March 19, 1957 O. NÜBLING 2,785,637

OIL PUMPS OPERATING ON THE DISPLACEMENT PRINCIPLE

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Fig. 1

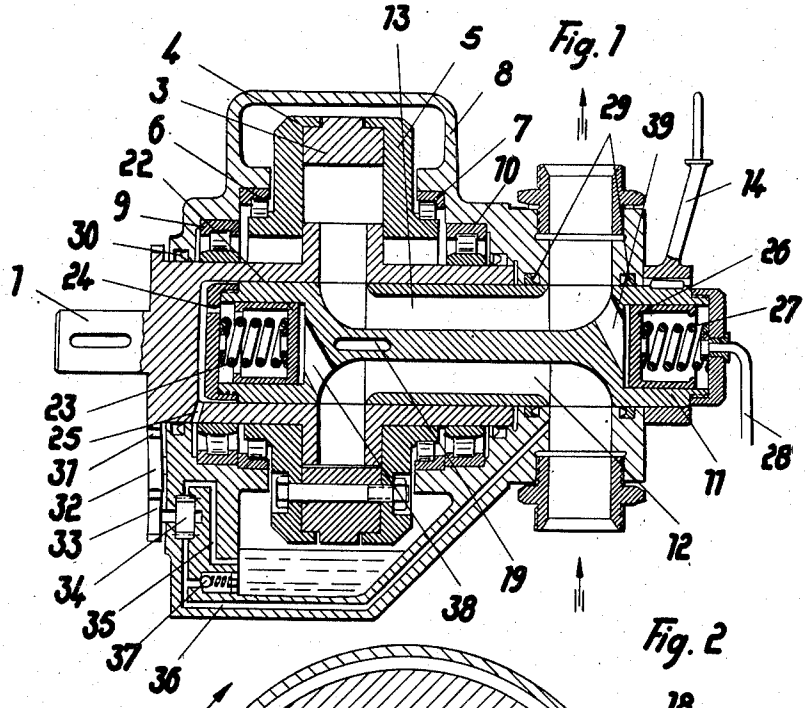
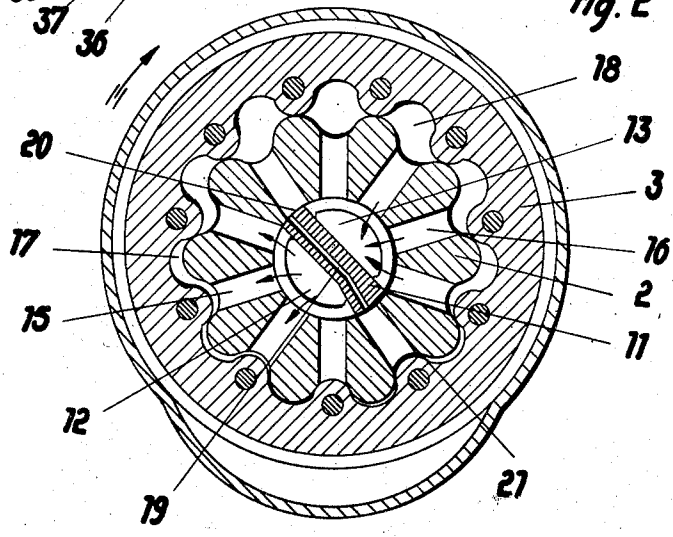


Fig. 2



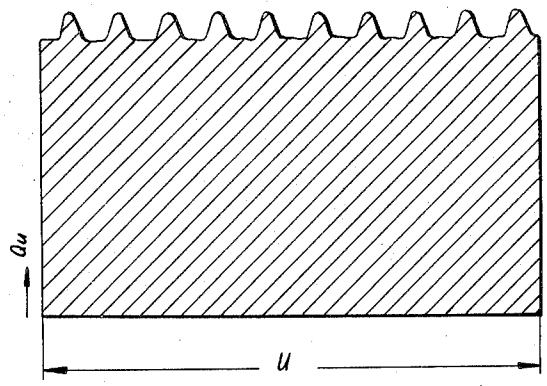
Inventor:
Otto Nübling
By Ernest G. Montague
Attorney

