HYDRAULIC VARIABLE SPEED GEAR

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Fig. 1.

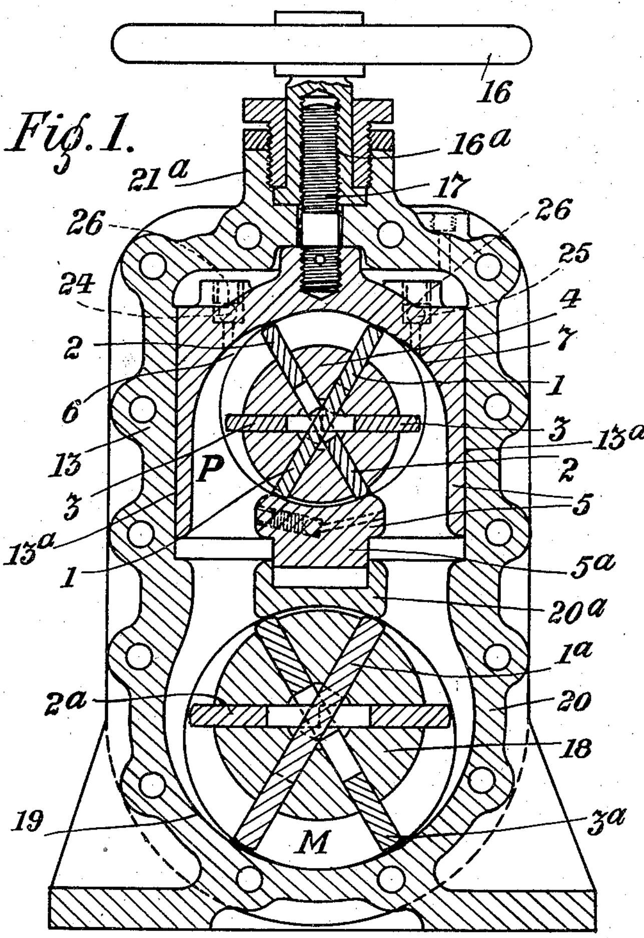


Fig. 3.

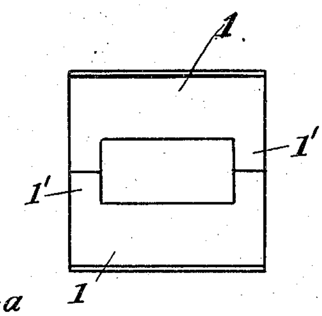


Fig. 4.

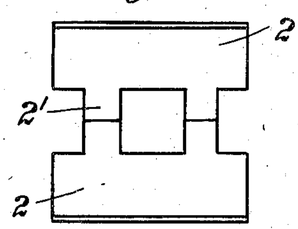


Fig. 5.

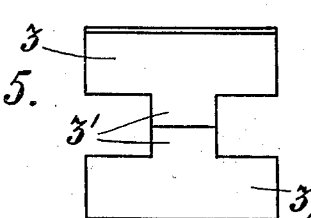
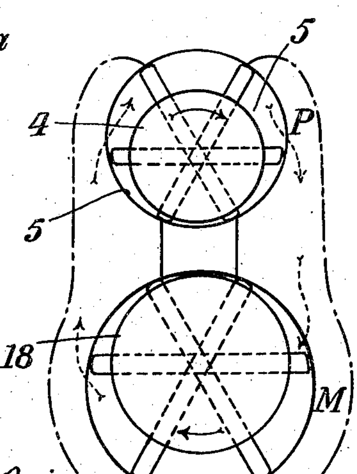


Fig. 6.



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HYDRAULIC VARIABLE SPEED GEAR

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Fig. 2.

