Sept. 24, 1935. A. R. N. HEATH 2,015,626

HYDRAULIC TRANSMISSION APPARATUS

Filed Jan. 24, 1934 2 Sheets-Sheet 1

Fig. 1.

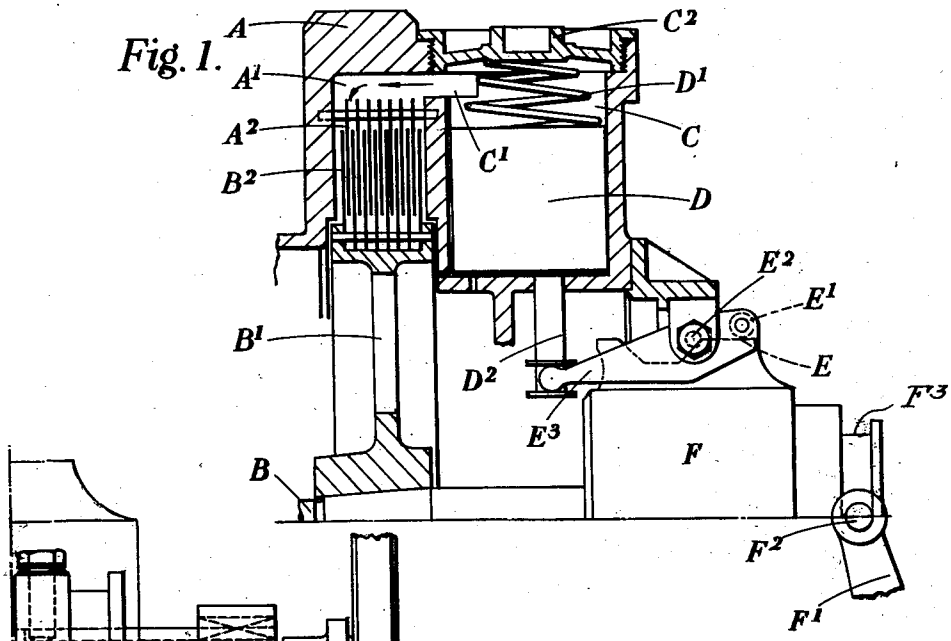
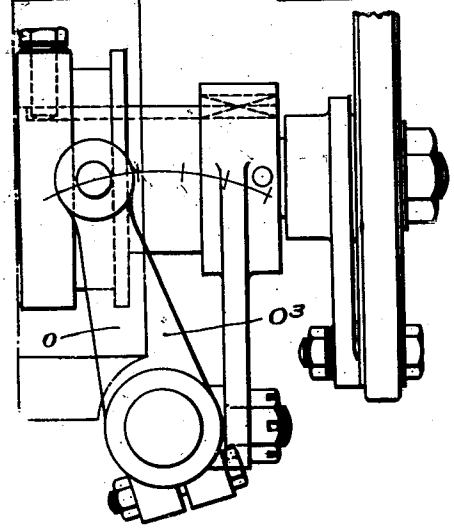



