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(54) Title: A METHOD IN A RADIAL PISTON ECCENTRIC MOTOR/PUMP AND A CORRESPONDING RADIAL PISTON ECCENTRIC MOTOR/PUMP

(57) Abstract

The object of the invention is a radial piston eccentric motor/pump, which consists of a ring structure (1') and an axle (7) as an opposing member rotating in relation to it in bearings, a joint ring formed of first joints (13') and set centrally in relation to the axle, secured in one of these opposing members, and an eccentrically set force collector member (3) in the other member, and supported on this second joints (9') on the force collector member (3), several essentially radially set separate linear force members (4'), each secured to the first and second joints. The intention of the invention is to prevent the mutual rotation of the first and second joints. In accordance with the invention the first and second joints are pulled towards each other and the operating joints are permitted to rotate around the centre point of the force collector member (3) either connected to one another or separately or otherwise forced into a suitable angle.

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A METHOD IN A RADIAL PISTON ECCENTRIC MOTOR/PUMP AND A CORRESPONDING RADIAL PISTON ECCENTRIC MOTOR/PUMP

The object of the invention is a radial piston eccentric motor/pump, which includes

- a ring structure (1') and an axle (7) as an opposing member rotating in relation to it in bearings,
- a joint ring formed of first joints (13') and set centrally in relation to the axle, secured in one of these opposing members, and an eccentrically set force collector member (3) in the other member,
- second joints (9') on the force collector member (3) and supported on this,
- several essentially radially set separate linear force members (4'), each secured to the first and second joints,
- operating medium distribution devices (5, 6) to connect the feed and return lines to the aforesaid linear force members (4') at regular intervals. The invention is also concerned here with an applicable method.

Here the term operating medium signifies either liquid or gas and the matter is thus one of either pneumatic or hydraulic devices. The matter may also be one of a combustion motor. Here linear force member means a device, for example a hydraulic cylinder, which directs a force in a linear direction in relation to its attachment point.

The motor may also be a so-called hub motor, in which the shaft remains stationary and the case revolves around it. Low-revolution hydraulic motors are required in various kinds of machines to rotate drums and other components of the machines with great power. Hydraulic motors of this kind have long been sought for landfill compactors, but motors of this kind have not been available. Therefore high-revolution hydraulic motors and reduction gearboxes as well as chain-drive transmissions to the rollers have been used in these.

Especially in radial motors that have been used as aircraft motors the end of the piston rod of one cylinder has formed a collector ring, to which the other piston rods are jointed. Great lateral forces act on the piston, as for example in the machines in accordance with US-publications 2,939,403 and 3,981,229, which can be avoided by making the cylinder and piston able to swing. Thus the cylinder and piston act as a connecting rod. A hydraulic motor, operating in the same way as the type referred to
in the introduction, is shown in patent publications US 2,235,486, SE 129350, and EP 117 152. A solution of this kind is, however, extremely difficult to use in a hydraulic motor running at low revolutions, in which the torque is very great. For example, in the aforementioned case of a landfill compactor the torque requirement from a hub motor is about 100,000 Nm. The torque required to lock the collector ring is then also tens of thousands of Newton-metres. The great bending loading of the hydraulic cylinder used to lock the collector ring causes a difficult constructional problem. This and the other cylinders must also be dimensioned in accordance with buckling. A hydraulic motor, in which the ends of the piston rods slide along the circumference of the crankshaft that they propel, is known from the Swiss patent publication 372259. A construction of this kind is poorly applicable to back and forwards rotation. In general the case forms the ring structure, but the ring structure too may in turn be attached by bearings to a separate case. Publications US 4,469,013 and SE 463111 show solutions of this kind. In these too mechanical locking devices are used to create a corresponding synchronization.

The intention of this invention is to create a general method, by means of which the mutual rotation of the aforesaid first and second joints is prevented. The intention of this invention is also to create such a motor, in which the aforementioned problems have been solved, and a motor with a great torque can be created by means of a simple construction. The intention of the invention is also to create a simple pump/compressor, operating at a good efficiency. It is also the intention of the invention to make it possible to locate the motor/pump in a small space. The characteristic features of two methods in accordance with the invention are presented in Patent Claims 1 and 2 and the characteristic features of a motor/pump that implements two separate methods in accordance with Patent Claim 1 are shown in Patent Claims 3 and 17. Patent Claim 4 shows another motor/pump using the method in accordance with Patent Claim 2. All the motors/pumps in accordance with the invention have a common tendency towards creating such an angle between the first and second joints that the force rotating the joints of the force collection member are cancelled.

In the form of application in accordance with Patent Claim 17 the collector member attached to the crankshaft by bearings corresponds to an eccentrically set rolling or
sliding ring surface, along which the corresponding joints are free to move. In a machine equipped with an external rolling ring surface the self-centering of the rolling that takes place by means of pulling force presupposes that the first joint is closer to the centre point of the rolling ring surface than the centre point of the rolling component. When sliding components or bogie constructions are used, the situation is more complicated. So that pulling in general is possible the rolling ring surface must be directed against the pulling of the rolling component. Often the first joints are on the opposite side of the rolling ring surface to the corresponding rolling components, but not always.

The most surprising feature of the form of application in accordance with Patent Claim 3 lies in the fact that the locking of the collector member, generally a ring or wheel, can be dispensed with, if the hydraulic cylinders are arranged to operate on the pulling side and the resultant force tends to naturally rotate the collector member towards a difference of angle of equilibrium. Because there is no longer any danger of buckling, the piston rod becomes much thinner and the piston much shorter than in a corresponding motor/pump operating with cylinders in thrust. When there is generally also excess pressure on the return side of a pressure medium circuit, the piston rods can be replaced with even a flexible cable, the material of which may be metal, carbon, or other reinforced fibres. In particular the cable or rope can then replace the normal joint at both the case and collector member ends. Here jointing thus signifies operational jointing. A unique case of jointing is formed by piston rod pins held beneath the circumference of the ring, which can always slide or roll along the surface of the circumference to such a position that the cylinder forces travel continuously through the centre of the crankshaft. Here in addition to operational jointing the ends of the piston rod or cylinder are able to move in the direction of the ring and to direct the cylinder force to always travel through the centre of the crankshaft.

The synchronization of the collector ring to the aforesaid angle can take mechanically. It is important that the cylinder either is not bent at all, or that the bending load of the cylinder being used for locking remains a fraction of what it has been previously, because the collector member is rotated to such an angle in relation to the case that
the resultant of the cylinder forces travels through the crankshaft and at the same time through the centre of the collector member and close to it.

Cylinders in thrust tend to increase the deviation from the point of equilibrium. Controlling the rotation by means of pressure of the cylinders of the return side adjustment is quite complicated, on account of which a motor/pump with cylinders in thrust is preferably equipped with mechanical locking, which retains the rotation of the collector ring in the region of the average angle of equilibrium, when the forces to be carried mechanically remain a fraction of the previous ones.

