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HYDRAULIC POWER TRANSMISSION APPARATUS
Filed April 8, 1939

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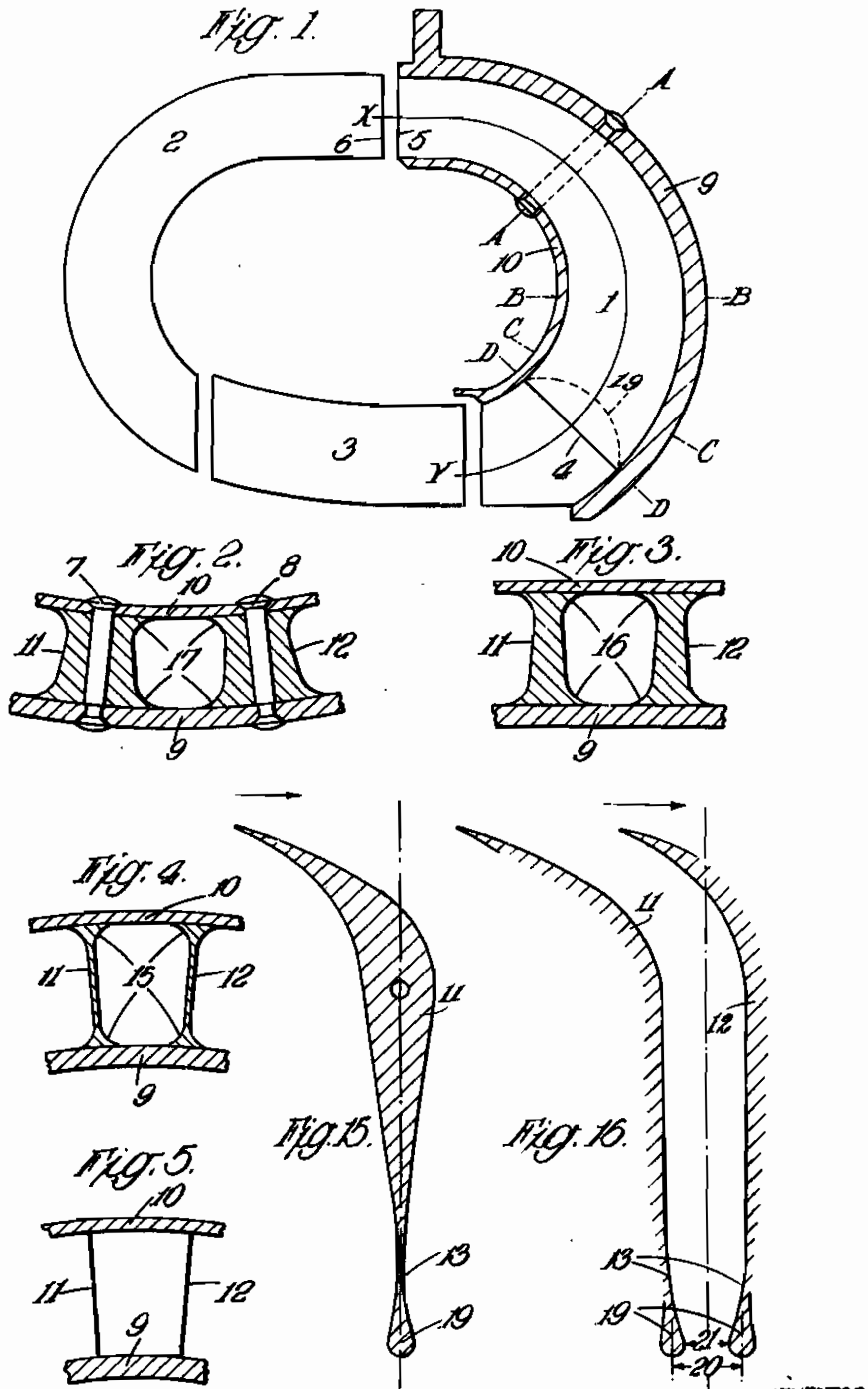
2 Sheets-Sheet 1



