Feb. 12, 1952 P. M. SALERNI 2,585,851

ROTARY TORQUE CONVERTER OF THE IMPELLER TURBINE REACTOR TYPE

Filed Feb. 14, 1948 2 SHEETS—SHEET 1

FIG. 1.

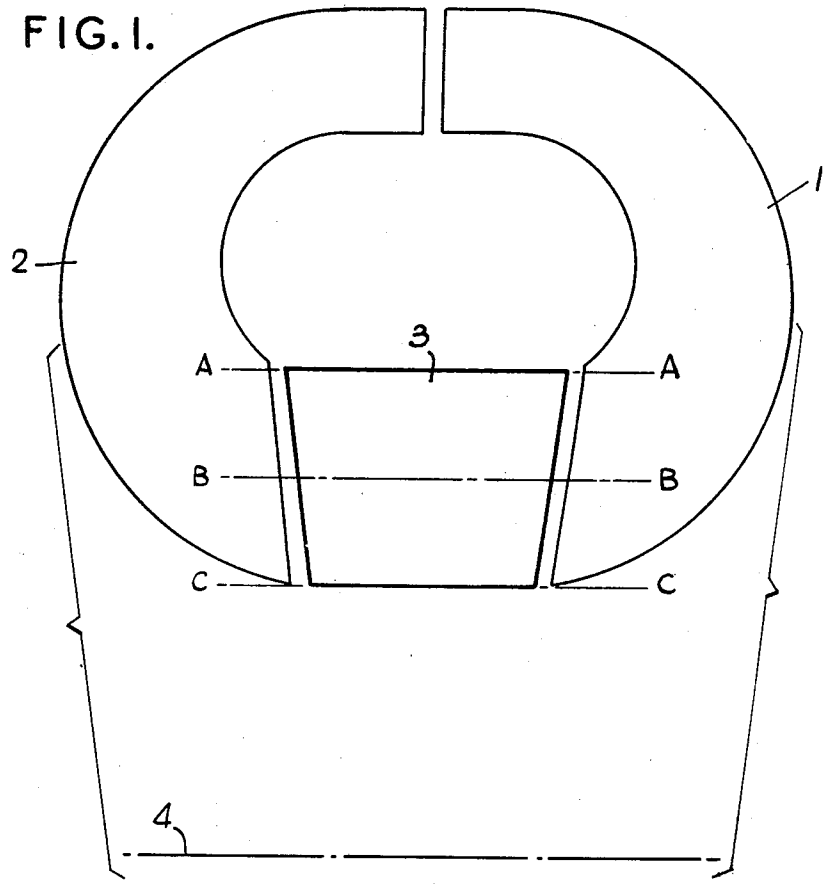
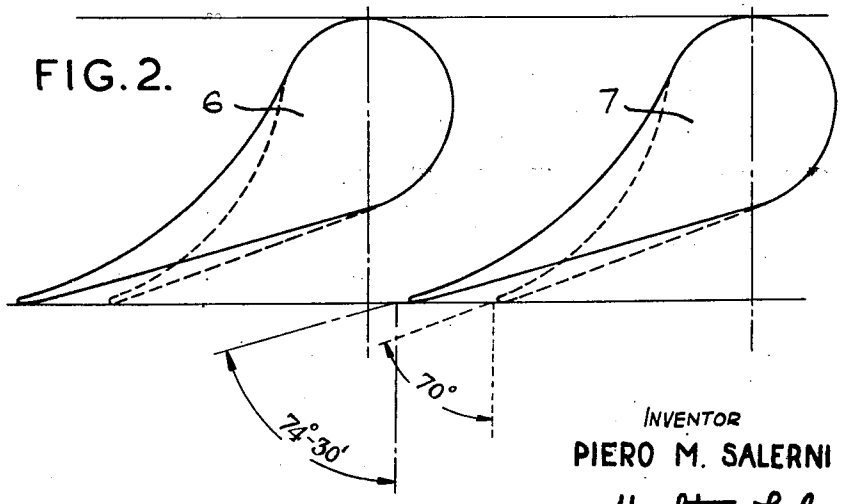


FIG. 2.



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FIG. 3.