Fig. 2a




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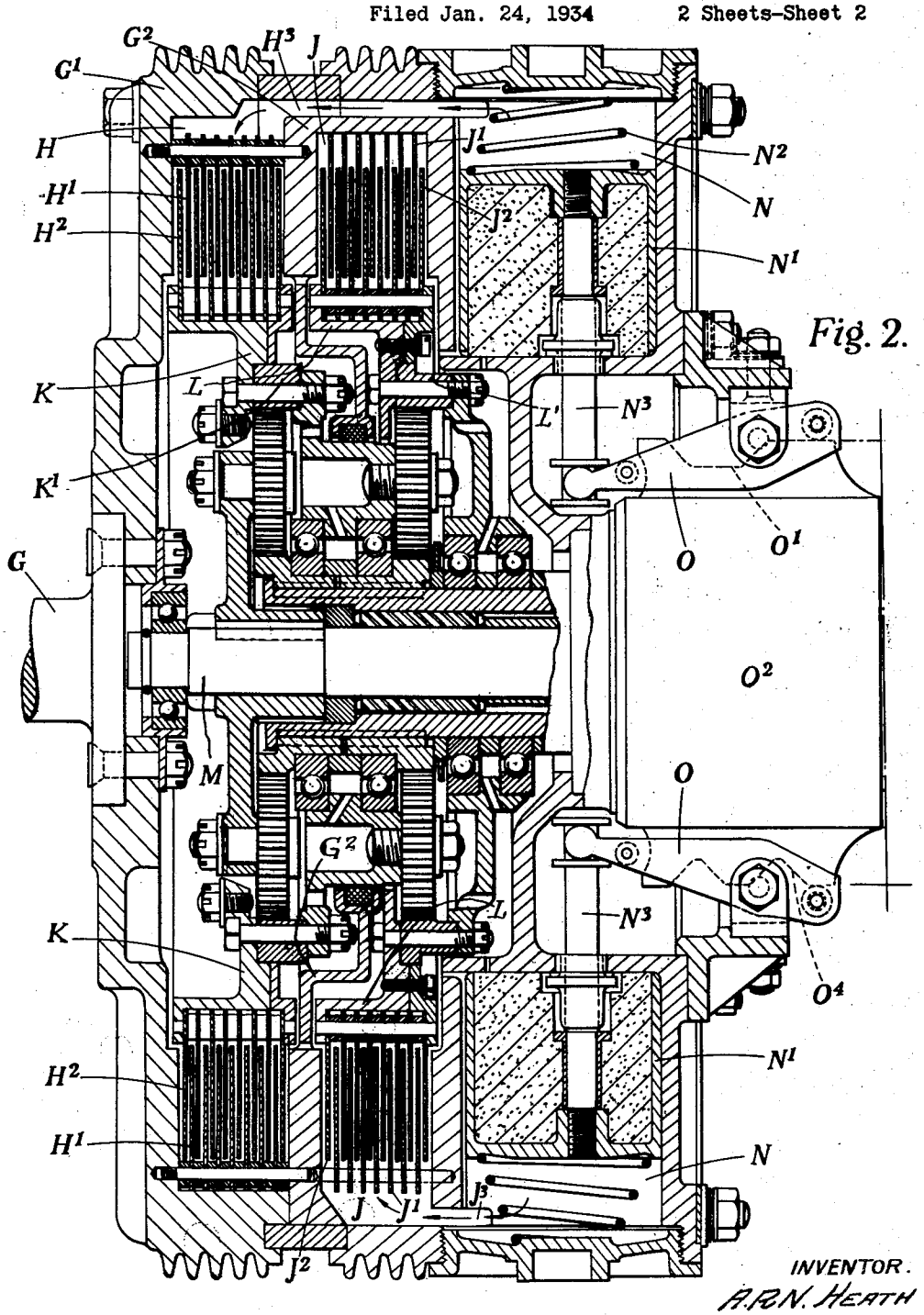



Fig. 2.

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# UNITED STATES PATENT OFFICE

2,015,626

## HYDRAULIC TRANSMISSION APPARATUS

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In Great Britain February 7, 1933

19 Claims. (Cl. 74—260)

This invention relates to hydraulic transmission apparatus of the kind in which liquid contained in an annular working chamber concentric with the driving and driven members transmits power from a part or parts of the driving member lying within or constituting part of the working chamber to a part or parts of the driven member lying within or constituting part of the working chamber, the quantity of liquid in the working chamber being controlled by displacer members each arranged in and rotating with a receiving chamber which rotates with the driving or driven member and communicates with the working chamber, the displacer members being adapted to move radially outwards to cause displacement of liquid from the receiving chamber or chambers into the working chamber, and vice versa.

In this specification the expression "annular chamber" is to be read as including not only a plain annular working chamber containing liquid whereby power is transmitted from a part of the driving member lying within the chamber to a part of the driven member lying within said chamber, but as including also the working chamber of a hydraulic transmission device of the reaction type comprising, for example, a turbine type pump the blades of which direct the liquid either directly or through an annular series of guide vanes coaxial with the pump rotor on to the blades of a turbine wheel constituting the driven member.

In hydraulic transmission apparatus of the kind above indicated and according to the present invention, each receiving chamber extends radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, and the inner end of each displacer member when in its outermost position lies at a radial distance from the axis of rotation not greater than that of the said circumference of the working chamber.

In this way, without making the displacer members form a fluid-tight joint with the walls of the receiving chamber, it is readily possible to ensure that when the displacer members are moved into their outermost positions substantially the whole of the working chamber shall be filled with liquid.

A plurality of receiving chambers may be provided each of which extends radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from the axis of rotation than the outer circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber. Each displacer member is then radially movable inwards and outwards within its receiving chamber so as either to permit fluid to flow under the action of centrifugal force radially outwards from the working chamber into the receiving chambers, or to displace the fluid in the receiving chambers and cause it to enter the working chamber, each displacer member being so constructed and arranged that when in its outermost position its inner end lies at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber.