The small remaining moment, which is caused by fluctuations in the difference of the angle of equilibrium on both sides of the average during revolution, remains to be taken care of by possible mechanical locking.

The forms of application in accordance with Patent Claims 6 - 9 have in common the fact that some intermediate member is connected between the case and collector member and is operationally jointed at both ends. Here too a normal joint can be replaced with flexible material or engaged teeth, when the operational joint rotates along the ring. The operational point of jointing only transmits pulling, but no moment at all. In the form of application in accordance with Patent Claim 9 a cylinder or other telescopic member that is as such known is used to carry the moment and thus to create locking, but the bending load of this remains small in accordance with the nature of the invention.

In accordance with one form of application of the invention the cylinders are replaced by electrically operated linear spindle motors, in which case their precision of control can be combined with a great torque.

It is perfectly possible to make the motor operate with as few as three hydraulic cylinders, but it is advantageous to use a considerably greater odd number of cylinders, because then the difference of angle between the state of equilibrium of the collector ring and the distribution of the cylinders varies as little as possible during a revolution. This variation can additionally be reduced by controlling the return line pressure, i.e.
the feed pressure, or the volume of flow. Other advantageous forms of application and advantages of the invention appear in the forms of application presented later.

In what follows the invention is illustrated with reference to the accompanying figures, which show hydraulic motors, a pump, details, and general principles, in accordance with the invention.

Figure 1 shows the principle of the method in accordance with the invention.
Figure 2 shows a cross-section of a hydraulic motor equipped with pulling cylinders and installed at the end of a roller.
Figure 3 shows a cross-section of the hydraulic motor in Figure 2 at the point II-II.
Figure 4 shows the feed and distribution plates of the hydraulic motor in Figure 2.
Figure 5 shows the geometry relating to optimal dimensioning.
Figures 6 and 7 show a motor equipped with thrust cylinders.
Figure 8 shows second kind of motor equipped with thrust cylinders.
Figure 9 shows a third kind of motor equipped with thrust cylinders.
Figure 10 shows a fourth kind of motor equipped with thrust cylinders.
Figures 11 and 12 show a second kind of motor equipped with pulling cylinders.
Figures 13 and 14 show a collector ring adapted to a cut crankshaft.
Figure 15 shows a second type of collector ring construction.
Figure 16 shows a third type of collector ring construction.
Figures 17 and 18 show a fourth hydraulic motor equipped with pulling cylinders.
Figures 19 - 21 show fifth type of hydraulic motor equipped with thrust cylinders, and details of it.
Figures 22 - 25 show a sixth type of hydraulic motor equipped with thrust cylinders, and details of it.
Figure 26 shows the hydraulic diagram of one pump.

In known radial piston eccentric machines the joints connected to the crankshaft are collected to a collector piece, the rotation of which in relation to the case is prevented mechanically. If we call the fixed joints the first joints 13' and the ends on the side of the force collector member 3 the second joints 9', the problem is to prevent the mutual rotation of the first and second joints. The arrangement in accordance with the
invention to arrange this synchronization is shown in Figure 1. The arrangement in accordance with the invention can be used in three different cases (a, b, c). In case a collector member is used, which in this case is attached to the crankshaft 2 by bearings without mechanical attachments to the case. The cylinders, or in general the linear force members 4', are attached to the ring structure 1' with the aid of joints 13'. In this case synchronization is taken care of by the pulling cylinders, the resultant force of which tends to always rotate the collector member 3, here a ring, into a position of equilibrium, which is at a angle $\alpha$ dependent on the angle of rotation from the position of the case. There is also usually a small pulling force in the other cylinders.

The same method can also be applied to individual cylinders by permitting the first or second joints to slide/roll along the surface of the ring and by arranging pulling from the side of the sliding/rolling surface. In this case each joint point that is able to move along the ring surface tends to adopt a position vertical to the rolling surface. There are two cases of this kind, i.e. it is possible to use either an internal rolling surface (Figure 1b) or an external rolling surface (Figure 1c). In Figures 1b and 1c corresponding reference numbers 13' and 9', as above, are generally used for the first and second joints. In cases in accordance with case B the pulling linear force members 4' are attached to the ring structure 1' with the aid of joints 13 as in the previous case. An internal rolling surface 77 is attached to the crankshaft 2, this holding rolling components, e.g. ball bearings 75, which are attached to the attachment points of the linear force members 4' inside it.

In a corresponding manner, ball bearings 82 can be arranged in accordance with case C to roll along an external rolling surface 83, which is most advantageously attached to ring structure 1'. In this case the axle 7 does not have a crank, but has attached to it a suitable disc, to which the linear force members 4' are attached by means of the joints 80. Here the first joints 13' are permanently attached to axle 7 and the rolling ring 83 attached to ring structure 1' carries the second joints 9'.

In place of rolling components, it is naturally possible to use sliding members. The rings formed by the joints 13' are generally circles, but a form deviating from this, e.g. an ellipse, is possible. Because continual pulling is required in all cylinders in solutions
in accordance with cases B and C, a corresponding pump requires a feed pressure, and thus is poorly applicable as a vacuum pump.

Even though in the basic method opposite joints are pulled by a linear force member, the device solution in accordance with case A also makes possible the use of thrust cylinders.

The collector member for the eccentric forces is formed in various cases of either a collector member attached to the crankshaft by bearings, or by an eccentrically arranged rolling ring surface. In accordance with the method pulling members are used that tend to rotate the joints that transmit forces to the collector member around its centre. In accordance with the invention the joints are permitted to rotate either together or singly, when a dynamic equilibrium is achieved, which is maintained, despite the rotational movement.

The hydraulic motor in accordance with Figures 2 - 4 is a so-called hub motor, in which case the crankshaft 2 is attached to the frame 72 of the machine, and the case 1 rotates a roller 33. The case is supported to rotate on the ends 32 and 7 of the crankshaft 2 by means of the bearings 14 and 15.

A collector ring 3' used as a collector member 3 is attached to crankshaft 2 by means of bearings 8 in such a way that it can rotate, to which the ends of the piston rods 10 of the hydraulic cylinders 4 are attached by means of joints 9. The end of each cylinder component 11 next to the piston rod 10 includes a forged end-piece 30, which also includes axle stubs 31 to secure the cylinder component to the case 1 with the aid of bearings 13.

