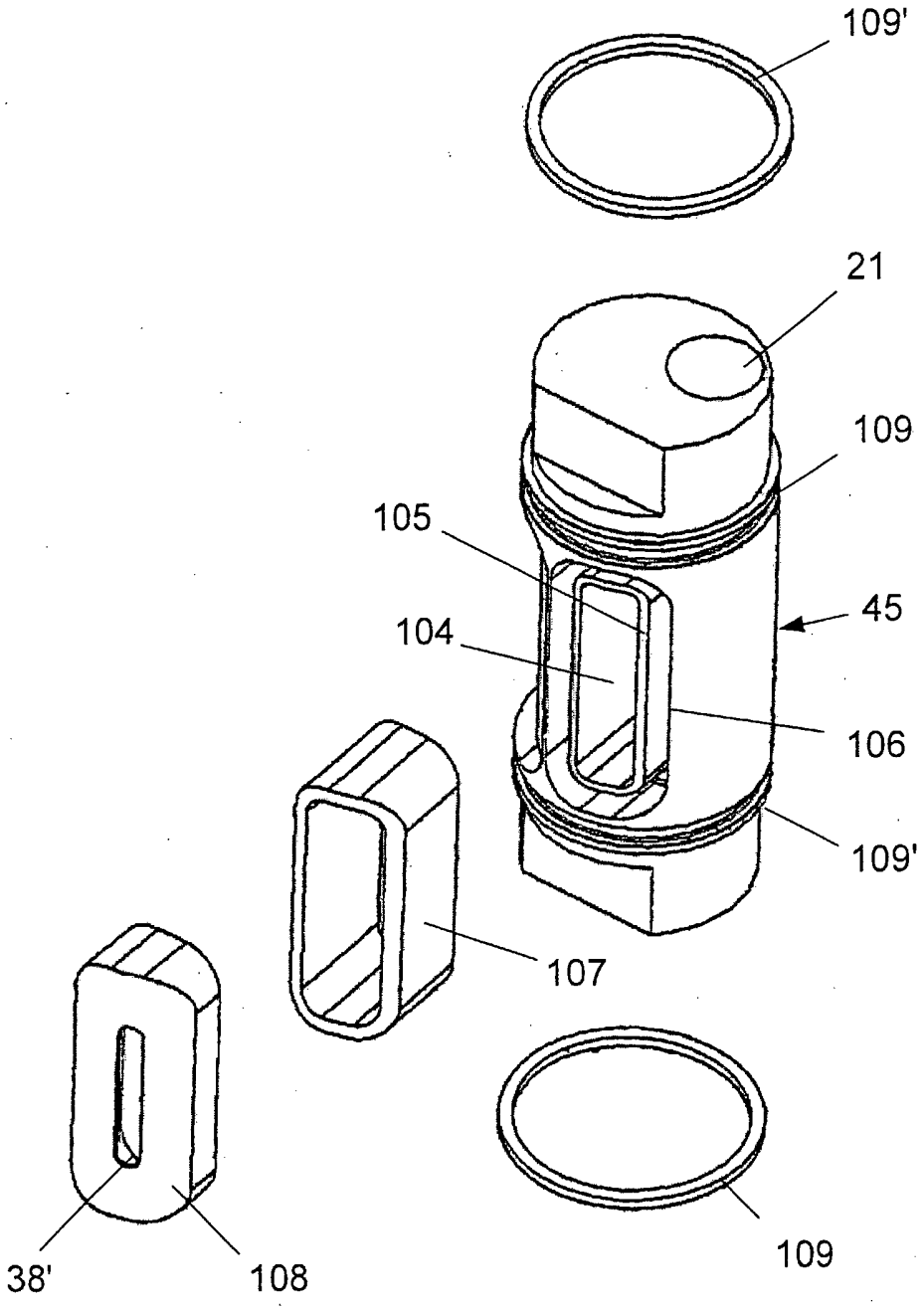

Fig. 5

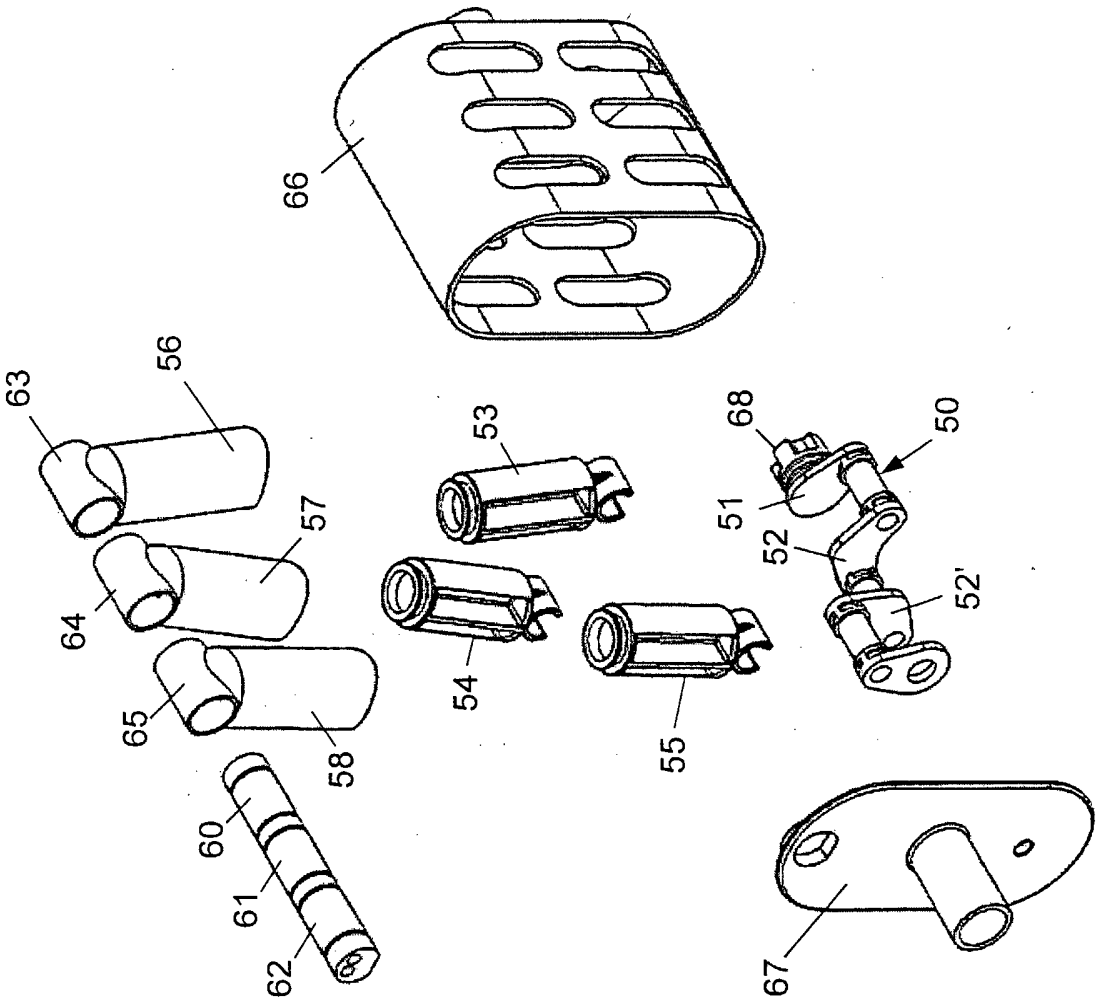

Fig. 6

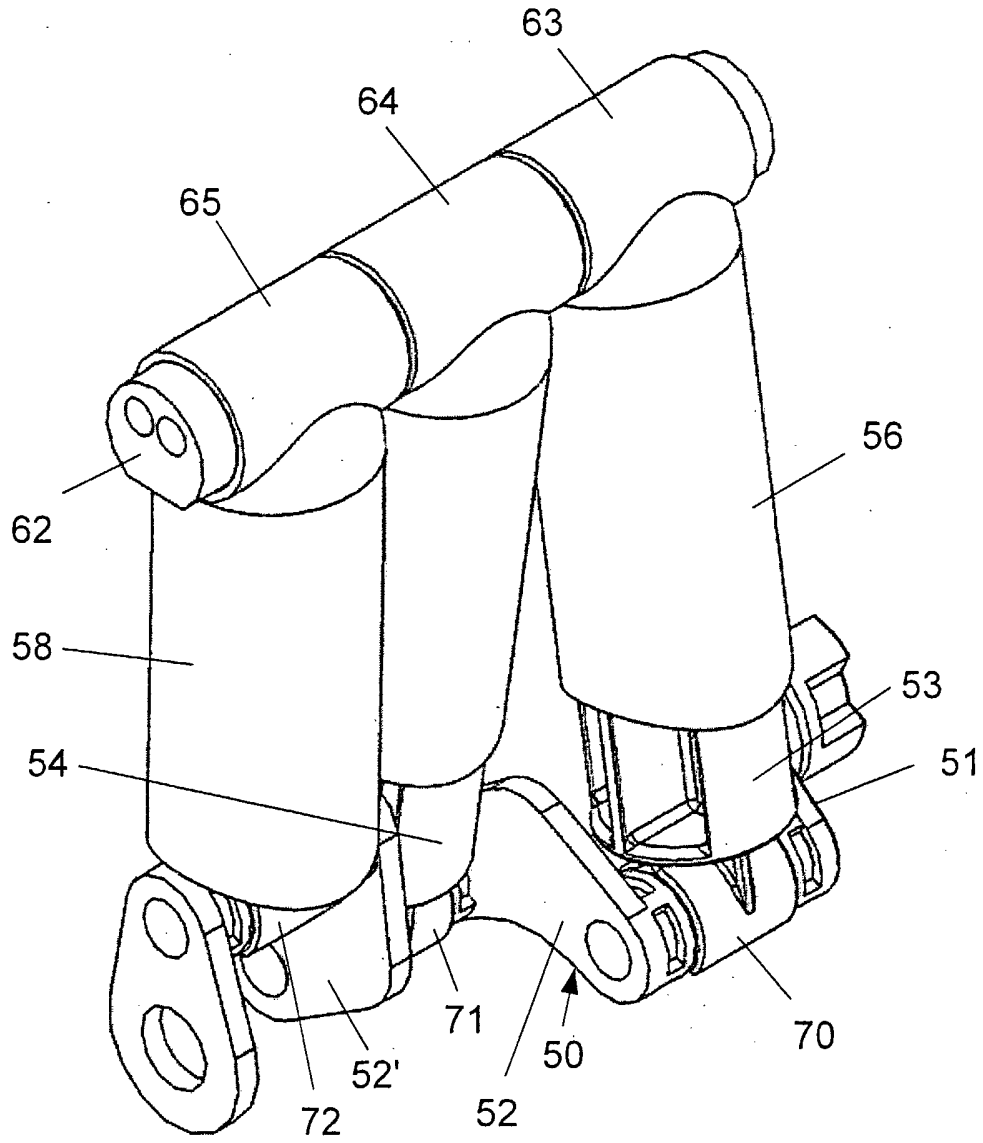

Fig. 7

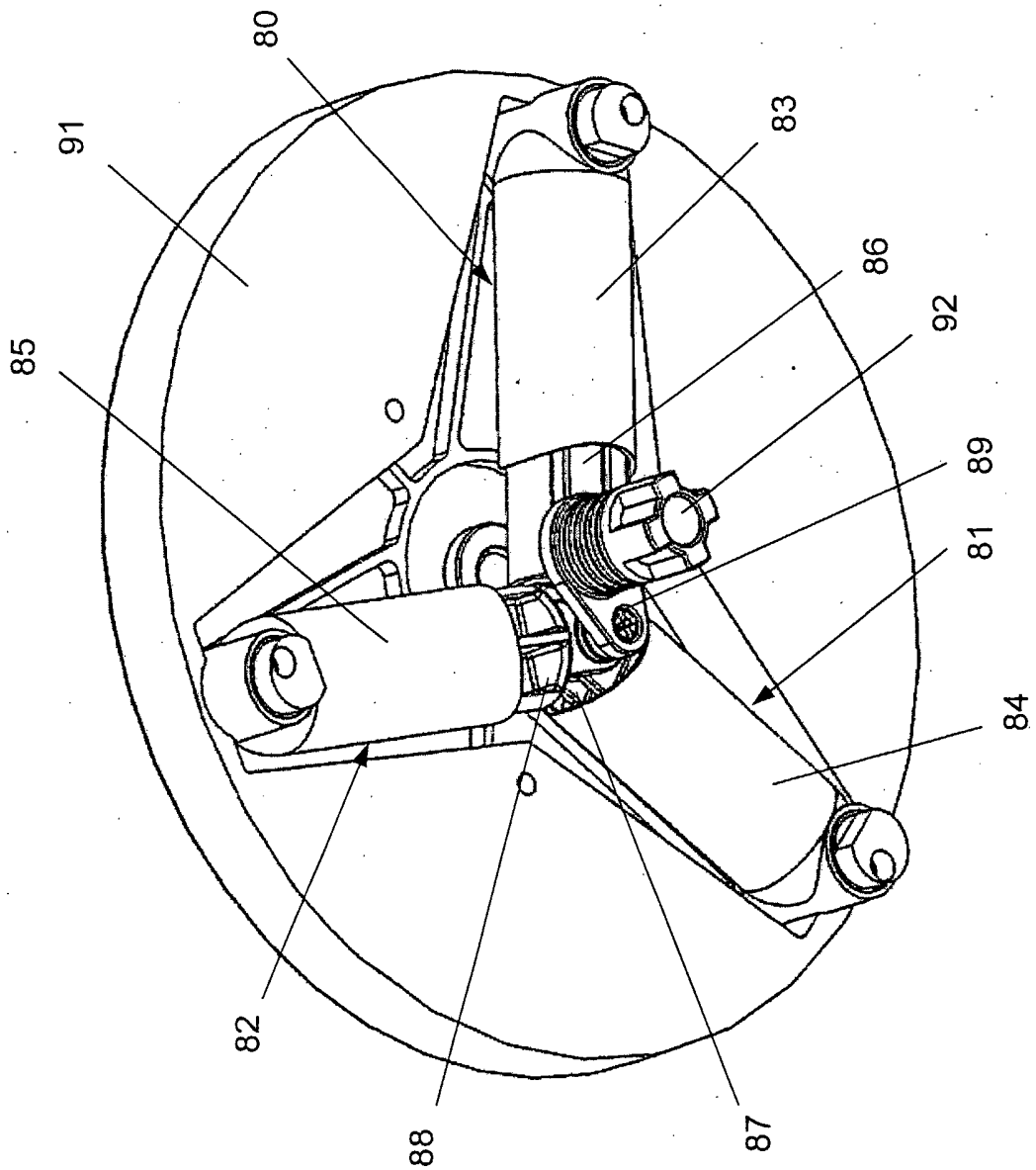

Fig. 8

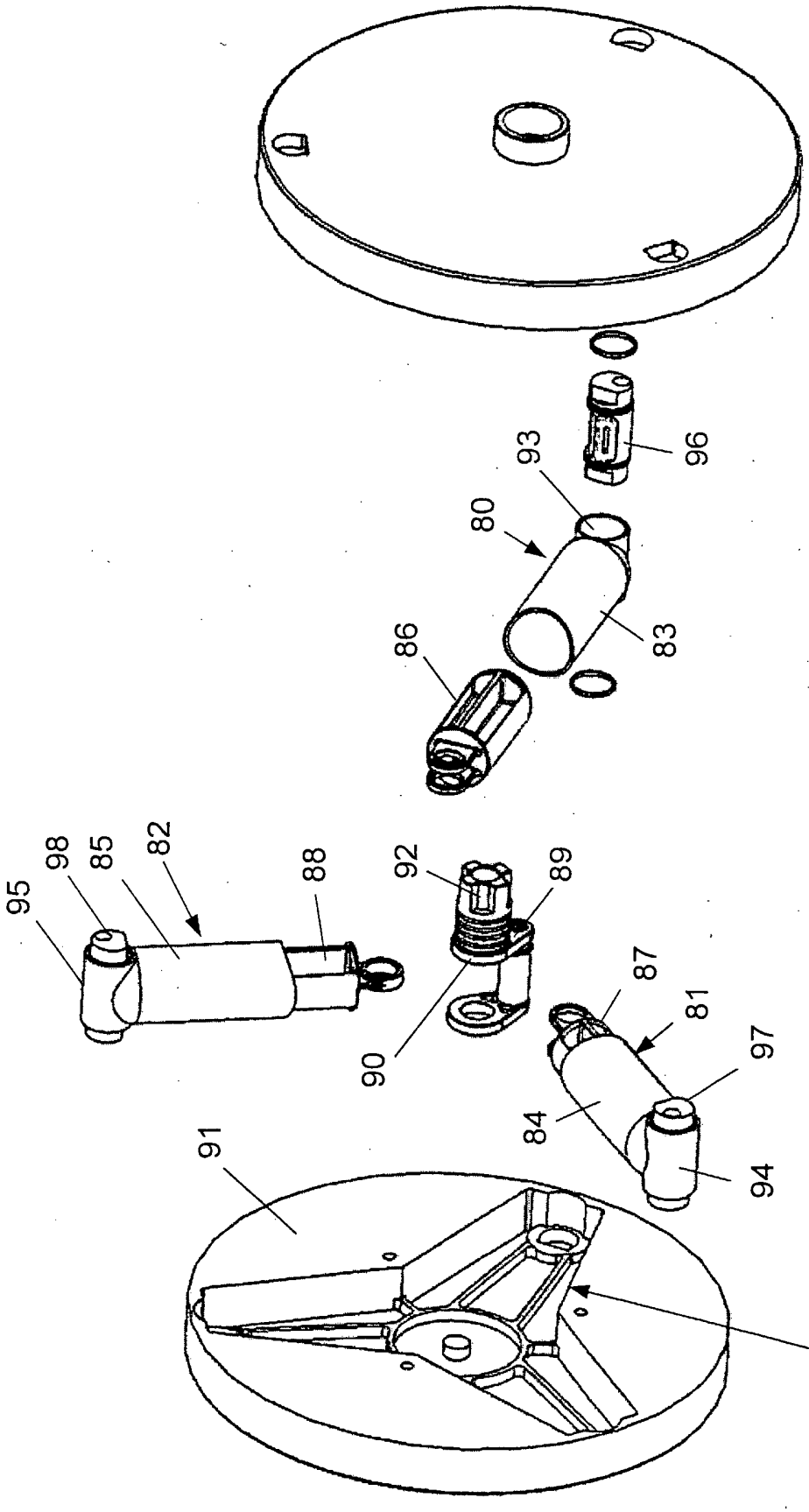