Whether each displacer member is arranged not to make a liquid-tight joint with the walls of the receiving chamber or not, these displacer members are conveniently so formed as to have approximately the same weight-volume ratio as the liquid employed in the apparatus so that at all speeds of the apparatus the centrifugal force acting on each displacer member is approximately equal to that acting on the same volume of liquid, whereby the force exerted by the liquid on the displacer members and tending to move them radially inwards is substantially equal to the centrifugal force exerted on the displacer members and tending to move them outwards so that the inward and outward movement of the displacer members is facilitated.

In some cases, however, the weight-volume ratio of the displacer members may be either greater or less than that of the liquid. For example, where, as may be the case, it is desired that the displacer members shall move outwards automatically against the action of a spring or springs as the speed of the apparatus increases, the weight-volume ratio of the displacer members may be somewhat greater than that of the liquid so that as the speed increases so the centrifugal force exerted on the displacer members increases to a greater and greater extent above the inward force exerted thereon by the liquid, whereby automatic outward movement of the displacer members takes place as the speed increases. Alternatively, where it is desired that as the speed increases the displacer members shall automatically move inwards against the action of a spring or springs the weight-volume ratio of each displacer member may be somewhat less than that of the liquid.

The invention may be carried into practice in various ways and may be applied to hydraulic transmission apparatus of various kinds, but the accompanying drawings illustrate, by way of ex-

ample, two constructions according to the invention as applied to hydraulic transmission apparatus of the kind in which liquid contained in a working chamber transmits power from part of a driving member lying within the chamber to part of a driven member lying within said chamber.

In the drawings,

Figure 1 is a side elevation, partly in section, of one construction showing only the parts of the apparatus lying on one side of the axis of rotation, and

Figure 2 illustrates a modified construction but on a larger scale and including the parts on both sides of the axis of rotation.

Figure 2a is a continuation of Figure 2 extending from the right thereof.

In the construction illustrated in Figure 1, the apparatus comprises a driving member A in the form of a drum-like casing having an annular working chamber $A^1$ formed therein. The driving member A carries a series of spaced plates $A^2$ extending radially inwards within the working chamber $A^1$ and constituting the driving elements of the apparatus. Interposed between the plates $A^2$ is a series of driven annular plates $B^2$ secured to and extending radially outwards from an inner drum-like support $B^1$, these plates, which constitute the driven elements of the apparatus, being adapted to rotate with the driven shaft B coaxially with the driving member A.

The arrangement is therefore such that liquid lying between the driving and driven plates $A^2$, $B^2$ will be subject to the action of centrifugal force when the apparatus is in operation and will, as hereinafter described, serve to transmit power. The width of the space between adjacent plates $A^2$, $B^2$ may vary but in one convenient arrangement the width of this space is of the order of one-sixteenth of an inch.

Formed in the drum-like casing A is a series of cylindrical receiving chambers C the axes of which extend radially with respect to the axis of rotation of the apparatus, each receiving chamber C, which communicates with the annular working chamber $A^1$ through a duct $C^1$, being closed at its outer end by a screw cap $C^2$. Each receiving chamber C extends, as shown, beyond the outer circumference of the annular working chamber $A^1$, the inner end of the receiving chamber lying nearer to the axis of rotation of the apparatus than the inner circumference of the annular working chamber $A^1$, i. e. the circumference of the working chamber which lies nearest to the said axis of rotation.

Arranged in each receiving chamber C is a piston-like displacer member D which, whilst being of cylindrical form, does not make fluid-tight engagement with the surrounding walls of the receiving chamber C. Each displacer member D is so dimensioned with respect to its receiving chamber C that when the displacer member is in its outermost position its inner end lies at a radial distance from the axis of rotation not greater than that of the said inner circumference of the working chamber A. In this way, though the displacer members D do not make a liquid-tight joint with the walls of the receiving chambers C, it is readily possible to ensure that when the displacer members D are moved radially into their outermost positions, substantially the whole of the working chamber $A^1$ shall be filled with liquid. To this end the dimensions of the displacer members D and receiving chambers C are such in relation to the total volume of the spaces between the plates $A^2$ and $B^2$ that when the displacer members D are moved radially inwards substantially the whole of the liquid between the plates $A^2$, $B^2$ can flow into the receiving chambers C so as substantially to prevent transmission of power from the driving to the driven plates.