The feed and return lines 18, 18' for the hydraulic oil are brought to the feed plate 5 through an eccentric plate 20 that forms part of the crankshaft. Between plate 20 and feed plate 5 there is in addition an intermediate case 16, which is secured to the feed plate 5 in such a way that feed plate can move in the direction of the shaft. The feed plate 5 feeds hydraulic oil to a distribution plate 6 attached to the collector ring 3', and distributes it to the cylinders 4 through hose 29 and at the same time collects oil from
them again through the distribution plate 6 back to the feed plate 5 and the return line. Later the operation of the distribution plate and the feed plate will be described in greater detail.

Figure 2 shows diagrammatically turning cylinder 19, one attachment point of which is attached to the eccentric plate 20 and the other to the intermediate case 16. The hydraulic cylinder 19 is double-acting and its thrust and traction connections are connected to the feed and return side lines. If it is desired to change the direction of revolution of the motor, the feed and return side pressure oil levels change and at the same time the turning cylinder 19 goes to its other extreme position, when the intermediate case 16 and with it the feed plate 5 turn by the selected angle round the crankshaft. The feed plate 5 is turned to the same direction in which distribution plate 6 is compared with the cylinder distribution of the case. In connection with the change in direction the state of equilibrium of the collector ring 3' moves to the opposite side, which is taken into account by turning the feed plate. Typically the difference of angle α in the state of equilibrium in relation to the distribution of cylinders is about 10°, that is, the movement of the feed plate from one side to the other is a total of 20°. The difference in angle α of the state of equilibrium of the collector ring 3' and thus also of the distribution plate 6 is not constant, but varies for example in the hydraulic motor in accordance with this example from 10° - 12°. Because the difference of angle also depends on the operating pressure, more precise compensation can be achieved by adding springs to either side of the piston of the hydraulic cylinder, by means of which compensation takes place dependent on the pressure.

A feed and distribution plate is shown in Figures 4a and 4b, in which the grooves 23 of the distribution plate 5 are located opposite the openings 25 in the feed plate 6. The aforementioned feed and return lines 18 are connected to the connection 21 of the feed plate 5, from which they gain access to the main channel 22. From there they are divided into corresponding feed and exit channels 23', Now they thus pass through the feed side channel 23 to their openings 25, which are in this area and thus in turn for operation. A channel leads from these openings 25 to connection 26, to which the hoses 29 leading to the corresponding hydraulic cylinders are connected. Correspon-
dingly the openings 25 of the distribution plate 6 in the area of the return side channel 23' feed the return oil from the corresponding hydraulic cylinders.

By means of the mutual rotation of the feed and distribution plate feed takes place only during the pulling phase of the cylinders and discharge when the crank pulls the piston rod up. As the distribution plate 6 revolves against the feed plate 5 one hole at a time moves onto the opening 23 and correspondingly the hole on the other side moves onto the return side channel 23' and at the ends of those channels 23 and 23' one opening at a time moves away from on top of them. By means of this one cylinder at a time comes into an operating phase, which lasts for nearly 180°, after which the opening moves away from on top of the feed side channel 23 and the groove 27 in the centre of opening 25 coincides with the hole 28 in the feed plate, which allows the cylinder to breathe into the case, which acts as a loss-oil tank. After this the corresponding opening 25 moves into the area of the return side channel 23', when the oil is free to flow from the cylinder space to the return line. In the feed plate 5, there is a ridge that is essentially the width of the openings 25, between the channels 23 and 23', which prevents a direct leak through the openings 25 from the feed side to the return side.

Several cylinder bores 24 are arranged in the circumference of the feed plate 5, into which piston 17 are placed. Figure 1 shows their operation. Feed or return pressure is fed under each piston 17, depending on its situation and a corresponding pressure naturally also operates on the opposing surface of piston 17. As a result of this the feed plate presses tightly against the distribution plate 6.

When using an operating pressure of 420 bar and a feed pressure of about 5 bar on the return line side a motor with a diameter of about 1000 mm will achieve a torque of about 100 000 Nm and a maximum speed of revolution of 17 revolutions per minute.

Case 1 acts advantageously as an oil tank, in which case the case oil cools the hydraulic devices.
The accompanying example motor can naturally be adapted by selecting a different number of hydraulic cylinders or by placing two or more series of cylinders or this type in parallel on the same crankshaft. The bearing load can be considerably reduced by setting the cranks of the different series of cylinder in different directions.

A motor/pump can be constructed to fit the smallest possible space by dimensioning it in accordance with the following formulae, which were discovered when developing the invention. Figure 5 shows schematically the geometry that determines the greatest swept volume of the cylinder. The theoretical stroke volume of a single cylinder is shown by broken lines. Its height is s and radius r and distance from the axis of rotation x. Seen from the axis of rotation the swept volume appears in the angle 2\(\gamma\). Next a formula is derived for the minimum value \(R_e\) of the extreme distance of the swept volume, when the revolution volume \(q\), the number of cylinders, and the constant \(c\) that determines the cylinder construction are given.

In the figure the cylinder wall, piston, lower end, and piston rod are shown by broken lines. This, and the constructions above the cylinder mean that the real circumference of the cylinders is somewhat larger. When calculating the dimension \(R_e\) the forms and dimensions of the lower end of the cylinder and the effect of the piston rod can be taken into consideration and from this, by taking into account the construction of the upper end of the cylinder, it is also possible to calculate the extreme distance \(R\) of the upper edge of the cylinder from the axis of rotation. The real installation and operating spaces of the cylinders and the radius \(R_{Re}\) are reached by taking into consideration the swing of the cylinder during revolution.

Because the cylinders are arranged radially, in extreme cases the lower corners of the cylinders nearly touch one another. In mathematical examination itself the lower corners of the swept volumes are marked as touching one another. By means of the co-efficient \(c\) the effects of the cylinder construction and the piston rod are taken into consideration, these reducing the real working surface area \(A_{work}\) in relation to the cross-sectional area \(\pi r^2\). By taking the co-efficient \(c\) into consideration the double-sided working surface area of a double-acting cylinder is also obtained. The co-efficient \(c\) is typically 0.7 - 0.9 for a single-acting and 1.5 - 1.7 for a double-acting cylinder.
The revolution volume $q$ can be derived from the following formula:

$$
q = sc\pi r^2 N
= c(R_c-x) x^2 \pi N (\tan \left(\frac{180^\circ}{N}\right))^2
$$

(1)

$$
k = c\pi N (\tan \left(\frac{180^\circ}{N}\right))^2 \quad \text{and} \quad c = \frac{A_{\text{work}}}{\pi r^2}
$$

From formula 1 $R_c$ is obtained as a function of $x$, which is derived and set to a value of zero in order to obtain the extreme value point:

(1) $\Rightarrow \quad R_c = \frac{q}{x^2 k} + x \quad \quad R_c' = -\frac{2q}{x^3 k} (\neq 0)$

(2) $x_{opt} = \sqrt[3]{\frac{2q}{k}}$, in which $k = c\pi N (\tan \left(\frac{180^\circ}{N}\right))^2 \quad \text{and}$

(2) $R_{c, opt} = \sqrt[3]{\frac{27q}{4k}}$, which corresponds to the former

By placing the formula 2 in the formula 1 the following simple expression for the optimal length of stroke $s_{opt}$ is obtained:

(3) $\quad x_{opt} = \frac{2}{3} R_{c, opt} \quad \Rightarrow \quad s_{opt} = \frac{1}{3} R_{c, opt}$

These very simple formulae have been found for the dimensioning of a motor or pump. In practice the calculation is iterative, because the constructive dimensions can only be fixed once its order of magnitude is known. The length of stroke of the cylinder is, according to formula 3, optimally one-third of the dimension $R_{c, opt}$.