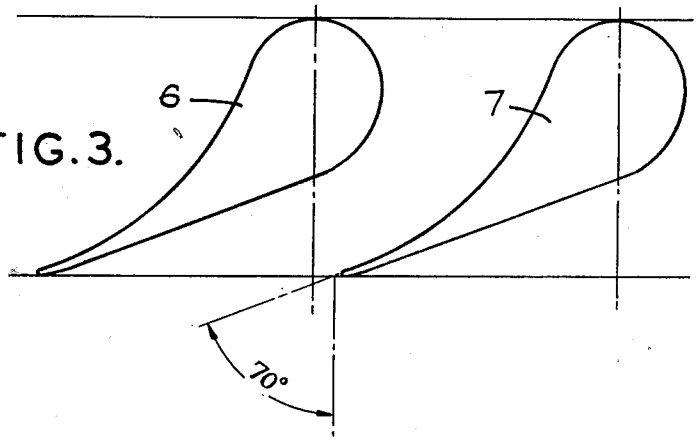


FIG. 4.

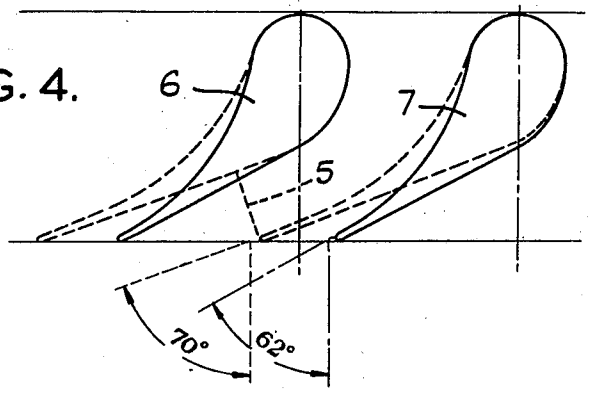
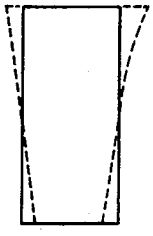


FIG. 5.



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ROTARY TORQUE CONVERTER OF THE IMPELLER TURBINE REACTOR TYPE

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15 Claims. (Cl. 60—54)

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This invention is a novel rotary torque converter of the impeller-turbine-reactor type, and particularly relates to apparatus wherein power is imparted from a driving to a driven shaft by means of a liquid, and is concerned largely with the construction of certain of the vanes interposed in the path of the liquid, particularly important where such vanes must be contained within a space which is relatively short in the direction parallel to the main axis of rotation and are located in a part of the apparatus near to the main axis.

The invention is applicable to a reaction member of hydraulic power transmission apparatus of the kind having a vaned driving member or impeller, a vaned driven member or turbine and a vaned reaction member, also termed a reactor, which can be held against backwards rotation, the liquid circulating in a closed or toroidal circuit, whereby transmission of power can be effected at a torque ratio greater than 1:1 independently of any mechanical gearing. Apparatus of the general kind referred to is described and illustrated for example in my British Patents Nos. 456,276, 456,306, 493,459 and 505,356, as well as in my U. S. Patents Nos. 2,122,353, 2,293,765, 2,293,766 and 2,293,767. The invention will hereafter be described by way of example with reference to the reaction member of such apparatus.

A reaction member in accordance with this invention is adapted to be situated between the outlet of a turbine member and the inlet of an impeller member in a part of the hydraulic circuit such that the outlet end of the reaction member has a substantial radial height or extent, with varying cross-section.

The reaction member is provided with curved vanes, the angle which each vane makes with a plane containing the axis of rotation and intersecting the vane being largest at the outlet end, so as to be rotated by the liquid, or to impart to the liquid a rotational component of velocity, or both.

The expression "outlet end" in relation to vanes refers only to the outlet end of vanes which extend to the outlet end of the reaction member and does not include any part of any vane which, though forming part of such reaction member, does not extend to the outlet end thereof. By "outlet angle" is meant the angle formed between the outlet end of a vane and a plane containing the axis of rotation and just intersecting such outlet end.

In order to enhance steadiness of flow in the

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liquid entering the reaction member and to turn or deflect the liquid satisfactorily with a smaller number of vanes than might otherwise be necessary and to reduce shock and turbulence when the liquid strikes the vanes at an angle to the direction of the inlet end, the vanes are formed at the inlent end with bulbous heads, i. e., the vanes are thickened substantially and are smoothly rounded near the inlet end.

In certain cases it is desirable to make the reaction member as short as possible in the axial direction. It is also frequently desirable to position the reaction member in that part of the circuit which lies nearest to the main axis of rotation. Since the main purpose of the reaction member is to impart to the liquid a rotational velocity about the main axis, it is desirable to ensure that no part of the liquid has an uninterrupted path (or "gap") through the reaction member without being deflected or acted upon by any vane of the reaction member. Accordingly if the reaction member and its vanes are to be kept short, it is necessary to provide a large number of vanes as compared with the number necessary when the reaction member is long. But if the least possible number of vanes is used that will avoid gaps in the direction of flow at the part of the reaction member located furthest from the axis, for an appropriate outlet angle, e. g. of the order of 70°, in order to accommodate this number of vanes with this outlet angle in that part of the reaction member situated nearest the axis, the space between the delivery ends of the vanes may be so small that undue frictional and other hydraulic losses are occasioned. Furthermore the cross-section of the outlet of the duct formed between each pair of consecutive vanes will be of irregular width throughout the radial dimension and this fact, combined with the disadvantage first mentioned, decreases efficiency.