Each displacer member D is formed hollow and is acted on at its outer end by a spring $D^1$, the displacer being so constructed as to have a weight-volume ratio somewhat greater than that of the same volume of the liquid used in the apparatus so that the force of the liquid and spring $D^1$ tending to move each displacer inwards is slightly less than the centrifugal force acting on the displacers, whereby the inward and outward movement of the displacers is facilitated. Each displacer member D is provided with an inwardly extending stem $D^2$ which is acted on by one end of an arm $E^3$ pivoted at $E^2$ on a part carried by the drum-like casing A, the other end of the arm $E^3$ carrying a roller $E^1$ which bears on a cam surface E. The cam surface E is formed on a cylindrical member F rotatable about the axis of the driven shaft B and axially movable thereon by means of a lever $F^1$ carrying a follower $F^2$ which engages an annular groove $F^3$ in the member F.

When the apparatus is in operation the liquid between the plates $A^2$ and $B^2$ is always tending to flow through the duct $C^1$ into the receiving chambers C since each receiving chamber extends beyond the outer circumference of the working chamber $A^1$ so that liquid tends to flow from the working chamber to the receiving chambers. During normal operation, however, the member F is moved outwards from the position shown in the drawings so that the rollers $E^1$ can move into the recessed portion of the cam surface E. The displacer members D can therefore move radially outwards under the action of centrifugal force and against their springs $D^1$, whereby the displacer members extend from the outer end of the receiving chambers C to a point adjacent to the inner circumference of the working chamber A. The displacer members D thus cause the annular chamber $A^1$ and the spaces between the plates $A^2$ and $B^2$ to be filled with liquid so that the drive is transmitted from the driving to the driven plates.

The apparatus thus acts as an automatic clutch. When, however, it is desired to eliminate the transmission of power between the driving and driven plates, the member F is moved into the position shown in the drawings whereby the displacer members D are positively moved inwards and locked in their innermost positions so that the liquid will be displaced from the working chamber A into the receiving chambers C.

Apparatus as above described may be combined with variable speed gear of the epicyclic type and, in this case, two or more hydraulic transmission devices according to the invention may be provided controlling the different elements of the epicyclic gear to effect different transmission ratios through this gear. One such arrangement is illustrated in Figure 2 in which a driving shaft G is rigidly coupled to a drum-like driving member $G^1$ having an internal partition $G^2$ which divides the interior of the driving member $G^1$ into two annular working chambers H and J. Secured to the driving member $G^1$ are two sets of plates $H^1$, $J^1$ which constitute

the driving plates and extend radially inwards within the working chambers H and J respectively. Cooperating with the driving plates $H^1$, $J^1$ are two sets of driven plates $H^2$ and $J^2$ carried respectively by two drum-like carriers K and L. The carrier K is rigidly secured to an annulus $K^1$ having internal teeth meshing with planets which in turn mesh with a sun wheel on a driven shaft M. The carrier L is similarly secured to an annulus $L^1$ having internal teeth meshing with planets which in turn mesh with a second sun wheel on the driven shaft M. The planets and sun wheels are not shown in the drawings since their arrangement may be similar to that normally employed in epicyclic change speed gearing.

The annular working chamber H communicates through a series of ducts $H^3$ with some of a plurality of receiving chambers N each containing a piston-like displacer member $N^1$ acted on at one end by a spring $N^2$ and having at the other end a spindle $N^3$ operatively connected to an arm O. Each arm O is controlled by a cam surface $O^1$ formed on a cylindrical control member $O^2$ axially movable relatively to the driving shaft M by means of a control lever $O^3$. The working chamber J similarly communicates through a series of ducts $J^3$ with the remainder of the receiving chambers N whose displacer members $N^1$ are controlled through arms O by cam surfaces $O^4$ formed on the member $O^2$. Thus whilst some of the receiving chambers N communicate with the working chamber H, the remaining receiving chambers communicate with the working chamber J. The displacer members $N^1$, which are hollow and preferably filled with cork or the like, are controlled in a manner similar to that described with reference to the displacer members D in Figure 1. Preferably the receiving chambers N associated with the working chamber H are alternated in the circumferential direction with the receiving chambers N associated with the working chamber J.