In practice one gets very close to the optimal dimension given by formula 2 if the cylinders are jointed at the lower end. The lower corners of the cylinder then move very little in the direction of the circumference during a revolution. If the cylinders are jointed at their upper ends, the real minimum clearly deviates from the calculated $R_{c, opt}$ because the constant $c$ does not take into account the additional space required by the swing of the cylinder. Plenty of space remains for the crankshaft and the collector ring. By means of good construction the swinging can be minimized.

Figures 6 and 7 show a hub motor equipped with thrust hydraulic cylinders. The same reference numbers as in the above are used for the operationally same components,
in which case the following components have been dealt with above: case 1, crankshaft 2, its ends 32 and 7, collector ring 3', hydraulic cylinder 4, cylinder case 11, piston 12, piston rod 10 and jointing 9, feed and distribution plates 5 and 6, eccentric plate 20, and turning cylinder 19.

In this form of application the cylinder case is attached, in relation to the piston rod, to the case by joint 34 at its opposite end. The changes in angle of the thrust forces are then smaller during revolution than those in the former, which is significant especially in the case of a hydraulic motor equipped with thrust cylinders.

Here the operation of the feed and distribution plates 5 and 6 is the same as in the above, but the distribution plate 6 distributes hydraulic oil to the channel 35 of the piston rod 10. In addition to this the lower end of the piston rod 10 is forged into a transverse pin 36, at the opposite end of which is the piston 37 which is larger than the channel, and which rests against the pressure bearing 38, which in turn rests on the opposite eccentric plate of the crankshaft. By means of this arrangement the transverse pin 36 presses the distribution plate 6 against the feed plate 5 with the desired force that depends on the pressure of the system.

Because the collector ring 3' continually tries to escape in a motor equipped with thrust cylinders, this must be prevented by means of dynamic control. In this case this takes place with the aid of hydraulic cylinder 19, which turns the feed plate by means of suitable adjustment so that the state of equilibrium returns. This control system it not to be highly recommended, as it requires a complicated and precise sensor. More preferable are the mechanical locking devices referred to later that prevent the collector ring 3' from rotating in relation to the case.

Figure 8 shows various means of locking the collector ring 3' with the case at a certain stage. In this figure too the same reference numbers as in the above are used for the operationally similar components, these being: case 1, crankshaft 2, collector ring 3', hydraulic cylinders 4, hydraulic cylinders' jointing 9 and 34, hydraulic cylinder case 11, piston 12, and piston rod 10. Because in a motor equipped with thrust cylinders the collector ring 3' attempts to continually escape from a state of equilibrium, the twist
can be limited by means of some intermediate device with a fixed dimension, which may be a spring 41, cable 42, or a hydraulic cylinder carrying pulling with a piston and having a fixed dimension. In the figure the cable 42 is located inside spring 41 and thus a compact pulling device 40 is created. Here the task of the spring is, however, mainly to keep the loose cable in a compact packet, out of the way of the hydraulic cylinders. In the figure the upper hydraulic cylinder is marked with the reference number 4.1, and it is at the moment shown carrying the pulling loading at the end of the stroke. When one of these alternative methods is used to lock the collector ring 3' to the case 1 at a certain phase, the collector ring 3' is, however, subject to a small pendulum movement.

These alternatives easily permit a change in the direction of rotation, because these traction devices are each jointed at both ends and can flip by the same difference of angle from one side to the other.

In this form of application an advantageous piston rod gasket construction is also shown. The lower end of cylinder 4 can be made quite long without this being a nuisance, is the corners are rounded in the manner shown. The gasket 39 of the piston rod 10 can then be lengthened to a considerable extent.

The following figure 9 shows a precise method of locking the collector ring 3'. Here too the same reference numbers as in the above are used for the operationally same components, these being: case 1, crankshaft 2, collector ring 3', bearings 8, hydraulic cylinder 4, its case 11, piston 12, piston rod 10, crankshaft bearing axles 32 and 7 as well as bearings 15 and 14, feed and distribution plates 5 and 6, eccentric plate 20, and hoses 29.

The sealing of the feed and distribution plates 5 and 6 against each other is here of the same kind as in the form of application shown in Figure 1. Here, however, the distribution plate 6 is locked to rotate with the case 1 and it includes piston 17, which rests against the case. The surface opposite this in the distribution plate 6 presses it against the feed plate 5, which rests in turn on the eccentric plate 20 of the crankshaft.
Pressure bearing 49 is outside of the case, in which case axial loads do not act on bearings 15 and 14.

The locking of the collector 3' takes place by means of gearwheel transmission, which includes the circumferential toothing 43 in the collector 3', the gearwheels 44 and 45 secured to the crankshaft, toothed ring 46 belonging to the case, and the adjustment gearwheel 47 equipped with handle 48. The toothed ring 46 can at first be thought of remaining in place, when the gearwheels 45 and 44 of the gearwheel transmission transmits the rotation of the case to the collector ring 3' at the same angular velocity. Here, however, the toothed ring 46 of the case is attached to the case in such a way that it can be rotated and it can be adjusted by means of gearwheel 47 by turning it by handle 48. Suitable control devices, which are not shown here, are attached to this handle 48. By means of these control devices the gearwheel 47 and thus the toothed ring 46 can be turned, when at the same time the collector ring 3' can be rotated in the desired way in relation to the case. A turning is then obtained in the correct direction depending on the direction of rotation and the turning can be even controlled in such a way that the position of the collector ring 3' remains continually at the point of equilibrium during the entire revolution.

Figure 10 shows another alternative way of using an intermediate device of a fixed dimension in order to lock the collector ring 3'. Here the same reference numbers as above are used for similar parts, these being: case 1, crankshaft 2, collector ring 3', hydraulic cylinder 4, its case 11, piston 12, and piston rod 10.

Here the lower end of the hydraulic cylinder 50 is shaped in such a way that spring 51, which is loaded only at the end of the stroke, fits beneath the piston. This levels out the locking event considerably when compared to the aforementioned forms of application in Figure 8.