According to this invention, there is provided a reaction member of the kind specified wherein the inlet ends of the vanes are formed with bulbous heads and wherein, the number and construction of the vanes are such that every plane containing the axis intersects at least one vane and wherein the outlet angle is greater at a part more remote from the main axis and smaller at a part nearer the main axis. By this construction the outlet of the duct constituted between two consecutive vanes assumes a form which is more rectangular or more nearly equivalent hydraulically to a rectangular outlet and can be made if desired substantially rectangular. Further it is possible both to obviate gaps at the

outer part of the reaction member with a fewer number of vanes and also to provide a sufficiently large opening between the delivery ends of the vanes at the inner part of the reaction member to avoid undue frictional losses.

It will be understood that the nearer the reaction member is situated to the axis, the greater will be the proportionate differences between the circumferential lengths of the outermost and innermost parts thereof and therefore the greater will be the differences between the outlet angles at these parts respectively.

Referring to the accompanying drawings which show by way of example one embodiment of the invention:

Figure 1 shows a diagrammatic representation of a section of a hydraulic torque converter embodying the invention.

Figure 2 shows the development of the sections of two vanes of the reaction member shown in Figure 1 on a cylindrical surface passing through the line A—A in Figure 1.

Figure 3 shows the development of the sections of the same two vanes on a cylindrical surface passing through the line B—B of Figure 1.

Figure 4 shows the development of the sections of the same two vanes on a cylindrical surface passing through the line C—C of Figure 1.

Figure 5 shows an approximate representation of the preferred shape of the outlet from the duct constituted between the said two vanes.

Referring to Figure 1, **1** indicates the impeller, **2** indicates the turbine and **3** indicates the reaction member of a hydraulic torque converter. The reaction member **3** is situated in the inner part of the hydraulic circuit. **4** indicates the axis or centre line of the hydraulic torque converter around which rotation takes place.

The reaction member **3** is constituted by a number of similar vanes, two consecutive vanes of which, indicated by **6**, **7**, are shown in Figures 2, 3 and 4, the space between each pair of consecutive vanes constituting a duct through which the liquid of the hydraulic circuit is canalized so that it is given a forwards direction of flow relative to the direction of rotation of the impeller.

Figure 3 and the full or continuous lines in Figures 2 and 4 show the development of three sections (at the maximum, middle and minimum distances from the axis respectively) of the delivery ends of normal reaction vanes by means of which it is desired to turn the direction of flow of the liquid forwards through an angle of say 70°. The number of vanes can be chosen so that at the middle distance (B—B in Figure 1 and in Figure 3) the arrangement is satisfactory for any desired outlet angle. It will be observed from Figure 3 that every plane containing the axis of rotation will intersect at least one vane, and in many cases two vanes, and at the same time the outlet of each duct is not unduly restricted in width. Assuming that the optimum number of vanes for the middle distance has been selected, the conditions obtaining at the maximum distance from the axis (A—A in Figure 1) are shown in Figure 2. If the outlet angle remains 70° as shown in dotted lines, it is possible to draw vertical lines or planes of substantial width which do not intersect any vane, thus indicating that a substantial amount of liquid can pass through the reaction member without being properly deflected. The direction of such flow of this liquid is therefore not turned forwards in the desired manner and as an additional disadvantage there may be increased turbulence and other causes of inefficiency. The conditions obtaining at the minimum distance from the axis (C—C in Figure 1) are shown in Figure 4. If the outlet angle remains 70° as shown in dotted lines, the width of the outlet at this distance from the axis is shown by the dotted line **5** and this width is so small as to give rise to undue frictional, and possibly other, losses.

Vanes according to this invention are made as shown in full lines in Figures 2, 3 and 4. The shape of the vane does not differ from normal at the middle distance (Figure 3). At the maximum or furthest distance (Figure 2) the outlet angle is increased beyond the normal to, for example, 74° 30′ where the normal would be 70°. As a result the vanes are caused to overlap each other sufficiently to prevent the possibility of any part of the liquid being able to flow through the reaction member without being properly acted upon or deflected and owing to the relatively large radial distance from the axis to this part of the vane there is no undue constriction of the duct outlet notwithstanding this increased angle. At the minimum distance (Figure 4) the outlet angle is decreased below the normal and is made, for example, 62°. As a result the gap between the delivery ends of the vanes **6**, **7** at this part is increased as compared to the normal, so that there is no undue constriction of the outlet. At the same time the decrease of outlet angle is not sufficient to cause "gaps" between the vanes in the axial direction.