Fig. 9

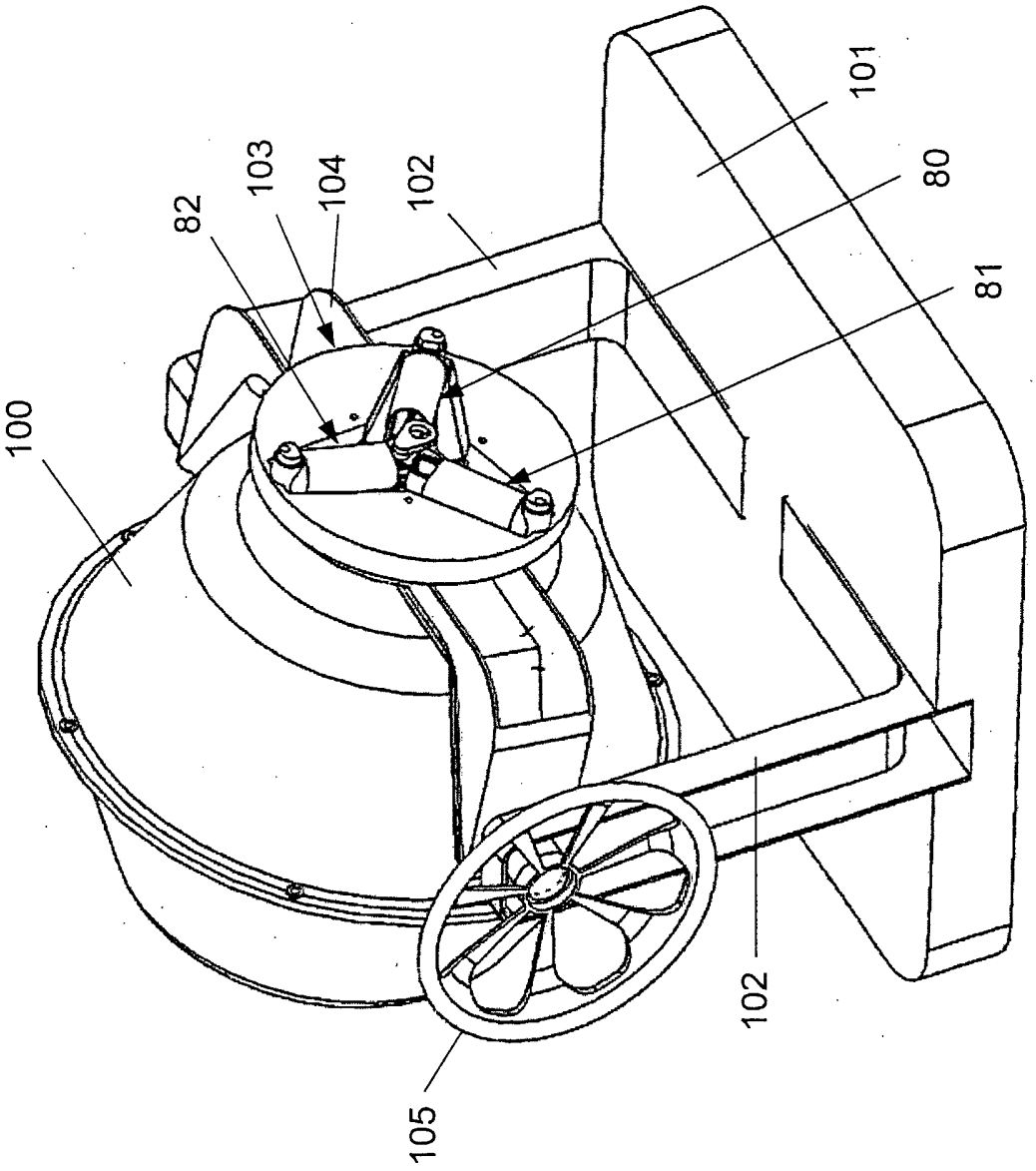

Fig. 10

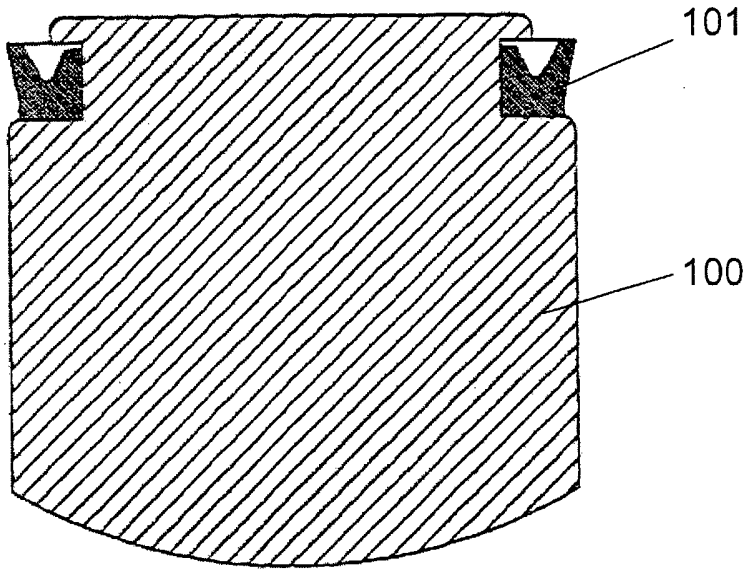

Fig. 11

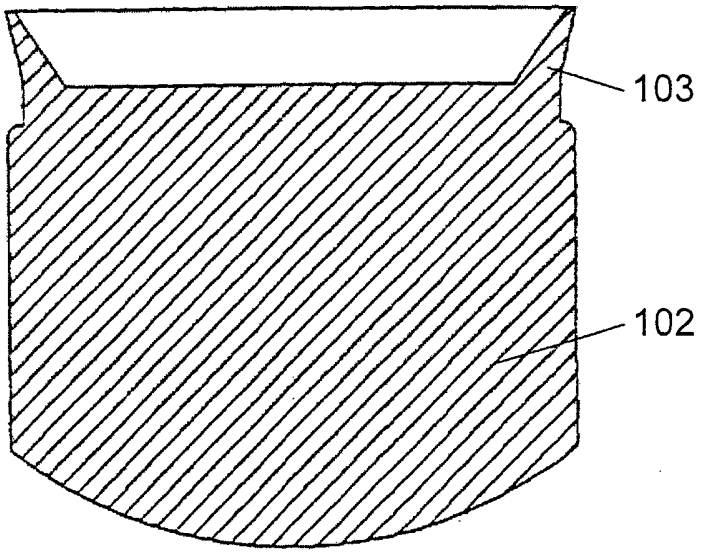

Fig. 12

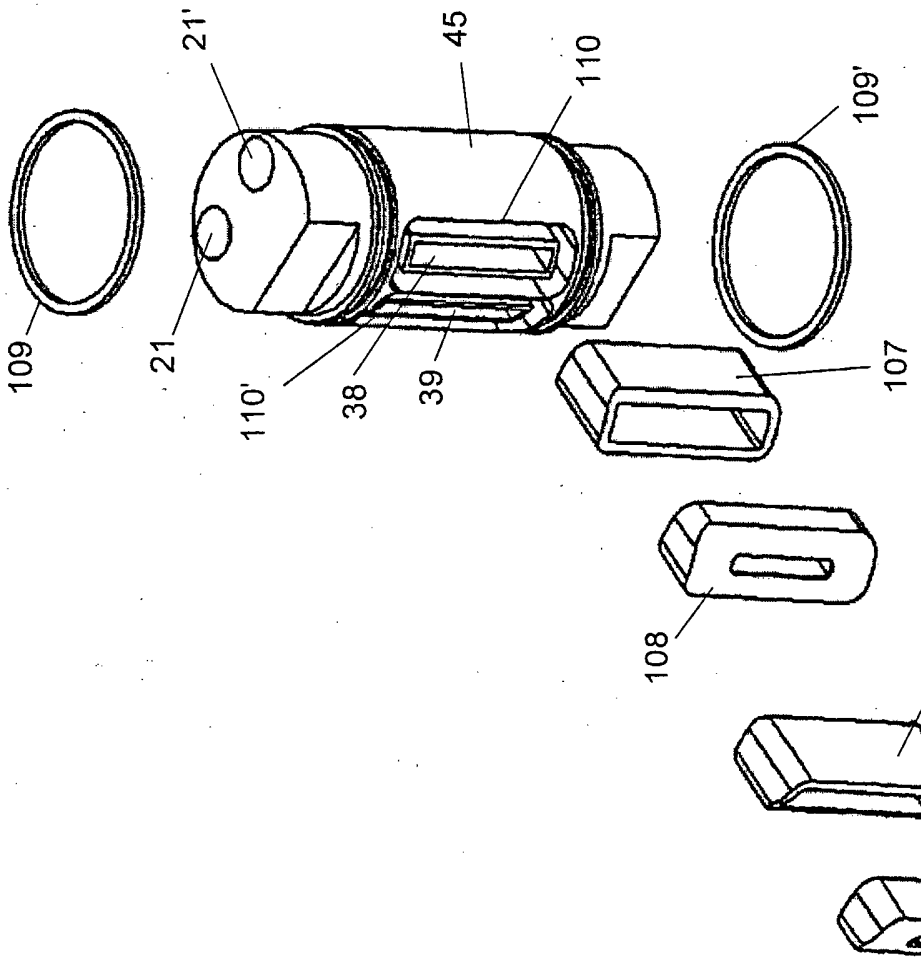

Fig. 13