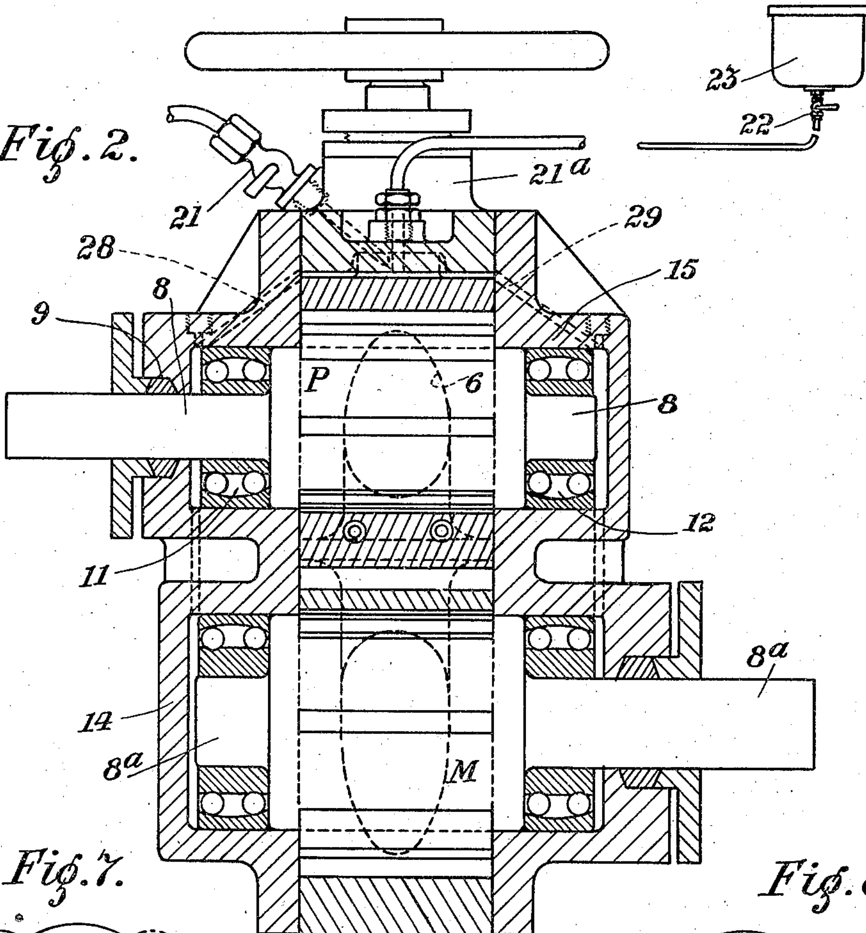
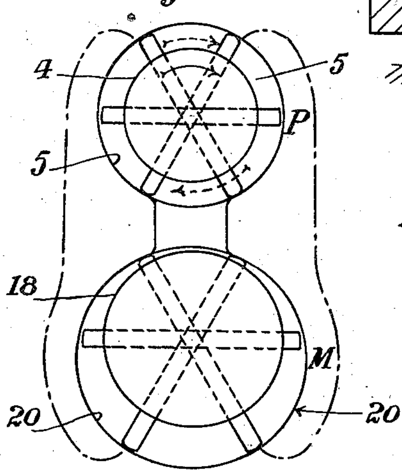


Fig. 7.



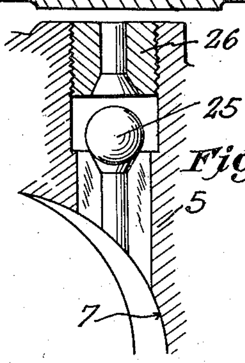
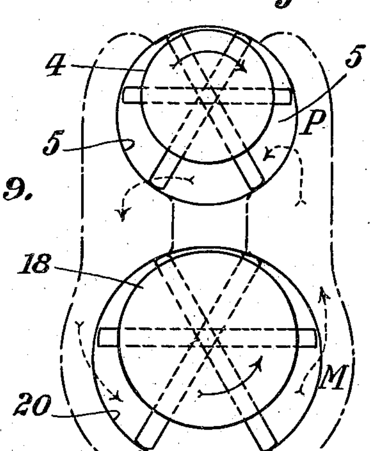


Fig. 8.



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Patented Mar. 29, 1932 1,851,456

UNITED STATES PATENT OFFICE

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HYDRAULIC VARIABLE SPEED GEAR

Application filed August 16, 1928, Serial No. 300,098, and in Great Britain September 2, 1927.