The forms of application in Figures 11 and 12 show a new method of locking the collector ring and a hydraulic oil distribution device. Here too the same reference numbers as above are used for the operationally similar components, these being: case 1, crankshaft 2, its bearing axles 32 and 7, collector ring 3', hydraulic cylinder 4, its case
11, piston 12, piston rod 10, its jointing 9, the lower end 30 of the hydraulic cylinder, and the axle pin 31. The collector ring 3' includes a lug 52 in which there is a link 58. The axle pin 31 of the upper hydraulic cylinder 4 is adapted to fit this link 58, the length of which corresponds to the length of stroke. The collector ring can then rotate round the ring along with the crankshaft 2, but it does not turn in relation to case 1. Because the initial turning of the collector ring is set in the region of the position of equilibrium, the remainder moment is small nor does the lug have to withstand large forces. In this case the lug is set at a fixed angle, when a change of direction is not possible. A motor that changes direction of rotation can, however, easily be created in such a way that the lug is jointed to turn to a limited extent, for example \( \pm 9^\circ \), and it is secured to an extreme position in accordance with the direction of rotation by means of a hydraulic cylinder.

The hydraulic oil distribution device 53 is suitable for low revolution pump and motors. The distribution device 53 consists of a valve block 57, which contains hydraulic oil feed and return channels 18 and 18' as well a spring-loaded spindle valve 55 for each cylinder, the feed openings of which are each connected by separate hoses 56 to each cylinder through the cylinder axle pin 31 and the end section 30. The spindle valves 55 are operated by a counter-wheel 54 attached to the axle end 7, and which is raised for about half of the diameter. By means of this each spindle valve is pressed inwards by turning 170', when the corresponding hydraulic cylinders are connected to the feed line and correspondingly the protruding spindles direct the hydraulic oil from the cylinders to the return channel.

As has been seen above, the difference of angle of the position of equilibrium is not constant, but oscillates on either side of an average value. One attempt is to entirely remove the torque that affects the collector member, when it should follow precisely the difference of angle of equilibrium in relation to the case during rotation. Another attempt, which is generally in contradiction to the first is to achieve an even volume of flow, when an even output moment is obtained from a motor, and an even output is obtained from a pump. In both cases in order to achieve the objective the collector member should rotate under forced control or by means of a control circuit in a manner corresponding to the stated objective. This control requires a sensor device,
by means of which the relative positions of the case, collector member, and crankshaft can be ascertained.

In the previous form of application the collector member has always been a ring type in that it is attached to the crankshaft by bearings. A wheel attached to the crankshaft by bearings in accordance with Figures 13 - 19 can, however, also be used as a collector member. In the form of application shown in Figures 17 and 18 cranks 2', which are attached to the case by bearings by means of the axles 7', correspond operationally to a crankshaft. Wheels 3", which here are formed of short lengths of axle, and which are used as a collector member, are attached by bearings to crank 2'. Axle pins 69, which act as a joint 9' together with the end of piston rod 10, are attached to the circumference of the opposite collector wheels 3". In this way the ends of the piston rod are brought very close to the centre of the crankshaft, when the moment of rotation of the collector wheel 3" is reduced and at the same time the swinging of the cylinders can also be minimized. This arrangement comes into question especially in a high-revolution pump.

Figure 15 shows another example of the form of the collector wheel 3". Here collector wheel 3" recalls the aforementioned collector rings, because a protrusion that is operationally similar to the aforementioned wheel is formed in the axle of the combined collector wheel 3", the ends of the piston rod 10 being attached to this by means of joints 9. Here too the collector wheel 3" is attached by bearings to the opposite cranks 2", which here form operationally the said crankshaft.

Because the forces acting on the crankshaft are extremely great, it is constructionally advantageous to make the crankshaft as far as possible as one piece. Figure 20 shows one solution for bringing the joints 9 of the piston rods as close as possible to the centre of a crankshaft 2 of this kind. Here components that operationally have been dealt with previously are given the same reference numbers, i.e. crankshaft 2, collector ring 3', piston rod 10 and its jointing 9, eccentric plate 20, and crankshaft bearing axles 32 and 7. Here the halves 67 of the collector ring 3' as a first pair, the crankshaft 2, and as a second pair the pin 68 of the piston rod 10 are manufactured in such a way
that bearing metal pairs are created directly. Suitable lubrication, for example splash
lubrication or pressure lubrication can be combined with this solution.

Figures 17 and 18 show still another form of application of a hydraulic motor equipped
with pulling cylinders, in which a construction is used that deviates from that used in
previous versions and in particular uses the principle in accordance with section B of
Figure 1. This case is one of a double row motor. Here too the same reference
numbers as previously are used for operationally similar components, these being case
1, its bearings 14 and 15, crankshaft 2, its eccentric plate 20 and bearing axles 32 and
7, hydraulic cylinder 4, piston rod 10, and jointing 13 of the hydraulic cylinder 4 to the
case 1. Here the collector member 3 of the forces is formed by the ring series which
holds the ends 74 of the piston rods 10, together with the rolling bearings of the pins
74. In this case the outer rings 76 are attached to the eccentric plates 20 of the
 crankshaft 2, but they may also be freely rotating if suitably shaped. In the centre there
is a freely rotating ring 73 equipped with a support rib. Between these there remains
an opening the width of a piston rod 10. The lateral pin 74 of the piston rod 10 is
equipped with sleeve bearings 75, which are free to roll along the internal circum-
ference 77 of rings 76 and 73. This arrangement means that each cylinder takes up its
own equilibrium angle of difference independently of the others. The pulling forces of
the cylinders travel continually through the centre of the crankshaft. The ring series
collects the cylinder forces and transfers the resultant force given by them to the
 crankshaft.

The ring surfaces need not be continuous if the rings rotate, because the movement
of the sleeves circumferentially is only 10° - 20°, depending on the case. In addition the
ring surfaces can be shaped to deviate from the cylindrical, if it is desired to
advantageously alter the direction of the forces, among other things in order to even
out the moment.

When used in a motor a construction of this kind gives a more even moment curve
than previously and correspondingly in pump use the flow volume is more even. The
optimal feed and return phases are located more simply than in the other versions
shown, i.e. symmetrically at the 0° and 180° sides.
Figures 19 and 20 show yet another radial piston eccentric motor, which corresponds to the case in section C of Figure 1. Here too the same reference numbers as previously are used for operationally similar components, these being: case 1, hydraulic cylinder 4, its casing 11, piston 12, piston rod 10, and feed and return lines 18 and 18'.

In contrast to all the previously shown forms of application the eccentric force collector member is here located in the case and is formed of eccentric plate 20, the circumference surface of which is formed by rolling surface 83. In this case the axle is straight and is marked by reference number 7 and the case is suspended from it by means of bearings 14 and 15, as previously. Here the force collector member 3 is mainly formed by the eccentric rolling ring surface 83.