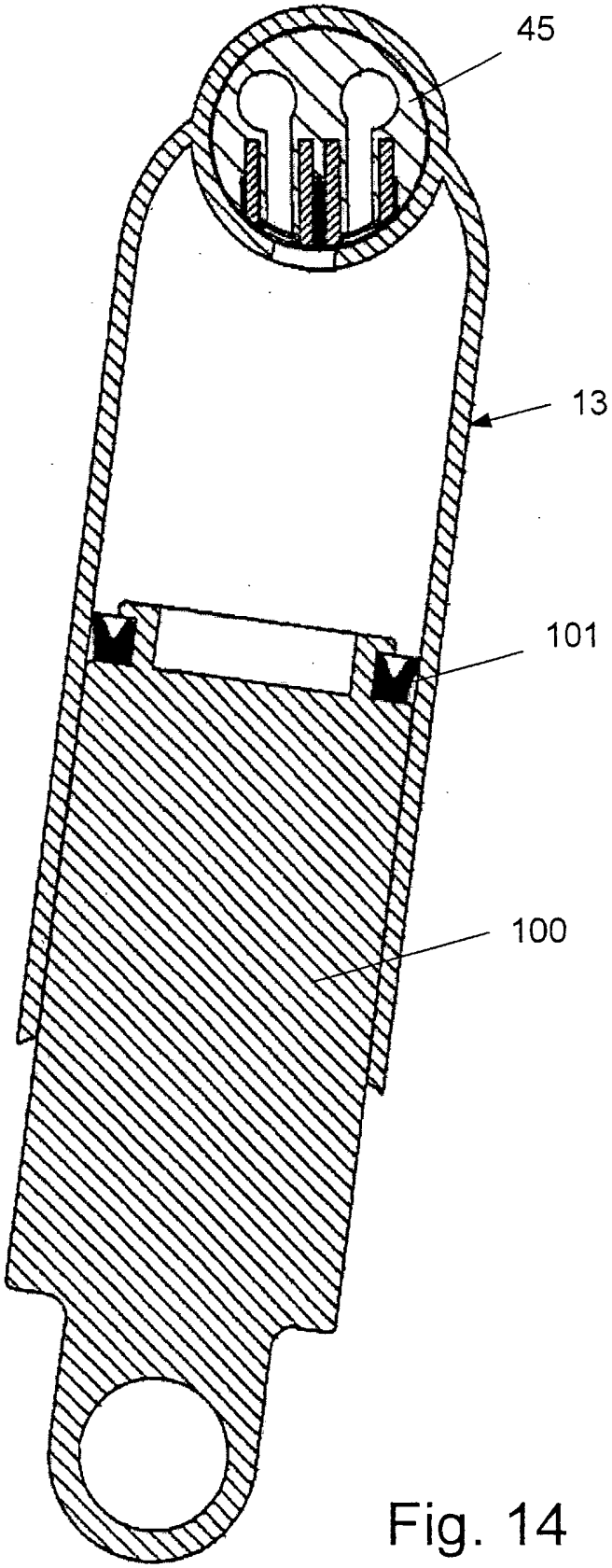

Fig. 14

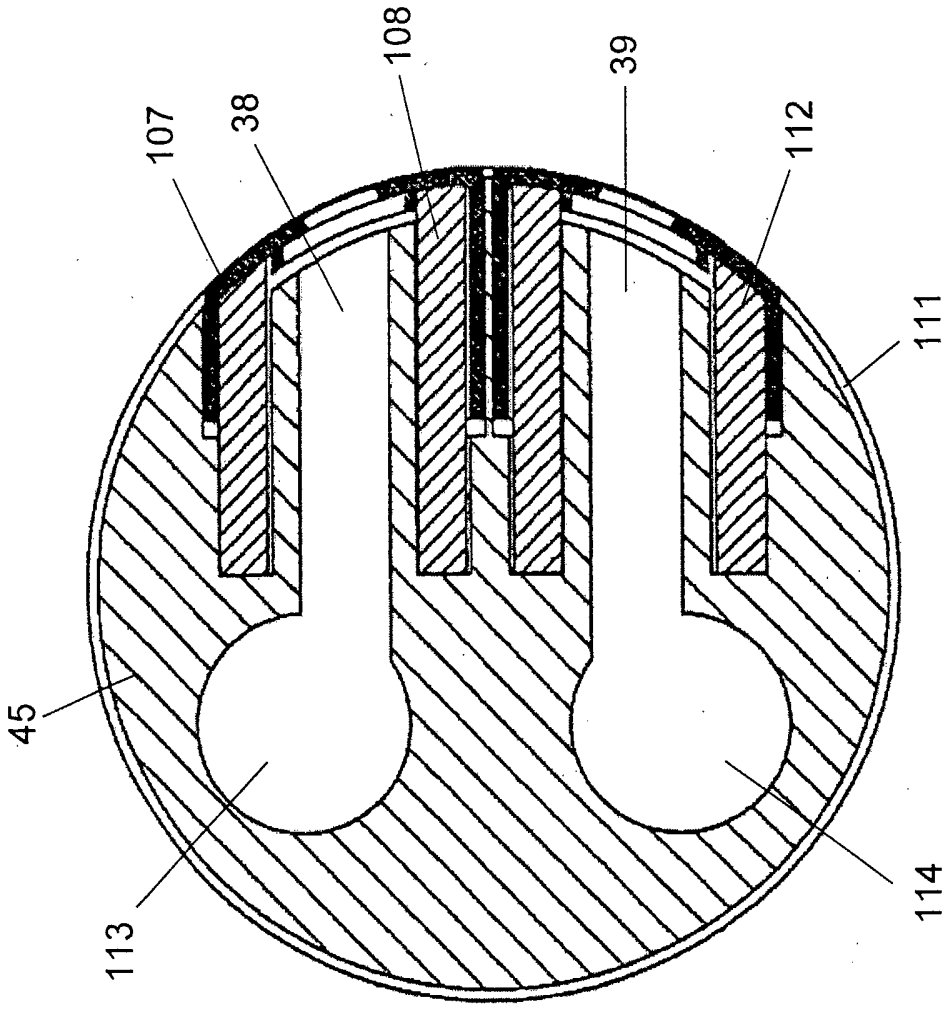

Fig. 15

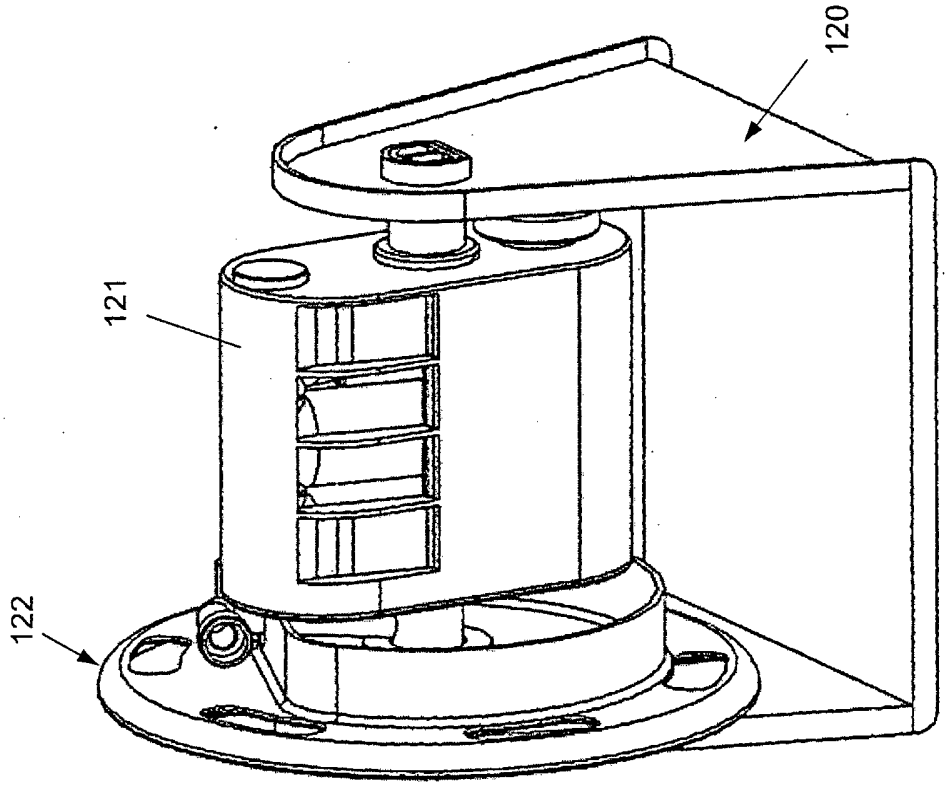

Fig. 16

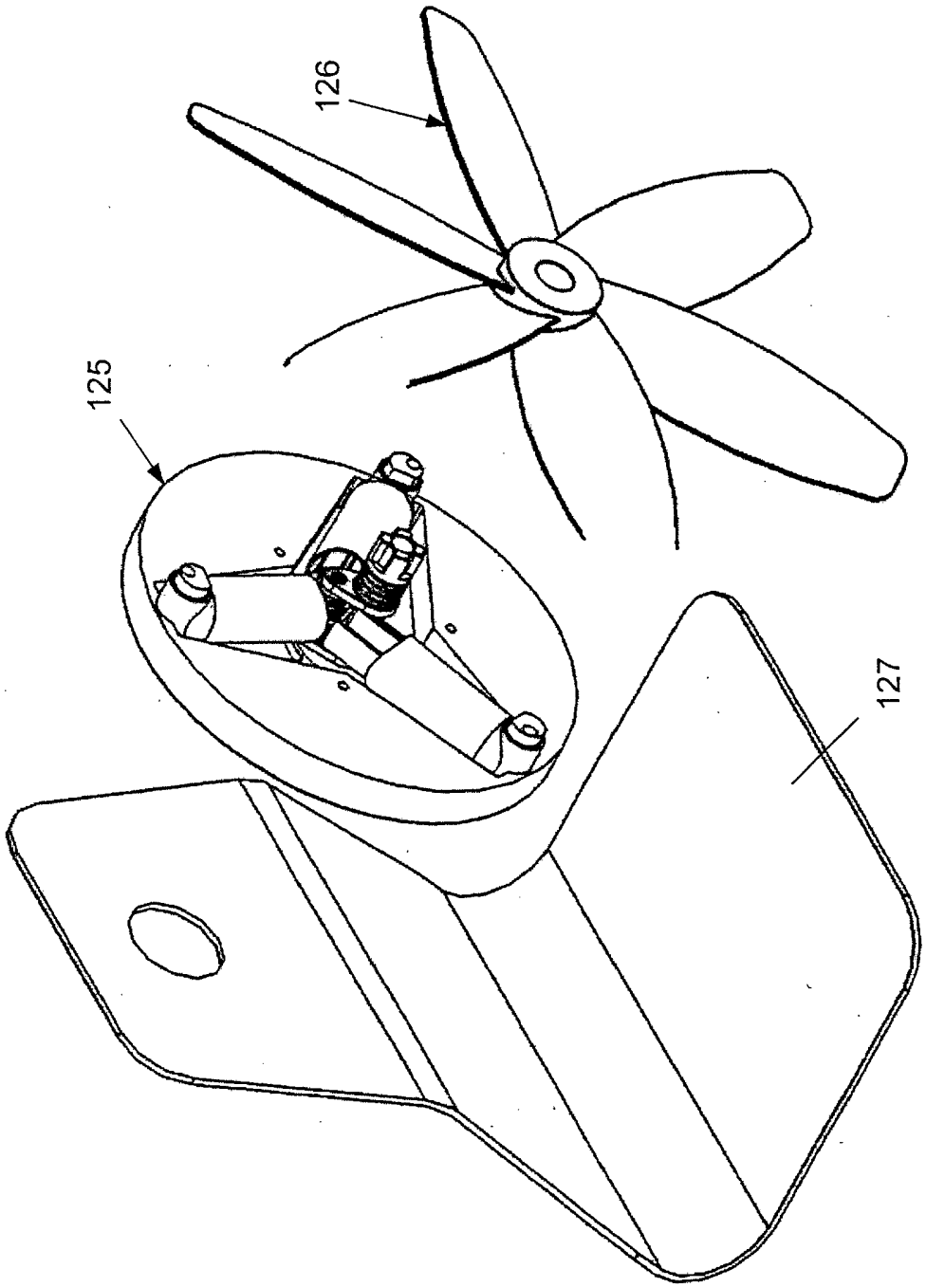

Fig. 17

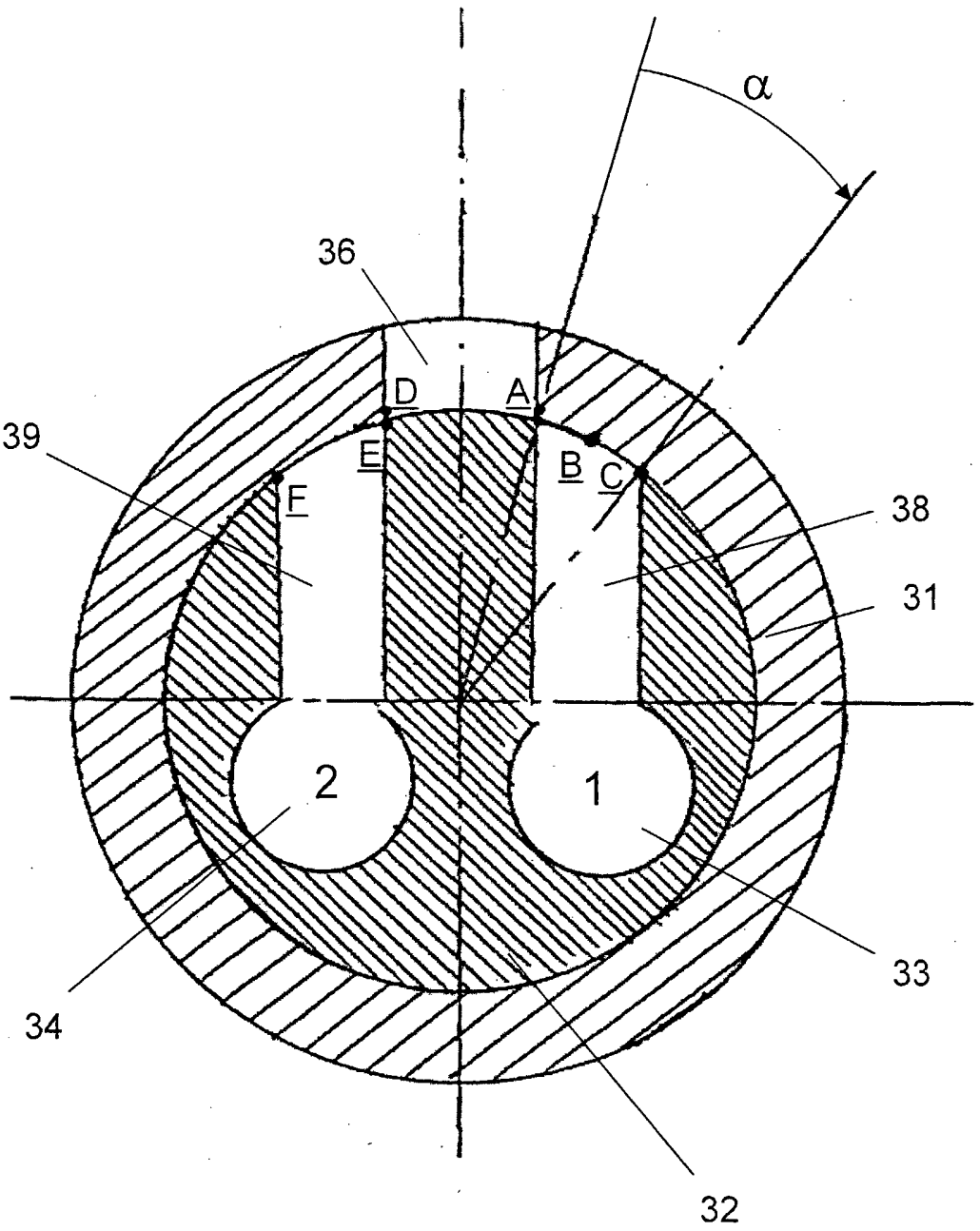