With this apparatus different gear ratios can be obtained by bringing into operation one or other of the hydraulic transmission devices. Thus, one gear ratio will be obtained by actuating the control lever $O^3$ so that on the one hand the cam surfaces $O^1$ will permit the displacer members $N^1$ associated with the working chamber H to move outwards under the action of centrifugal force so as to fill the spaces between the plates $H^1$ and $H^2$ with liquid, whilst on the other hand the cam surfaces $O^4$ will hold the displacer members $N^1$ associated with the working chamber J against such outward movement so that the liquid will be displaced from the spaces between the plates $J^1$ and $J^2$. The drive will then be transmitted from the driving shaft G through the plates $H^1$, $H^2$ and the annulus $K^1$ to the associated sun wheel on the driven shaft M. Similarly, another gear ratio can be obtained by operating the control lever $O^3$ so that whilst the cam surfaces $O^1$ hold the displacer members $N^1$ associated with the working chamber H against outward movement, the cam surfaces $O^4$ allow the displacer members associated with the working chamber J to move outwards. The drive will then be transmitted from the driving shaft G through the plates $J^1$, $J^2$ and annulus $L^1$ to the other sun wheel on the driven shaft M. By moving the member $O^2$ into the position shown in chain lines, all the displacer members $N^1$ will be rendered operative and a direct drive will be obtained through the epicyclic gear. Finally, by moving the member $O^2$ into the position shown in full lines, all the displacer members $N^1$ are rendered inoperative and the liquid will be displaced from both the working chambers H and J and no power will be transmitted.

It will be seen that in this construction, since the working chambers H and J are arranged adjacent to one another at one end of the apparatus with all the receiving chambers N at the opposite end, the control of the two hydraulic transmission devices is facilitated because it can be readily effected from one end of the gear without control mechanism having to pass through the driving liquid which, during operation, is under considerable pressure so that difficulty might arise in maintaining liquid-tight joints through which the control mechanism passed.

It will be understood that when a plurality of radial receiving chambers are provided, as for example in the constructions above described, sufficient space is provided circumferentially between the adjacent receiving chambers to allow for the full inward movement of all the displacers. Further, though in the constructions above described the displacer members move outwards against the action of springs so that the weight-volume ratio of each displacer member must be somewhat greater than that of the corresponding volume of liquid, when springs are not employed and the displacer members are positively actuated each displacer member may have a weight-volume ratio substantially equal to the corresponding volume of liquid. Alternatively, each displacer member may move inwards automatically against the action of a spring and under the action of the liquid as the speed of the apparatus increases, the weight of each displacer member being then less than that of a corresponding volume of the liquid employed.

In the arrangements above described it will be seen that the displacer members do not necessarily make liquid-tight engagement with the walls of the receiving chambers but merely act to displace the liquid inwards from the receiving chambers into the working chamber or to permit it to flow out of the working chamber into the receiving chamber. In some cases, however, the receiving chambers might be in the form of radial cylinders with pressure-tight pistons in them adapted to cause the liquid to flow into the space or spaces between the driving and driven members or to permit this liquid to be forced radially out of these spaces, the arrangement being such in any case that the displacer members are subject to centrifugal force so that when the apparatus is rotating this centrifugal force balances either wholly or partially the inward force exerted upon the displacer members by the liquid.

What I claim as my invention and desire to secure by Letters Patent is:—

1. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, at least one receiving chamber which rotates about the said axis and communicates with the working chamber, each receiving chamber extending ra-

dially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, a displacer member in each receiving chamber and movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber to the receiving chamber, thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

2. Hydraulic power transmission apparatus including in combination driving and driven members each having blades, an annular working chamber concentric with the axis of rotation of the driving and driven members and containing liquid which liquid transmits the power, at least one receiving chamber which rotates with the driving member and communicates with the working chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, a displacer member in each receiving chamber and movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber to the receiving chamber, thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

3. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis of rotation and communicate with the working chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting liquid to flow under the action of centrifugal force radially outwards from the working chamber into the receiving chamber and, on the other hand, radially outwards thereby displacing the liquid from the receiving chamber into the working chamber, the inner end of each displacer member when this is in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

4. Hydraulic power transmission apparatus including in combination driving and driven members each having blades, an annular working chamber concentric with the driving and driven members and containing liquid which liquid transmits the power at least one blade on the driving member lying within the working chamber to at least one blade on the driven member lying within the working chamber, a plurality of receiving chambers which rotate about the said axis of rotation and communicate with the working chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting liquid to flow under the action of centrifugal force radially outwards from the working chamber into the receiving chamber and, on the other hand radially outwards thereby displacing the liquid from the receiving chamber into the working chamber, the inner end of each displacer member when this is in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

5. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis of rotation, means whereby each working chamber communicates with at least one receiving chamber each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the

inner circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting fluid to flow under the action of centrifugal force radially outwards from the associated working chamber into the receiving chamber and, on the other hand, movable radially outwards thereby displacing the liquid from the receiving into the working chamber, the inner end of each displacer member when this lies in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

6. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, at least one receiving chamber which rotates about the said axis and communicates with the working chamber, each receiving chamber extending radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from the axis of rotation than the outer circumference of the working chamber, a displacer member in each receiving chamber and movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber to the receiving chamber, thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

7. Hydraulic transmission apparatus including in combination driving and driven members each having blades, an annular working chamber concentric with the axis of rotation of the driving and driven members and containing liquid which liquid transmits power at least one blade on the driving member lying within the working chamber to at least one blade on the driven member lying within the working chamber, at least one receiving chamber which rotates with the driving member and communicates with the working chamber, each receiving chamber extending radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from the axis of rotation than the outer circumference of the working chamber, and a displacer member in each receiving chamber and movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber, to the receiving chamber thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

8. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis and communicate with the working chamber, each receiving chamber extending radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from the axis of rotation than the outer circumference of the working chamber, a displacer member in each receiving chamber and movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber to the receiving chamber, thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

9. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power

from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis of rotation, means whereby each working chamber communicates with at least one receiving chamber but does not communicate with any other working chamber, each receiving chamber extending radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from said axis than the outer circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting fluid to flow under the action of centrifugal force radially outwards from the associated working chamber into the receiving chamber and, on the other hand, movable radially outwards thereby displacing the liquid from the receiving into the working chamber, the inner end of each displacer member when this lies in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

10. Hydraulic power transmission apparatus including in combination driving and driven members each having blades, a plurality of annular working chambers concentric with the driving and driven members and each containing liquid which liquid transmits the power at least one blade on the driving member lying within the working chamber to at least one blade on the driven member lying within the working chamber, a plurality of receiving chambers which rotate about the said axis of rotation and communicate with the working chamber, means whereby each separate working chamber communicates with at least one receiving chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting fluid to flow under the action of centrifugal force radially outwards from the associated working chamber into the receiving chamber and, on the other hand, movable radially outwards thereby displacing the liquid from the receiving into the working chamber, the inner end of each displacer member when this lies in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

11. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis, means whereby each separate working chamber communicates with at least one receiving chamber, each receiving chamber extending radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from the axis of rotation than the outer circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting fluid to flow under the action of centrifugal force radially outwards from the associated working chamber into the receiving chamber and, on the other hand, movable radially outwards thereby displacing the liquid from the receiving chamber into the working chamber, the inner end of each displacer member when this lies in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

12. Power transmission apparatus including in combination driving and driven members, epicyclic gearing comprising at least three elements, means for connecting one element to the driven member, a plurality of hydraulic transmission devices each comprising an annular working chamber containing a liquid and arranged concentric with the axis of rotation of the driving and driven members between which parts the liquid transmits the power from the driving member to an element of the epicyclic gearing, a plurality of receiving chambers which rotate about the said axis of rotation, means whereby each separate working chamber communicates with at least one receiving chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member, a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting fluid to flow under the action of centrifugal force

radially outwards from the associated working chamber into the receiving chamber and, on the other hand, movable radially outwards thereby displacing the liquid from the receiving chamber into the said associated working chamber, the inner end of each displacer member when this lies in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, and means for controlling the displacer members in the receiving chambers communicating respectively with the different working chambers.

13. Power transmission apparatus including in combination driving and driven members each having blades, epicyclic gearing comprising at least three elements, means for connecting one element to the driven member, a plurality of hydraulic transmission devices each comprising an annular working chamber concentric with the driving and driven members and containing liquid which liquid transmits the power, at least one blade on the driving member lying within the working chamber to at least one blade on the driven member lying within the working chamber, a plurality of receiving chambers which rotate about the said axis of rotation and communicate with the working chamber, means whereby each separate working chamber communicates with at least one receiving chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member, a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting fluid to flow under the action of centrifugal force radially outwards from the associated working chamber into the receiving chamber and, on the other hand, movable radially outwards thereby displacing the liquid from the receiving into the working chamber, the inner end of each displacer member when this lies in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, and means for controlling the displacer members in the receiving chambers communicating respectively with the different working chambers.