This invention relates to a hydraulic variable speed gear of the class in which rotary vane pumps and motor units are employed and in which the pump unit has an adjustable barrel member which is movable to vary the quantity and direction of the liquid delivered by the pump to the motor whereby variations in the speed and direction of rotation thereof are obtained.

The primary objects of the present invention are to obtain in a gear of the above class uniformity of flow of the liquid and positivity of drive to a greater extent than has been obtainable heretofore, and at the same time to make provisions for the prevention of leakage past the vanes and also for the compensation of internal displacement of the liquid, such provisions being of course contributory to the completeness of the above-mentioned uniformity and positivity.

The above and other objects are attained by the apparatus illustrated in the accompanying drawings, in which:—

Fig. 1 is a transverse section of the hydraulic variable speed gear;

Fig. 2 is a corresponding longitudinal section of the gear;

Figs. 3, 4 and 5 are views of the vanes showing the form which they would take in a unit having three double vanes;

Figs. 6, 7 and 8 are diagrammatic views showing different positions into which the gear may be adjusted.

Fig. 9 is a view to a large scale of a constructional detail.

The gear shown comprises two units, namely a pump unit P and a motor unit M.

The pump unit P includes three double vanes 1, 1 and 2, 2 and 3, 3 which have curved tips and which are slidably mounted in diametral slots formed in a rotor 4. The double vanes are located within the bore of a barrel 5 which is adjustable in a manner to be hereinafter described. The rotor 4 is provided with a driving shaft 8 which extends on one side through a stuffing box 9 to the prime mover (not shown), the shaft ends running in ball bearings 11 and 12. The barrel 5 is a hollow casting and is a sliding fit between the machined surfaces 13ª on the fixed casing 13; it is also a sliding fit between the machined inside faces of two covers 14, 15. The eccentricity between the bore of the barrel 5 and the pump rotor shaft 8 may be adjusted to vary the quantity and direction of discharge by movement of the barrel 5 in a vertical direction. This movement is obtained by rotating a handwheel 16, the spindle of which is formed as a nut 16ª engaging with a stud 17 fitted to the top of the barrel 5.

The double vane 1, 1 shown in Fig. 3 has side extensions 1′ for making contact between the halves (or individual vanes). The double vane 2, 2, shown in Fig. 4, has the extensions 2′ situated a short distance inwards from the sides so as to clear the side extensions 1′ of the double vane 1, 1 when the halves of the vane 2, 2 are brought together. The individual vanes 3, 3 shown in Fig. 5 each have an extension 3′ situated centrally so as to clear the extensions 1′ and 2′ when the halves composing the double vane 3, 3 are brought together.

As will be obvious, any combination of shapes may be adopted for the contacting ends of the halves of each vane, provided that the halves are symmetrical in order to obtain proper balance.

It will be seen that the three double vanes, or a greater number if suitably shaped, intersect one another along a common axis, namely, the axis of the rotor 4. The halves being in contact, the double vanes are each diametrally continuous, so that they transmit diametrally the reactional pressure due to the wedging action of the liquid acting between the bore of the barrel and the curved tips of the vane during the working stroke of each vane. The double vanes can each move in a diametral direction for a small distance independently and clear of each other, so that they can co-operate freely with the working and idle surfaces of the bore of the barrel.

The double vanes are made to gauge, their diametral length being minutely less than the diameter of the working bore of the barrel 5, so that they do not make contact with said bore. The upper and lower parts of the bore extending between the port openings

6, 7 constitute the working surfaces, which are as nearly truly circular as possible. The said bore is enlarged slightly in diameter at the parts of its circumference defined by the port openings 6, 7, the enlarged parts constituting the idle, or non-working, surfaces. The arcs forming this relieved diameter are described from points a small distance to right and left of the centre of the working surfaces of the barrel 5, the said distance being sufficient not only to prevent seizing between the vanes and the barrel on account of the eccentricity of the rotor but also to release the vanes when in the idle position or stroke and so to maintain reactional balance when they are in a position diametric with the suction and discharge ports.