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OIL PUMPS OPERATING ON THE DISPLACEMENT PRINCIPLE

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Fig. 3



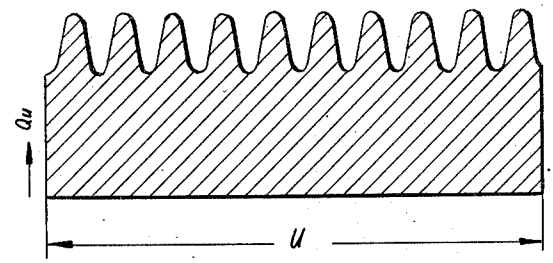


Fig. 4

Inventor:
Otto Nübling
By Barnes & Thornburg
Attorney

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OIL PUMPS OPERATING ON THE DISPLACEMENT PRINCIPLE

Otto Nübling, Berlin-Frohnau, Germany, assignor to Hanomag Aktiengesellschaft, Hannover-Linden, Germany, a corporation of Germany

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Claims priority, application Germany May 15, 1954

3 Claims. (Cl. 103—120)

The present invention relates to hydraulic pumps and motors operating on the displacement principle, in which the oil supply is gradually controllable by turning a rotatably adjustable valve arranged inside the driven or driving shaft. It is known to form the operating chambers from where the oil is displaced, through means of gears, one of which being an internally toothed outer gear which is in mesh with an externally toothed inner gear. Through channels provided in the inner gear the oil is passed into the operating chambers. In this embodiment the distance of the bearings for the outer and the inner gear and the size of the operating chambers are not variable. When controlling a small volume of oil, a quantity of the displaced oil rotates between the operating chambers without doing effective work. The other part is supplied and, respectively, discharged through the hollow control valve.

In such pumps it is necessary to fill the operating chambers completely. If this is not done the operating chamber is filled completely only after it becomes connected with the pressure side. Considerable pressure variations, increased noise, and a reduced output and low efficiency are the result.

To improve the filling operation it has been proposed to pre-compress the oil in the system by a filling pump. A comparatively small filling pump will do this. Its dimensions should be slightly greater only as is necessary to replace the volume of leak oil.

In such gradually controllable rotary pumps small oil volumes can also be supplied at high speeds when the rotatable adjustable valve is disposed accordingly. Thereby it is difficult to fill and empty the operating chambers which pass over the sealing control ledges of the rotatably adjustable valve. It has therefore been proposed to fill the operating chambers which are shut off on the suction side, through means of a transverse channel provided in the control valve. On the pressure side the control ledges are dimensioned so that the pressure in the shut off operating chamber does not increase excessively.

When the oil speed in the feed lines is low such design will suffice. In pumps with higher speeds this arrangement is not sufficient for the following reasons: Due to the transverse channel a small oil volume is periodically diverted to fill the opposite shut off operating chamber. If, for instance, there are ten operating chambers this action takes place ten times per revolution. When the pump and the motor are set up separately the complete system contains a comparatively big volume of oil. Due to its inertia the oil is not able to follow the fluctuations in the oil stream at higher speeds. Thus, the oil stream on the suction side breaks off continuously so that the oil chambers cannot be filled completely, although the suction chambers are filled to a great extent due to the above described action of the transverse channel.

At maximum oil supply the rotatably adjustable ledges of the control valve are lying in the direction of eccentricity. Since the operating chambers disposed in the direction of eccentricity show the smallest change in their

volume, the action of the transverse channel at maximum oil supply is not as effective as it is under part load when the operating chambers, shut off by the control ledges, are subjected to a great variation of their volume per unit of time. Thus, the variation in the oil supply under part load is much greater than under full load. The noise is correspondingly greater, and the efficiency is lower when by means of the rotatably adjustable valve the oil supply is reduced. It is one object of the present invention to eliminate this deficiency by providing the rotatably adjustable valve with spring-loaded pistons of the following characteristics:

(1) They are arranged as close as possible to the control ports in the rotatably adjustable valve.

(2) The diameter of each piston is as large as possible, and the stroke is comparatively short.

(3) Spring-loaded pistons are arranged on both the suction and the pressure side. The following is achieved with such arrangement: The oil in the oil lines flows at a steady rate. The periodically varying oil volume taken in by the gears is supplied to the ports on the suction side by means of the spring-loaded piston. Due to the pre-compressing action of the filling pump the spring-loaded piston is in an intermediate position. If the gears suck in more oil than supplied the difference in volume is pressed into the operating chambers by the piston through means of the spring. On the other hand the oil stream increases the spring tension when the oil supply is bigger than the volume taken in by the gears. Since the piston has to accelerate the oil volume between the piston and the operating chamber, in accordance with the present invention, the spring-loaded piston is arranged at least on the feed side in the rotatably adjustable valve so that the oil volume to be accelerated is as small as possible. Such arrangement in the rotatably adjustable valve allows for utilization of the total diameter of this valve for the piston. Thus, the stroke of the piston becomes very short due to the large diameter. This is of advantage in that a comparatively stiff spring can be installed having a correspondingly high own frequency, and that the spring force at both piston end positions is only slightly different due to the short piston stroke.