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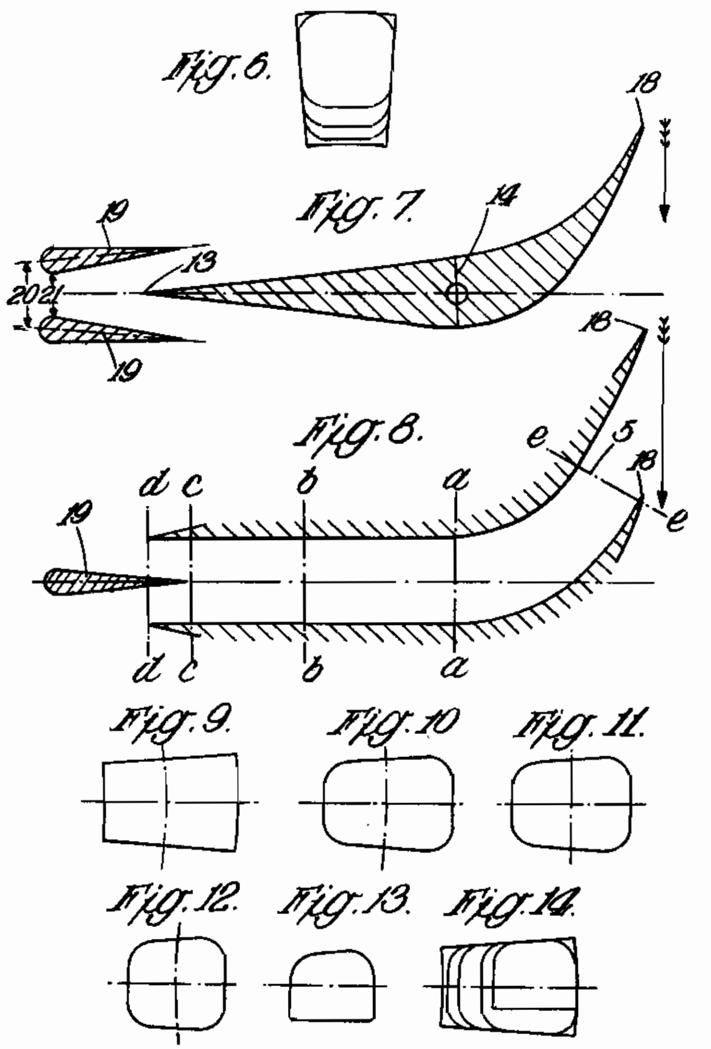

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ALIEN PROPERTY CUSTODIAN

HYDRAULIC POWER TRANSMISSION APPARATUS

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Application filed April 8, 1939

This invention relates to hydraulic power transmission apparatus of the kind in which an impeller or driving member having ducts between vanes drives a turbine or driven member by means of liquid, and in which the torque imparted by hydraulic means to the turbine is or can be substantially greater than that imparted to the impeller whereby transmission of power may be effected by hydraulic means at a torque ratio or ratios substantially greater than the ratio of 1 to 1 independently of any associated mechanical change speed gearing. This invention is concerned with the design of the impeller.

According to this invention the impeller has ducts, whose outlets are situated in the outer part of the circuit (i. e. in that part of the circuit in which the direction of flow has an axial component and which is more remote from the axis of rotation than the parts wherein the direction of flow is radial) and of which ducts at least a substantial part is so constructed that the flow of the liquid therein remains stable (i. e. without objectionable eddies or turbulence) at the velocities obtaining during transmission of a substantial proportion of the full power for which the apparatus is designed at a torque ratio higher than 1 to 1.

Such a construction gives increased efficiency of transmission. The greater the length of the part so constructed the higher will be the efficiency and in any case such part must be substantial, i. e. long enough to give, in any particular apparatus, the required degree of efficiency.

In order that the flow in a duct or a part thereof shall tend to remain stable, its cross sectional area must be progressively reduced in the direction towards the outlet and it must be non-divergent (i. e. any normal cross section if superimposed on any normal cross section more remote than itself from the outlet will not overlap the same) or nearly so. The degree to which divergence can be permitted without causing the flow to become unstable depends upon the size and capacity of the apparatus and the nature of the liquid employed.