It should here be pointed out that portions of the inner ends of the individual vanes are always in contact and thereby transmit pressure positively and diametrally from one tip to the other of a double vane. The reaction, therefore, due to the wedging action of the fluid seal at the tips of the vanes is equal and opposite, and the fluid pressure due to the head at which the gear is working is also balanced during the working stroke of the vanes. During the idle stroke, the double vanes are not diametrally continuous with the relieved portion of the surface of the bore. Whilst performing the idle stroke, that tip of each vane which happens to be adjacent to the discharge or pressure side of the pump is clear of the adjacent relieved surface. Thus, the pressure due to the pressure head acting upon this tip is balanced by the wedging action of the fluid between the relieved surface diametrally opposite and the opposing tip of the same double vane. Where sealing is required during the working stroke, the vanes are diametrally continuous with the working surfaces of the bore. At no period is the rotor itself employed in conjunction with the bore for the purpose of forming a seal.

As explained beforehand, the reactions due to the wedging action of the fluid upon the vane tips, combined with the pressure on the tips due to pressure head, are equal and opposite during the working stroke. When a double vane rotates past the working surfaces into the idle part of the stroke, that tip of the individual vane which is inclined towards the pressure side of the pump ceases to co-operate with the bore of the barrel. As the double vane is then diametrally across the relieved portion of the barrel, the said tip is free of the bore, and the wedging action of the fluid seal is broken down. The said tip is then subjected only to the pressure head of the liquid. Reaction equal and opposite to this is set up by the wedging action of the fluid upon the opposing tip of the double vane which opposing tip is at the same time co-operating with that portion of the relieved bore or barrel diametrally opposite. The double vanes therefore are balanced by reaction equal and opposite upon their opposing tips or edges at all points during the working and idle strokes, and this condition of balance is maintained at all positions of the rotor relative to the co-operating barrel, no matter what may be the eccentricity.

The rotating parts of the motor unit M are similar to the corresponding parts of the pump unit P, but in the present construction they have been made of larger dimensions in order that the gear may effect speed reduction. Of course, the motor parts might be similar in size to or smaller than the corresponding pump parts.

As shown, the rotating parts comprise a rotor 18, double vanes 1^a, 2^a and 3^a, and a driven shaft 8^a also running in ball-bearings. The bore of the motor barrel is formed at 20 in the stationary gear casing, a part 20^a of which acts as a guide to a projection 5^a on the adjustable barrel 5. As will be obvious, the eccentricity between the rotor 18 and its barrel is constant.

As shown in Figs. 6, 7 and 8, the change of speed and the reversing of direction of rotation is effected by adjustment of the position of the barrel 5 relatively to the pump rotor 4, the directions of rotation of the parts being indicated by arrows in full lines and the direction of flow of the liquid being indicated by arrows in dotted lines. The positions of the parts shown in Fig. 6 are such that the two rotors rotate in the same direction, the rotor 18 rotating at its highest relative speed. Fig. 7 shows the neutral position in which the gear is inoperative, no liquid being discharged and the rotor 18 therefore being at rest. In the position illustrated in Fig. 8, the pump and motor rotate in directions that are opposite to each other, the rotor 18 rotating at its highest relative reverse speed. As will be obvious, the speed of the rotor 18 will vary between the limits of the range defined by the Figs. 6 and 8 positions, since any movement of the volume control barrel above or below the neutral position causes liquid to be delivered to the motor in quantities proportionate to the volume displaced or swept by the vanes of the pump.

Reverting to Figs. 1 and 2, the clearance space shown above the barrel 5 is, in the operation of the gear, continuously flooded with liquid, but air and/or vapour cavities are formed in this liquid seal, mainly when extra demand for fluid is made by the high pressure side upon the low pressure or suction side due to compressibility of the fluid if subjected to higher pressures. Periodically, therefore, an escape cock 21 fitted to a boss 21^a on top of the casing and, at the same time, a cock 22 on a liquid "make-up" vessel 23, are opened by hand. Any air or vapour cavities in the liquid above the barrel 5 will thus pass through the escape cock 21 and will be replaced by liquid from the vessel 23.