Fig. 18

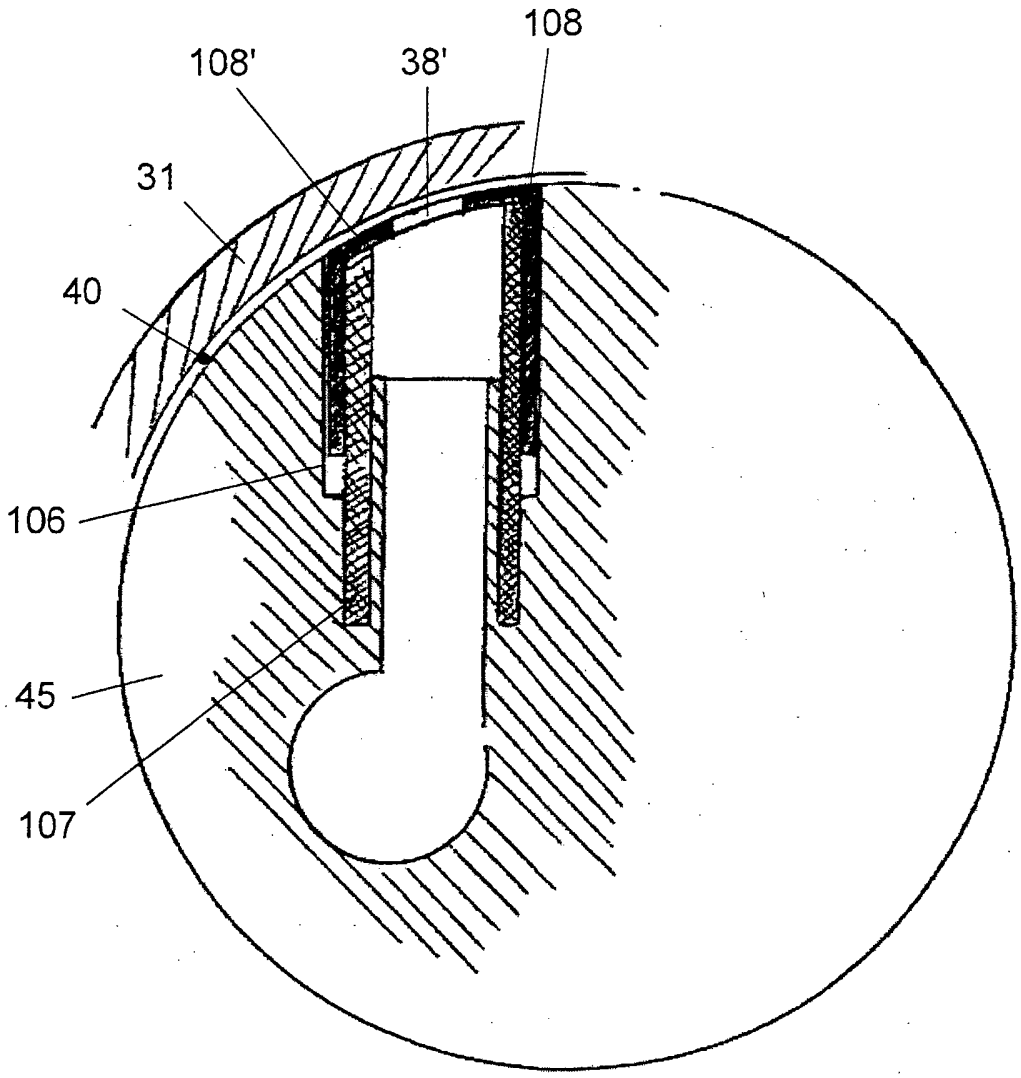

Fig. 19

INTERNATIONAL SEARCH REPORT

PCT/IL 03/00231

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F01B15/04

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)
IPC 7 F01B

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 practical, 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 1 954 408 A (SAMUEL ELIOT) 10 April 1934 (1934-04-10) page 1, line 1 -page 3, line 59; figures	1-6,9, 11-14, 17-19, 23,25, 26,29
X A	US 3 055 170 A (WESTCOTT JR WILLIAM B) 25 September 1962 (1962-09-25) column 1, line 1 -column 3, line 34; figures 1-3,5	1,2,5, 15,16, 25,26 9,11,12, 14
X	DE 21 57 735 A (OTT MATHIAS PROF DIPL ING) 24 May 1973 (1973-05-24) page 3, line 19 -page 4, line 2; figure 1	1-8,14, 15,23, 25,26,29

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 July 2003	24/07/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Luta, D

INTERNATIONAL SEARCH REPORT

Information on patent family members

PCT/IL 03/00231

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 1954408 A	10-04-1934	NONE	
US 3055170 A	25-09-1962	GB 911969 A	05-12-1962
DE 2157735 A	24-05-1973	DE 2157735 A1	24-05-1973