It is another object of the present invention to fit a spring-loaded piston also on the pressure side. Since the spring tension has to be calculated for the high pressures on the pressure side it might be necessary, if the available space is limited to arrange the spring-loaded piston outside the rotatably adjustable valve. On the pressure side it is of no great importance that the oil volume to be accelerated is as small as on the suction side, since on the pressure side a correspondingly high pressure for accelerating the oil is available through means of the considerably higher spring force.

With these and other objects in view which will become apparent in the following detailed description, the present invention will be clearly understood in connection with the accompanying drawings, in which:

Fig. 1 is a sectional view through a pump;

Fig. 2 is a cross section through the pump, the rotatable adjustable valve being adjusted to approximately half load;

Fig. 3 diagrammatically shows the varying oil volume per revolution at maximum oil supply; and

Fig. 4 shows the oil volume per revolution when the oil supply is reduced.

Referring now to the drawings, the pump is driven by a shaft end 1 which is fixedly connected to the inner pump gear 2. The shaft is journalled in bearings 9 and 10 inside the housing 8. The internally toothed gear 3 is bolted to the end plates 4 and 5, and with the bearings 6 and 7 arranged eccentrically in relation to the inner gear 2 in the housing 8.

A rotatable adjustable valve 11 is provided in the hollow inner gear 2. By means of channels 12 and 13 the oil is fed and, respectively, discharged through the control valve 11. The channels 12 and 13 are in connection with the ducts 15 and 16 which feed and discharge the oil to and from the operating chambers 17 and 18, respectively. In Fig. 2, with a direction of rotation as shown by the arrow, the chambers 17 suck in the oil, and the chambers 18 press it into the channel 13. Within range of the ducts 15 and 16 the rotatable adjustable valve 11 is provided with control ledges 20 and 21. A traverse channel 19 is arranged in a manner already known, said channel at reduced oil supply filling the chamber which is shut off on the suction side by the control ledge 20, from the pressure side. The rotatable adjustable valve is turned by means of the lever 14 for varying its oil supply. The position of the rotatably adjustable valve in Fig. 2 corresponds to a medium oil supply. The rotatable adjustable valve is journalled oil-tight in the bore of the inner gear 2. In the housing 8 the rotatable adjustable valve is journalled with a certain play. Rubber seals 29, 30 prevent the oil from leaking out of the control valve.

The filling pump 34 is driven by the shaft 1 through means of gears 31, 32, 33. In the sectional drawing the filling pump is illustrated as a small gear-type pump. The oil is sucked from the oil sump provided in the pump housing through the channel 35 and pumped into the suction channel 12 of the rotatably adjustable valve through the channel 35. Sinec the inner gear on its lateral faces between the end covers 4 and 5 is not absolutely oil-tight the leak oil has to be replaced continuously. Thus the filling pump serves a double purpose:

(1) Leak oil is pumped back into the oil line system.

(2) The pump's suction side is subjected to a precompression to positively fill the operating chambers. An overflow valve 37 returns excess oil to the oil sump. The filling pump, however, is not able to balance the varying volume of the oil stream. If, for instance, the oil volume varies by 10%, as in Fig. 4, the filling pump would have to supply 10% more oil to balance such varying oil volume. Under part load, according to Fig. 4, the volume supplied by the filling pump would have to be increased considerably. This would mean a loss in output, since only the smallest part of the oil supplied by the filling pump could be utilized effectively. The biggest part would flow back through the overflow valve to the oil sump.

In accordance with the present invention, this deficiency is eliminated in that on the suction side a piston 22, subjected to the action of a spring 23, acts on the oil passing through the suction channel 12. Through means of the slot 38 the piston chamber is connected with the feed line 12. Due to the action of the filling pump and the overflow valve, respectively, the oil in the suction channel 12 is pre-compressed, the piston 22 is under load, and the tension of the spring 23 increased. If the operating chambers receive more oil than supplied through the channel 12 the piston 22 presses the difference volume into the operating chamber. On the other hand, the piston is moved to the other side and the tension of the spring 23 is increased when the volume of oil taken in the operating chamber sinks below average. The rear side of the oil piston 22 is ventilated through means of the bores 24 and 25.