Pressure equilibrium between the clearance space on top of control barrel 5 and whichever side of the rotors may be the suction side, at the moment, is maintained by virtue of two ball valves 24 and 25 situated in the crown of the barrel 5. The ball valve 24 or 25 which happens to be on the high pressure side of the gear is kept closed against its upper seating 26, while the valve situated on the low pressure or suction side of the gear normally remains in its lower position (in which position the valve is open) because the pressure at this side remains somewhat similar to that in the clearance space on top of the control barrel 5. Any increase in pressure likely to take place within the suction side of the gear will be insufficient to raise the corresponding valve into its closed position, but should the pressure in this side of the gear momentarily fall below that prevailing in said clearance space, due say to compression of the liquid at the pressure side, then make-up liquid automatically passes from said space through the open valve at the suction side into the gear, thus restoring equilibrium.

As shown, the housings for the ball-bearings 11, 12 within the covers 14, 15 are in communication by way of passages 28 and 29 with the clearance space on top of barrel 5. In consequence, any air leakage from the exterior of the pump through the stuffing boxes of the shaft 8 will pass to the clearance space. However, the tendency of the air to leak into the gear is counteracted by the slight head or pressure of liquid maintained within the clearance space on top of barrel 5.

In practice, the variable speed gear is easy to manufacture with accuracy, it is durable, it is so made that the working fluid is efficiently guided, and it is of compact construction.

The pump and motor units need not be contained in one unitary structure, but may be separate units.

It has been found in practice that the symmetrical double vanes, when carefully machined to leave a minute clearance space between their integral uninterrupted curved tips and the working surfaces of the respective barrels, are subjected by the fluid to a powerful wedging action at their tips, which action forces the individual part-vanes hard together. In consequence, the wedging action is positively opposed, and so an effective seal is created, which effectively prevents leakage of fluid past the vane tips during the working stroke.

We claim:—

1. A hydraulic variable speed gear comprising a pump unit and a motor unit, each including a rotor mounted within a barrel, a plurality of diametral slots in each rotor, two-part symmetrical diametrally continuous vanes slidably mounted in said slots, each vane being machined minutely shorter than the diameter of the barrel which contains it and having its tips shaped to form minute wedge-shaped spaces with working surfaces of said barrel, a casing enclosing both of said units, passages through said casing for conducting liquid between said units, a liquid accommodating space enclosed between said casing and the barrel of one unit, means for effecting relative adjustment between this barrel and its rotor, and valve means in said barrel acting automatically to equilibrate the pressures in said liquid-accommodating space and within said barrel at one side thereof.

2. A hydraulic variable speed gear comprising a pump unit and a motor unit, each including a rotor mounted within a barrel, a plurality of diametral slots in each rotor, two-part symmetrical diametrally continuous vanes slidably mounted in said slots, each vane being machined minutely shorter than the diameter of the barrel containing it and having its tips shaped to form minute wedge-shaped spaces with working surfaces of said barrel, a casing enclosing both of said units, passages through said casing for conducting liquid between said units, a liquid accommodating space enclosed between said casing and the barrel of one unit, means for effecting relative adjustment between this barrel and its rotor, valve means in said barrel acting automatically to equilibrate the pressures in said liquid-accommodating space and within said barrel at one side thereof, a manually operable valve on said casing for discharging when desired air or vapour cavities from the interior thereof, and liquid make-up apparatus communicating with said casing.

3. A hydraulic variable speed gear comprising a unitary casing, a pump barrel adjustably mounted in said casing, a pump rotor journalled in said casing and contained within said barrel, a stationary motor barrel provided in said casing, a rotor journalled in said casing and contained within said motor barrel, a plurality of diametral slots in each rotor, two-part symmetrical diametrally continuous vanes slidably mounted in said slots, each vane being machined minutely shorter than the diameter of the barrel which contains it and having tips shaped to form with working surfaces of the barrel minute wedge-shaped spaces, passages for circulating liquid through said casing between said barrels, means for adjusting said pump barrel so as to vary the quantity and direction of liquid delivered by the pump unit to the motor unit, a liquid-containing clearance space above said pump barrel, and non-return valves in said pump barrel for automatically equalizing the pressures within its low pressure side and said clearance space.