Here the construction is somewhat complicated, because the pulling member used is formed by thrust cylinders and the related auxiliary mechanism. Ring plates 87 and 88, which carry the cylinder cases are attached to axle 7, their lower ends having specially formed end pieces 85. These include pins 80 adapted to the aforesaid ring plates 87 and 88. The cylinders 4 are free to swing on these pins 80. The lateral bar 86 attached to the pin 10 of the piston rod is able to move inside the above end piece 85 and it pulls the bridge piece 81 by means of the bolts 81. This is free to slide outside of the cylinder casing and has attached to it ball bearings 82, which are arranged to roll along the rolling surface 83 of the eccentric plate 20, which is attached to case 1.

Auxiliary distribution plate 91 is installed inside axle 7 for the feed and removal of oil, in between feed plate 7 end plates 92 of distribution plate 6. The are locked in place by means of retaining rings 93. Auxiliary distribution plate 91 and distribution plate 6 are immovably attached to axle 7. Feed plate 7 on the other hand rotates with case 1, to which it is attached by means of plate 98 and axle 99. Pipes going through ring plate 87 are connected to distribution plates 6. Hoses 29, one end of which is connected to the feed connection of the cylinder are connected to the pipes on the outer circumference of the disc.

As has been stated above, in this case the cylinder mechanism pulls the bearings 82 against the rolling surface 83. This could also have been realized directly by changing
the direction of the piston rod and connecting it directly to the bridge 81. By means of the construction shown the sealing of the piston rod is avoided.

Figure 21 shows the construction of the distribution plates in greater detail. The construction of feed plate 5 and distribution plate 6 corresponds essentially to the construction of the form of application in Figure 3. In this case the feed plate 5 is, however, rotated by means of the axle and high-pressure oil is fed to it through the permanently attached auxiliary distribution plate 91. The feed and return pipes 18 and 18' are connected to the connections 95 and 95' of the auxiliary distribution plate 91. From these channels are led to concentric channels 96 and 96' on the opposite side. In feed plate 5 there are opposing eccentric channels 97 and 97', from which there are channels leading to the distribution level proper, in which there are feed and return grooves 23 and 23'. As in the form of application in Figure 3, here too the distribution plate includes openings 25 that travels along the circumference of the grooves 23 of the distribution plate, and which lead to the feed pipe of each cylinder, these being connected to the connection 26. In distribution plate 6 there are cylinder bores 24 on the opposite side, in which pistons are used in a manner corresponding to that in the form of application in Figure 3, which, when they are pressed against end plate 92, create an internal reaction force in the distribution plate, by means of which the distribution plate 6, the feed plate 5, the auxiliary distribution plate 91, and the opposing end plate 92 press tightly against one another.

In a motor of this form of application the critical component from the point of view of strength and durability, i.e. the ball bearings that roll along the circumference surface 83, can be located on the outer circumference, and they can be made quite large without the size of the motor having to be increased on account of this.

Figures 22 - 25 show another radial piston eccentric motor corresponding to the use in accordance with section C of Figure 1. Here too the operationally similar components are given the same reference numbers as above in Figures 19 - 20, these being case 1, axle 7, ring plates 87 and 88, bearings 14 and 15, rolling ring surface 83, rolling bearings 82, hydraulic cylinder 4, its case 11, piston 12, piston rod 10, feed and return lines 18 and 18', distribution and feed plates 91, 5, and 6, feed plate turning axle
99, end plate 98, and connection hoses 29. Here too the force collector member 3 is formed mainly of the eccentric rolling ring surface 83.

In this case too each hydraulic cylinder 4 forms a mechanism implemented by means of the thrust cylinders, which pull together the rolling ring surface 83, locking case 1 and operational joints 80 connected to axle 7. Unlike in Figures 19 and 20, the operational joint 80 is not formed by an actual pin held by bearings in a fixed place, but is formed by the combined action of the segment 104 of the sliding ring surface 107 attached to axle 7 and sliding shoe 106 attached to the hydraulic cylinder case 11. By means of this method the operational joints 80 are brought closer to the centre line of axle 7 than when using ordinary joint bearings.

Bridge piece 105, the protruding edges of the sides of which include the aforesaid sliding shoes 106, is attached to the lower end of case 11. In this case too axle 7 includes ring plates 87 and 88, the outer edges of which here include flanges 103. Internal segments 104 are attached to these at each cylinder. Pulling piece 111, which forms a bogie with sequential rolling bearings 82, gives a very large settling power to the sliding shoe 106 by means of the determining sliding shoe of segment 104.

Here the supporting structure formed by bogie 111 gives considerable assistance to the joint to settle in a stable position.

Some cylinder may suffer a loss of pressure because of a pipe fracture or other cause. In case of this a support ring, which prevents them from detaching from segment 104, can be used beneath bridge pieces 105.

Rolling bearings 82 are fitted to axle pins 110, which are attached to pulling piece 111, the lower part 112 of which rotates beneath the piston rod 10 and arch piece 113. Arch piece 113 creates such a form in the lower part 112 of pulling piece 111 that it carried all loads purely as tensile stress, and shear stress does not appear at all. Axle pins 110 extend partly cut beside cylinder case 11 from the first rolling bearing 82 to the corresponding bearing on the other side, Figure 24. There is also a partly cut sleeve
120 set on top of axle pins 110, which prevents the upper part of pulling piece 111 from bending against one another.

Each rolling ring surface 83 is formed of a ring attached eccentrically to plate 101. Plate 101 is secured to loops 109 of case 1 by means of adapted pins 108 and adjustment plates 89, which are further attached to one another by means of cover plate 100. The adjustment of the eccentric is described in greater detail later.

The hydraulic oil distribution equipment is nearly the same as in previous cases. The adjustment of the eccentric, however, influences the dead point of the cylinders, when end plate 98 rotated by feed plate 5 is turned in relation to case 1 by means of lever 115 connected to pin 108.

A stepless gearbox can be very simply arranged for a motor of this kind by altering the length of stroke by means of internal eccentrics. Figure 25 shows the construction of an eccentric adjustment gearbox and three adjustment positions simplified. Part of case 1 and its loop 109 formed in the side plate are marked in the Figure. The adjustment eccentric ring 89 is set farthest out and once brake device 114 is released it is free to rotate inside case 1 round the centre point 119 of this. Inside the adjustment eccentric ring 89, against the sliding ring surface 116, is plate 101, which carries ring 102 forming rolling ring surface 83. Plate 101 includes pin 108 set in loop 109 of case 1, which prevents plate 101 from rotating in relation to the case.