14. Power transmission apparatus including in combination driving and driven members, epicyclic gearing comprising at least three elements, means for connecting one element to the driven member, a plurality of hydraulic transmission devices each comprising an annular working chamber containing a liquid and arranged concentric with the axis of rotation of the driving and driven members within said working chamber between which parts the liquid transmits the power from the driving member to an element of the epicyclic gearing, a plurality of receiving chambers which rotate about the said axis, means whereby each separate working chamber communicates with at least one receiving chamber, each receiving chamber extending radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from the axis of rotation than the outer circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member, a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting fluid to flow under the action of centrifugal force radially outwards from the associated working chamber into the receiving chamber and, on the other hand, radially outwards thereby displacing the liquid from the receiving chamber into the associated working chamber, the inner end of each displacer member when this lies in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, and means for controlling the displacer members in the receiving chambers communicating respectively with the different working chambers.

15. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, at least one receiving chamber which rotates about the said axis and communicates with the working chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, a displacer member in each receiving chamber and movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber to the receiving chamber, thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member, each displacer member having a weight volume ratio which is such in relation to that of the liquid employed in the apparatus that the force required to cause radial movement of the displacer member is small in relation to the total centrifugal force throughout the speed range of the apparatus.

16. Hydraulic power transmission apparatus including in combination driving and driven

members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis of rotation and communicate with the working chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting liquid to flow under the action of centrifugal force radially outwards from the working chamber into the receiving chamber and, on the other hand, radially outwards thereby displacing the liquid from the receiving chamber into the working chamber, the inner end of each displacer member when this is in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member, each displacer member having a weight volume ratio which is such in relation to that of the liquid employed in the apparatus that the force required to cause radial movement of the displacer member is small in relation to the total centrifugal force throughout the speed range of the apparatus.

17. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis and communicate with the working chamber, each receiving chamber extending radially outwards from a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber to a point further from the axis of rotation than the outer circumference of the working chamber, a displacer member in each receiving chamber and movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber to the receiving chamber, thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said circumference of the working chamber, thereby insuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member, each displacer member having a weight volume ratio which is such in relation to that of the liquid employed in the apparatus that the force required to cause radial movement of the displacer member is small in relation to the total centrifugal force throughout the speed range of the apparatus.

18. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, at least one receiving chamber which rotates about the said axis and communicates with the working chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, a displacer member in each receiving chamber with clearance between the displacer member and the surrounding wall of the receiving chamber whilst the displacer member is movable therein radially outwards with respect to the axis of rotation to cause displacement of liquid from the receiving chamber into the working chamber and radially inwards to allow liquid to flow under the action of centrifugal force from the working chamber to the receiving chamber, thereby controlling the quantity of liquid in the working chamber, the inner end of each displacer member when in its outermost position lying at a radial distance from the axis of rotation not greater than that of the said inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

19. Hydraulic power transmission apparatus including in combination driving and driven members, an annular working chamber containing liquid and arranged concentric with the axis of rotation of the driving and driven members and containing parts on the driving and driven members within the said working chamber between which parts the liquid transmits the power from the driving to the driven member, a plurality of receiving chambers which rotate about the said axis of rotation and communicate with the working chamber, each receiving chamber extending radially inwards to a point whose radial distance from the axis of rotation is less than that of the inner circumference of the working chamber, and a plurality of displacer members one arranged in each receiving chamber with clearance between the displacer member and the surrounding wall of the receiving chamber, each displacer member being movable on the one hand radially inwards within its receiving chamber thereby permitting liquid to flow under the action of centrifugal force radially outwards from

the working chamber into the receiving chamber and, on the other hand, radially outwards thereby displacing the liquid from the receiving chamber into the working chamber, the inner end of each displacer member when this is in its outermost position lying at a radial distance from the axis of rotation not greater than that of the inner circumference of the working chamber, thereby ensuring that no liquid will flow into the space vacated by the displacer member during its outward movement and that substantially the whole of the liquid displaced due to such outward movement of the displacer member is caused to enter the working chamber, reduction of the quantity of liquid in the working chamber taking place in accordance with the inward radial movement of the displacer member.

ALBERT RICHARD NORMAN HEATH.