4. A hydraulic variable speed gear comprising a unitary casing, a pump barrel adjustably mounted in said casing, a pump rotor journalled in said casing and contained within said barrel, a stationary motor barrel provided in said casing, a rotor journalled in said casing and contained within said motor barrel, a plurality of diametral slots in each rotor, two-part symmetrical diametrally continuous vanes slidably mounted in said slots, each vane being machined minutely shorter than the diameter of the barrel which contains it and having its tips shaped to form minute wedge-shaped spaces with working surfaces of said barrel, passages for circulating liquid through said casing between said barrels, means for adjusting said pump barrel so as to vary the quantity and direction of liquid delivered by the pump unit to the motor unit, a liquid-containing clearance space above said pump barrel, non-return valves in said pump barrel for automatically equalizing the pressures within its low pressure side and said clearance space, a manually operable valve on said casing for discharging when desired air or vapour cavities from the interior thereof, and liquid make-up apparatus communicating with said casing.

5. A hydraulic variable speed gear comprising a unitary casing, a pump barrel adjustably mounted in said casing, a pump rotor, journal bearings in said casing for supporting said rotor, a motor barrel provided in said casing, passages interconnecting said barrels for circulation of liquid, a rotor in said motor barrel, a plurality of diametral slots in each rotor, two-part symmetrical diametrally continuous vanes slidably mounted in said slots, each vane being machined minutely shorter than the diameter of the barrel which contains it and having its tips shaped to form with working surfaces of the barrel minute wedge-shaped spaces, and passages interconnecting said bearings with said clearance space for the purpose of leading to said clearance space such air as may leak into said bearings, thereby avoiding the entry of said air into the interior of the barrels of the gear.

6. A hydraulic speed gear comprising a unitary casing, a pump barrel adjustably mounted in said casing, a liquid-accommodating clearance space above said barrel and within said casing, a pump rotor, journal bearings in said casing for supporting said rotor, a motor barrel provided in said casing, passages interconnecting said barrels for circulation of liquid, a rotor in said motor barrel, a plurality of diametral slots in each rotor, two-part symmetrical diametrally continuous vanes slidably mounted in said slots, each vane being machined minutely shorter than the diameter of the barrel which contains it and having tips shaped to form with working surfaces of said barrel minute wedge-shaped spaces, valve means in one of the barrels acting automatically to equilibrate the pressures in said clearance space and within the barrel at one side thereof, and passages interconnecting said bearings with said clearance space for the purpose of leading to said clearance space such air as may leak into said bearings, thereby avoiding the entry of said air into the interior of the barrels of the gear.

7. A hydraulic variable speed gear comprising a unitary casing, a pump barrel adjustably mounted in said casing, a liquid-accommodating clearance space above said barrel and within said casing, a pump rotor, journal bearings in said casing for supporting said rotor, a motor barrel provided in said casing, passages interconnecting said barrels for circulation of liquid, a rotor in said motor barrel, a plurality of diametral slots in each rotor, two-part symmetrical diametrally continuous vanes slidably mounted in said slots, each vane being machined minutely shorter than the diameter of the barrel which contains it and having its tips shaped to form with working surfaces of said barrel minute wedge-shaped spaces, non-return valves in said pump barrel for automatically equalizing the pressures within its low pressure side and said clearance space, passages interconnecting said bearings with said clearance space for the purpose of leading to said clearance space such air as may leak into said bearings, thereby avoiding the entry of said air into the interior of the barrels of the gear, a manually operable valve on said casing for discharging when desired air or vapour cavities from the interior thereof, and liquid make-up apparatus communicating with said casing.

In testimony whereof we affix our signatures.

WILLIAM SLESSOR.
WILLIAM HALLIDAY MILLAR.