Preferably the ducts of the impeller are made non-divergent up to or nearly up to the outlet and preferably from a point at or near the inlet, and preferably the cross sectional area is progressively reduced throughout such length.

The cross sectional area may be made to decrease in the case of a tetragonal duct either by causing both pairs of opposite walls to converge or by keeping one pair parallel and causing the other pair to converge. If the liquid used has a high viscosity, e. g. as in the case of common engine lubricating oil, if one pair of opposite walls has a convergence of 5° while the other pair remains parallel, a substantial advantage is obtained. Up to a limit (which is at least 15°) the greater the degree of convergence the better will be the result.

The construction of the apparatus itself imposes limits to the possible amount by which the cross sectional area can be reduced towards the outlet. Thus the outlet must not be unduly constricted as otherwise the liquid will not be able to circulate sufficiently freely to transmit power efficiently. Moreover, the permissible largeness of the inlet is limited by considerations of the design of the circuit, since there must not be inordinate discrepancies in size between the dimensions of the channel through which the liquid is delivered to the impeller and the inlet of the impeller.

In the preferred construction the ducts have their outlets at the part of the circuit furthest away from the axis of rotation, so that the liquid issues therefrom in a direction having no radial component. In the preferred construction the ducts extend throughout practically the full radial dimension of the circuit and are curved also towards the inlet. The radius of the outside curve preferably at no point exceeds about twice the radius of the inner curve as otherwise there might be a tendency to eddying and turbulence from this cause. This requirement also, therefore, imposes a limit on the permissible largeness of the inlet.

The reduction of cross-sectional area towards the outlet is preferably as great as possible consistent with the above considerations.

The inlet and outlet of each duct are preferably substantially tetragonal, but from the inlet towards the middle portion of the duct the corners are preferably progressively rounded and the duct is preferably made again progressively to approach the tetragonal form towards its outlet.

Of the non-divergent part of each duct that portion which lies nearer to the inlet can be made non-divergent by progressively thickening the vanes of the impeller (i. e. the parts forming the walls separating a duct from adjoining ducts) in the direction towards the outlet. The vanes can be made integral with the impeller but it is convenient to make them separately and to assemble them upon the body of the impeller. Preferably the cross-sectional area is simultaneously progressively reduced and preferably this is accomplished by causing the remaining walls of the duct to converge.

It is preferred to form the outlet of each duct in such a manner that the stream issuing from a duct becomes merged gradually with those issuing from the adjoining ducts without objectionable eddying or turbulence. In order to achieve this the thickness of the vanes must be progressively decreased towards the outlet. This can be accomplished, while maintaining non-divergence, by turning the vanes as they approach the outlet. The turn must be backwards relative to the direction of rotation. Preferably this backwards turn takes place only in that portion of each duct of the impeller which lies in the outer part of the circuit and preferably in that portion the turn is sufficient to cause the walls constituted by the vanes to converge. Preferably the vanes are radially disposed elsewhere. It will be understood that the extent to which the vanes are turned backwards must not be so great that power is no longer efficiently transmitted (the optimum angle to which the vanes are turned relative to the direction of rotation usually lies between 30° and 60°) and therefore if the vanes are turned backwardly much before they approach the outlet of the ducts, since the thickness of the vanes can only be got rid of without divergence by further backward turning, the opportunity for so doing is correspondingly reduced.

The accompanying drawings show a typical embodiment of the invention.

Figure 1 is a side view of the liquid circuit.

Figures 2, 3, 4 and 5 are cross-sections of a duct on the lines of A—A, B—B, C—C and D—D respectively of Figure 1.

Figure 6 shows the cross-sectional areas of the duct sections of Figures 2, 3, 4 and 5 superimposed.

Figure 7 is a development of a vane on the line X—Y of Figure 1.

Figure 8 is a development of one duct on the line X—Y of Figure 1.