A particularly advantageous adjustment geometry is achieved by setting the centre point 117 of sliding ring surface 116 that lies against adjustment eccentric ring 89 to the side of the straight line between the pin 108 and the centre point 118 of the rolling ring surface 83. The figure shows, by means of an arrow against the rolling ring, the upper dead centre, the place of which varies but little in the adjustment region -51° - +51° of the adjustment eccentric ring.

When applying the invention to a low-revolution pump the hydraulic oil distribution devices become very simple. At the same time it is easy to create two separate circuits, which is often necessary. In Figure 26 the feed channels are marked by \( T_2 \) and \( T_1 \) and
the high-pressure output channels by P₂ and P₁. The cylinders used by circuits 1 and 2 alternate in the direction of the circumference, in order to even the loading. In each circuit the feed and return lines are connected to the cylinders by means of one-way valves 70 and 71, which permits flow from the feed lines to the cylinders and correspondingly from the cylinders to the pressure lines.
Patent Claims

1. A method in a radial piston eccentric motor/pump, which consists of
   - a ring structure (1') and an axle (7) as an opposing member rotating in relation to it in bearings,
   - a joint ring formed of first joints (13') and set centrally in relation to the axle, secured in one of these opposing members, and an eccentrically set force collector member (3) in the other member,
   - second joints (9') on the force collector member (3) and supported on this,
   - several essentially radially set separate linear force members (4'), each secured to the first and second joints,
   - operating medium distribution devices (5, 6) to connect the feed and return lines to the aforesaid linear force members (4') at regular intervals,
   characterized in that each first and second joint is pulled by the linear force member (4') and that the second joints (9') on the force collector member (3) are permitted to move around the centre point of the force collector member, either secured to one another or separately.

2. A method in a radial piston eccentric motor/pump, which consists of a ring structure (1'), a crankshaft (2) rotating in bearings in relation to it, a collector member (3) rotating in bearings in relation to this, several essentially radially set separate linear force members (4') jointed to both the collector member (3) and the ring structure (1'), operating medium distribution devices (5, 6) to connect the feed and return lines to the aforesaid linear force members (4') at regular intervals, characterized in that the force collector member (3) is forced into such an angle $\alpha$ in relation to the ring structure that the rotational moment of the collector member (3) diminishes or vanishes completely.

3. A radial piston eccentric motor/pump intended to implement the method in accordance with Patent Claim 1, which consists of a ring structure (1'), a crankshaft (2) rotating in bearings in relation to it, a collector member (3) rotating in bearings in relation to this, several essentially radially set separate linear force members (4') jointed to both the collector member (3) and the ring structure (1'), operating medium
distribution devices (5, 6) to connect the feed and return lines to the aforesaid linear force members (4') at regular intervals, characterized in that all or most linear force members (4') are arranged to operate only on the pulling side, in which case the resultant force of the linear force members tends to always pull the collector member (3) into a position of stable equilibrium.

4. A radial piston eccentric motor/pump intended to implement the method in accordance with Patent Claim 2, which consists of a ring structure (1'), a crankshaft (2) rotating in bearings in relation to it, a collector member (3) rotating in bearings in relation to this, several essentially radially set separate linear force members (4') jointed to both the collector member (3) and the ring structure (1'), operating medium distribution devices (5, 6) to connect the feed and return lines to the aforesaid linear force members (4') at regular intervals, characterized in that the radial piston eccentric motor/pump includes mechanical locking members (40, 43 - 47) jointed to the ring structure (1') to lock the collector member (3) into such an angle $\alpha$ in relation to the ring structure that the rotational moment of the collector member (3) diminishes or vanishes completely.

5. A radial piston eccentric motor/pump in accordance with Patent Claim 4, characterized in that the collector member (3) includes a radially directed protrusion (52), in which there is a loop (58) and that a pin (31) fitting the loop is attached to the ring structure (1'), this preventing the collector member (3) from rotating.

6. A radial piston eccentric motor/pump in accordance with Patent Claims 3 or 4, characterized in that between the ring structure (1') and the collector member (3) one or more springs (41, 51) are installed to prevent the collector member from rotating in relation to the ring structure.

7. A radial piston eccentric motor/pump in accordance with Patent Claims 3 or 4, characterized in that between the ring structure (1') and the collector member (3) there are pulling devices of a predetermined length jointed at both ends covering the entire circumference, for example cables (42), chains, or telescopic members, each one
of which in turn at its greatest extension pulls on the collector member in order to limit its rotation to a predetermined value.

8. A radial piston eccentric motor/pump in accordance with Patent Claim 4, characterized in that the motor/pump includes gearwheel transmission (43 - 48) installed between the ring structure (1') and the collector member (3), and which is arranged to create the above-mentioned locking.

9. A radial piston eccentric motor/pump in accordance with Patent Claim 4, characterized in that the mechanical locking devices consist of a telescopic member installed between the ring structure (1') and the collector member (3), for example one of the aforementioned cylinders, which is connected to the collector member in such a way that it carries a moment.

10. A radial piston eccentric motor/pump in accordance with one of Patent Claims 3 - 9 characterized in that the collector member (3) is composed of a ring (3') attached to the crankshaft (2) in bearings eccentrically in relation to the ring structure (1').

11. A radial piston eccentric motor/pump in accordance with Patent Claim 10, characterized in that the above ring (3') is manufactured from bearing metal in such a way that it forms directly a sliding bearing metal pair both with the crankshaft (2) and the pin of the piston rod (10).

12. A radial piston eccentric motor/pump in accordance with one of Patent Claims 3 - 9, characterized in that the collector member (3) is composed of a wheel (3'') that is attached to the crankshaft (2) by bearings eccentrically in relation to the ring structure (1').

13. A radial piston eccentric motor/pump in accordance with one of Patent Claims 3 - 9, characterized in that it is adapted as a so-called hub motor, i.e. the ring structure (1') formed by the case (1) rotates while the crankshaft (2) remains stationary and the hydraulic oil feed and return lines (18) are led to a feed plate (5) secured to the crankshaft (2) and through it to a distribution plate (6) that rotates with the collector
member (3), this distributing hydraulic oil to each cylinder (4) in its working phase and correspondingly collects hydraulic oil to the return line from the cylinders in the rest phase.

14. A radial piston eccentric motor/pump in accordance with one of Patent Claims 3 - 9, characterized in that the pressure medium distribution devices consist of a distribution plate (6) secured to the ring structure/collector member (1', 3) and a feed plate (5) secured to the crankshaft (2), and that the motor/pump includes an operating device (19) which is arranged to turn the feed or distribution plate (5, 6) to the side from a symmetrical position to the amount of a selected angle, by means of which the rotation of the distribution member in relation to the ring structure is taken into account in the feed and removal of the pressure medium.