Similarly, the pressure channel 13, through means of a slot 39, is connected with a piston 26 which is subjected to the action of a spring 27, the rear side of the piston 26 being ventilated by passages 28. Since the frequency of the variations in the oil stream corresponds with the number of operating chambers, high frequencies result at high speeds. The pistons 22 and 26, respectively, thus must be able to balance the varying oil stream. For this purpose it is necessary to have an oil piston diameter as large as possible so that the stroke of

the piston is about a few tenths of a millimeter only. If is within the scope of this invention that the oil piston 22, which is arranged on the suction side, utilizes approximately the entire diameter of the rotatably adjustable valve. This diameter has to be comparatively large to receive the suction and the pressure channel. By arranging the spring-loaded piston 22 in the rotatably adjustable valve 11 it is possible that only a small volume of oil has to be accelerated. Only the oil volume immediately in front of the piston 22 and in the channel 15 has to be accelerated.

While I have disclosed one embodiment of the present invention it is to be understood that this embodiment is given by example only and not in a limiting sense, the scope of the present invention being determined by the objects and the claims.

I claim:

1. In a hydraulic pump or hydraulic motor operating on the displacement principle, a housing, a hollow inner member rotatably mounted in said housing and having teeth on its perimeter defining a plurality of depressed portions thereon, said hollow inner member having an inner chamber bounded by a cylindrical surface and being formed with a plurality of radially extending ducts connecting each of said depressed portions with said inner chamber in said hollow inner member and forming slots in said inner cylindrical surface, and an annular outer member rotatably mounted in said housing eccentrically with respect to said hollow inner member and surrounding the same, said annular outer member having a plurality of inner teeth defining depressed portions on its inner face and meshing with said teeth on said hollow inner member, the number of teeth of said annular, outer member being increased by one tooth over that of said inner member, said depressed portions of said inner and outer members forming chambers successively increasing in volume on one side of said hollow inner member and decreasing in volume on the other side of said hollow inner member during each revolution, in combination, a rotatably adjustable valve turnably mounted in said housing extending into said inner chamber in said hollow inner member fitting therein, said rotatably adjustable valve including an inner transversal wall located in the region of said ducts and dividing said rotatably adjustable valve into two tubular sections, each of said tubular sections being formed with an opening in the region of said ducts for supplying and discharging, respectively, a liquid to said ducts, each opening extending for nearly half of the periphery of said rotatably adjustable valve opposite the opening in the other of said two tubular sections, said openings being located on diametrically opposite sides of said inner transversal wall, said inner transversal wall having diametrically arranged free edge portions extending substantially parallel to the axis of said rotatably adjustable valve and provided with diametrically located sealing faces flush with the outer surface of said rotatably adjustable valve, separating said openings in said two tubular sections and permanently abutting against said cylindrical inner surface of said hollow inner member in the region of said ducts, said sealing faces being adapted to cover opposite ducts during rotation of said inner and outer members, said transversal wall being formed with a transverse channel terminating in said sealing faces and adapted to establish communication between a contracting and an expanding chamber when said sealing faces cover said ducts associated with said last mentioned chambers, one of the said sealing faces being located during turning of said rotatably adjustable valve on the side of said hollow inner member on which chambers of increasing volume are formed, and the other of said sealing faces being located during turning of said rotatably adjustable valve on the side of said hollow inner member on which chambers of decreasing volume are formed, a filling pump disposed in said housing and the discharge side of said filling pump

connected with said chambers of increasing volume, in order to subject the latter to a pre-compression to positively fill said chambers of increasing volume, a liquid sump disposed inside said housing and connected with the suction side of said filling pump for supplying liquid to said filling pump, an overflow valve returning excessive liquid from said filling pump to said liquid sump, a chamber disposed at each end of said rotatably adjustable valve, one of said chambers being directly connected with the suction side of said rotatably adjustable valve, and the other of said chambers being directly connected with the pressure side of said rotatably adjustable valve, a first spring-biased piston reciprocating in said one of said chambers and subjected to pressure in said volume increasing chambers against the action of said first spring and a second spring-biased piston reciprocating in said other of said chambers and subjected to pressure in said volume decreasing chambers against the action of said second spring, the tension of said first spring being chosen to balance said pre-compression on the suction side of said valve, both said pistons being adapted to balance the pressure differences in the volume increasing chambers and the volume decreasing chambers, respectively.

2. The hydraulic pump or hydraulic motor, as set forth in claim 1, in which the diameter of said spring-biased pistons is close to that of said rotatably adjustable valve, in order to reduce the stroke of said pistons to a few tenths of a millimeter.

3. The hydraulic pump or hydraulic motor, as set forth in claim 1, in which said chambers receiving said pistons are vented from the rear side of said pistons to a point of low pressure.

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