Figures 9, 10, 11, 12, 13 show the cross-sectional area of the duct on the lines *d—d*, *c—c*, *b—b*, *a—a* and *e—e* of Figure 8, which correspond to the lines D—D, C—C, B—B, A—A and the outlet, respectively, of Figure 1.

Figure 14 shows the cross-sectional areas of the duct sections of Figures 9, 10, 11, 12 and 13 superimposed.

Figure 15 is a development of a vane having an extension at the inlet.

Figure 16 is a development of a duct between two vanes as shown in Figure 15.

In Figure 1, 1 is the impeller with which alone this invention is concerned. 2 is the turbine and 3 is the reaction member. When the impeller 1 is rotated by any prime mover, liquid flows therein by centrifugal action from the inlet 4 thereof to the outlet 5 thereof whence it is discharged into the inlet of the turbine through which it flows in a radially inwards direction imparting rotational movement thereto. The outlet is situated in the outer half of the circuit, i. e. on that side of the line B—B which is remote from the axis of rotation.

The outer and inner walls of the ducts in the impeller are formed by the members 9 and 10 and the side walls are formed by the vanes 11, 12. 7 and 8 are rivets securing these vanes to the members 9, 10.

At the inlet (Figure 5) the vanes are thin and the cross-sectional area of the ducts of the impeller is at a maximum. The thickness of the vanes is thereafter progressively increased as shown in Figures 4, 3 and 2 so as to maintain the walls of the ducts formed by the vanes 11 and 12 non-divergent, notwithstanding that the vanes are extending radially outwards from the axis of rotation. The walls 9 and 10 are progressively brought closer together to reduce the cross-sectional area, the height of the vanes being accordingly reduced. Figure 6 shows the successive cross-sections of the duct super-imposed and it will be seen that the side walls remain the same distance apart while the top and bottom walls are converging. The vanes have been thickened as shown in Figure 7 from the point 13 at the inlet to the point 14 corresponding to the line A—A of Figure 1.

Thereafter from the point 14, the vane is turned backwards towards the outlet so that the thickness of the vane may be progressively reduced while the duct remains non-divergent as shown in Figure 8. In the embodiment illustrated, in the latter part of each duct, i. e. from the line *a—a* (Figure 8) to the outlet, the sides of the duct constituted by the vanes converge (the backwards turn being sufficient for this purpose) and the walls of the duct formed by the members 9 and 10 are maintained parallel.

The vanes are progressively rounded as shown at 15 (Figure 4), 16 (Figure 3), and 17 (Figure 2) in order that the duct which is tetragonal at the inlet and the outlet may not have sharp corners throughout the greater part of its length. This accounts for the D-shaped cross-section of the outlet shown in Figure 13 on the line *e—e* of Figure 8. One side of the outlet is constituted by a part of a vane which is some distance from the tip and is still somewhat rounded, while the other side is constituted by the tip of a vane which has there ceased to be rounded.

The radius of curvature of the part 9 should not be more than about twice the radius of curvature of the part 10.

In order to avoid or decrease losses due to shock at the inlet the latter is preferably disposed at a little distance from the discharge outlet of the member through which the liquid has passed previously to entering the impeller and members 19 (Figures 7, 8, 15 and 16) are placed at or near the inlet in fixed relation to the vanes of the impeller. These members are of bulbous formation as shown and are shaped so as rapidly to constrict the space through which the liquid must pass before entering the inlet, i. e. from 20, to 21, and thereafter to provide a gradual expansion of such space up to the inlet, which must, as pointed out previously, be relatively large in order to permit a progressive reduction of cross-sectional area throughout each duct of the impeller from the inlet 4 to the outlet 5. Although the said gradual expansion up to the inlet tends to introduce some eddying and turbulence, the total amount thereof is smaller than that which would result from shock in the absence of the members 19 and of the initial constriction caused by the bulbous ends thereof as stated above.

The preferred form is shown in Figures 15 and 16 where the members 19 are formed as integral extensions of the vanes, but they may be offset as shown in Figures 7 and 8.

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