15. A radial piston eccentric motor/pump in accordance with one of Patent Claims 3 - 9, characterized in that the pressure medium distribution devices consist of a distribution plate (6) secured to the ring structure/collector member (1', 3) and a feed plate (5) connected to the crankshaft (2), and that the feed/distribution plate (5, 6) includes small pressure medium cylinders (24) equipped with pistons (17) formed on the opposite side in relation to the distribution/feed plate (6, 5), which are arranged to push the opposing plate (5, 6) against one another and each of which hydraulic cylinders (24) is connected to a groove (23, 23') on the corresponding feed or return side.

16. A radial piston eccentric motor/pump in accordance with Patent Claim 8, characterized in that the above gearwheel transmission (43 - 45) includes a wheel equipped with an internal circumferential tooth ring that rotates at least to a limited extent and its turning mechanism (47, 48) as well as operating devices for adjusting the internal tooth ring (46) to correspond to a desired rotational function of the collector member (3).

17. A radial piston eccentric motor/pump intended to implement the arrangement in accordance with Patent Claim 1, which consists of
- a ring structure (1') and an axle (7) as an opposing member rotating in relation to it in bearings,
- a joint ring formed of first joints (13') and set centrally in relation to the axle, secured in one of these opposing members, and an eccentrically set force collector member (3) in the other member,
- a rolling/sliding ring surface (77, 83) formed centrally to the force collector member (3) and rolling/sliding components (75, 82) supported on this,
- several essentially radially set separate linear force members (4') each attached to the first joint and to the rolling/sliding component (75, 82),
- operating medium distribution devices (5, 6) to connect the feed and return lines to the aforesaid linear force members (4') at regular intervals, characterized in that the rolling/sliding ring surface (77, 83) and the rolling/sliding components (75, 82) as well as the linear force members (4') are formed in such a way that by means of each linear force member (4') the first joint and the rolling/sliding component (75, 82) are pulled.

18. A radial piston eccentric motor/pump in accordance with Patent Claim 21, characterized in that the eccentric rolling/sliding ring surface (77) is arranged as an internal surface to the axle, when the traction members (4) are jointed to the ring structure (1').

19. A radial piston eccentric motor/pump in accordance with Patent Claim 21, characterized in that the eccentric rolling/sliding ring surface (83) is arranged as an external surface to the ring structure (1'), when the traction members (4) are jointed to the axle (7).

20. A radial piston eccentric motor/pump in accordance with Patent Claim 19, characterized in that it includes an adjustment eccentric plate (89) arranged to rotate in relation to ring structure (1'), inside of which a ring-like plate (101) carrying the aforesaid eccentric rolling/sliding ring surface (83) is located in such a way that by turning the adjustment eccentric the eccentricity of the rolling/sliding ring surface (83) is altered in relation to the ring structure (1').
21. A radial piston eccentric motor/pump in accordance with Patent Claim 20 characterized in that the ringplate (101) carrying the rolling/sliding ring surface (83) is secured to the ring structure (1') by means of a pin/loop (108, 109) attachment and that the centre point (117) of the sliding ring surface (116) moving the rolling/sliding ring surface (83) of the adjustment eccentric plate (89) is located to the side of the straight line between the pin (108) and the centre point (118) of the rolling/sliding ring surface (83).

22. A radial piston eccentric pump in accordance with one of Patent Claims 3 - 9 or 17 - 21, in which hydraulic cylinders are used, characterized in that several hydraulic cylinders (4) are connected to a common feed line (T₁, T₂) and to a common pressure line (P₁, P₂) by means of separate one-way valves (70, 71).

23. A radial piston eccentric motor in accordance with one of Patent Claims 3 - 9 or 17 - 21, characterized in that each linear force member (4') is one of the following: a hydraulic cylinder, a pneumatic cylinder, a steam-operated cylinder, a combustion engine cylinder, or an electrically-operated spindle motor.

24. A radial piston eccentric motor/pump in accordance with one of Patent Claims 3 - 9 or 17 - 21, in which the linear force members (4') consist of hydraulic cylinders, characterized in that the full working surface area of each cylinder of the motor/pump at the real extreme distance R from the axis of rotation is between \(1,01\ldots1,10 \times R_c\), in which \(R_c\) is defined as follows:

\[
R_c = \sqrt[3]{\frac{27q}{4\pi N \tan \left(\frac{180^\circ}{N}\right)^2}}
\]

in which \(q\) is the revolution volume

\(N\) is the number of cylinders

\(c\) is the effective working surface share of the theoretical total cross sectional area, and by means of which note is taken of the surface areas and forms of the piston rod and cylinder wall as well as the double sided working surface area of a double-acting cylinder.
25. A radial piston eccentric motor/pump in accordance with Patent Claim 24, in which the cylinders (4) are secured to the collector member (3), characterized in that the piston rod (10) is jointed to the collector member (3) and the cylinder cases (11) are jointed to the case (1) at the piston rod (10) side end.

26. A radial piston eccentric motor/pump in accordance with Patent Claim 24, in which the cylinders (4) are secured to the collector member (3), characterized in that the piston rod (10) is jointed to the collector member (3) and that the end of the cylinder cases (11) on the piston rod (10) side is formed as a cone or other wise narrower than the working diameter, when greater length is obtained for the seal (39) of the piston rod (10) without adjacent cylinders (4) being pushed into the same area.

27. A radial piston eccentric motor/pump in accordance with one of Patent Claims 3 - 9 or 17 - 21, characterized in that it includes devices, for example a throttle valve controlled at intervals in accordance with the rotation to control the feed pressure or return side pressure in such a way that the output moment is as even as possible.

28. A radial piston eccentric motor/pump in accordance with Patent Claims 3 or 17 - 21, characterized in that the piston rods (10) are manufactured from a flexible material, for example cable which is composed of metal, carbon or other reinforced fibre.

29. A radial piston eccentric motor/pump in accordance with Patent Claims 3 or 17 - 21, characterized in that the pulling linear force member (4') is formed of a thrust cylinder (4) and an auxiliary mechanism.

30. A method in accordance with Patent Claim 2, characterized in that one or more return-line side linear force members (4') are controlled dynamically during the period of the rotational movement in order to keep the collector member (3) at the aforesaid angle in relation to the case.
INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)\textsuperscript{6}

According to International Patent Classification (IPC) or to both National Classification and IPC
IPC5: F 03 C 1/04, F 04 B 1/04

II. FIELDS SEARCHED

Minimum Documentation Searched\textsuperscript{7}

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Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched\textsuperscript{8}

SE, DK, FI, NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT\textsuperscript{4}

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\*A* document defining the general state of the art which is not considered to be of particular relevance
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\*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.
\*Z* document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search
12th February 1992

Date of Mailing of this International Search Report
1992 - 02 - 14

International Searching Authority

SWEDISH PATENT OFFICE

Signature of Authorized Officer

Sune Söderling
ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/FI 91/00338

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 30/11/91. The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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