Referring to Figure 5 the dotted lines show the approximate shape of the outlet from each duct when the delivery ends of the vanes are turned forwards in the normal or prior-art manner, i. e. turned through the same outlet angle throughout the radial height. The continuous or full lines show the approximate shape of the outlet from each duct that can be obtained when the delivery ends of the vanes are made in accordance with this invention. Preferably the width of the outlet is substantially uniform in that the angle between the outlet ends of adjacent vanes in the radial or approximately radial direction (i. e. the angle between the lines **10—11** and **12—13** in Fig. 5) is less than 10°, and in general the best results are obtained when the width of the outlet is uniform, i. e., when the said angle is zero. The shape of the outlet resulting from the "twisting" of the vanes in accordance with this invention gives increased efficiency.

It will be appreciated that the variation in the outlet angle is preferably uniform throughout the radial height or extent of the vane, the outlet angle increasing progressively as the radial distance from the axis increases. Preferably the outlet angle varies from a minimum between 60° and 65° to a maximum between 70° and 75° where it is desired that the direction of flow of the liquid shall be turned forwards through an angle of the order of approximately 70°. The vanes are formed with bulbous heads at the inlet end as can be seen from Figures 2, 3 and 4.

I claim:

1. A vaned reaction member for use in hydraulic power transmission apparatus of the kind whereby transmission of power can be effected by liquid circulating in a closed circuit through an impeller, a turbine and a reaction member at a torque ratio greater than 1:1 independently of any mechanical gearing, the reaction member having vanes the mean outlet angle of which is well below 90° but not less than 65°, the inlet ends of the vanes being formed with bulbous

heads, the number and construction and arrangement of the vanes being such that every plane containing the axis intersects at least one vane and the outlet angle being progressively greater in parts of each vane more remote from such axis than in parts nearer to such axis.

2. Apparatus according to claim 1 wherein the outlet angle of each vane increases substantially uniformly as the radial distance from the axis increases.

3. Apparatus according to claim 2 wherein the outlet angle of the delivery ends of the vanes varies progressively from a minimum between 60° and 65° to a maximum between 70° and 75°.

4. Apparatus according to claim 1 wherein the thickness of each of the bulbous heads decreases as the radial distance from the axis decreases.

5. A vaned reaction member for use in hydraulic power transmission apparatus of the kind whereby transmission of power can be effected at a torque ratio greater than 1:1 by means of a liquid circulating in a closed toroidal circuit through the ducts formed between the vanes of an impeller, a turbine and a reactor arranged in close order around the general axis with the reactor in that part of the circuit nearest to the axis, and the flow sequence being from the turbine ducts into and through the reactor ducts for discharge into and through the impeller ducts to reenter the turbine ducts, and the spacing and construction of the reactor vanes being such that every plane which contains the general axis intersects at least one such vane; the reactor vanes each having its inlet end formed with a bulbous head, and having a variable or twisted vane contour with its means or median outlet angle of the order of 70 degrees, and such outlet angle being progressively greater than the mean in the part of each vane more remote from such axis, and progressively less than the mean in the part more near to such axis, thereby creating a twisted formation.

6. A hydraulic rotary torque converter apparatus of the vaned impeller-turbine-reactor type constituting per se a drive transmitter adapted to afford torque increase above unity under high loads at zero or intermediate speed conditions, with the liquid mass circulating about the general axis, within a closed toroidal circuit, centrifugally through the ducts defined by the impeller vanes thence centripetally through the turbine ducts and thence into and through the reactor ducts and outlets to the impeller, the reactor being located at the part of the circuit nearest to the general axis and having holding means adapted to prevent its backward rotation under certain running conditions, and said reactor having its vanes at their inlet ends thickened into bulbous heads; said transmitter being further characterized as to the reactor and its cooperative actions in that its vanes are of such form and circumferentially overlapped spacing that every plane which includes the general axis intersects at least one vane, and in that each vane has along its thinner marginal outlet portion a contour which is progressively warped or twisted throughout its extent radial to the general axis by reason of said outlet portion having at a median radial position a mean outlet angle at a substantial incline to a radial plane touching the vane tip end, and at a greater radial position a greater outlet angle and at a lesser radial extent a lesser outlet angle.

7. A hydraulic rotary torque converter apparatus of the vaned impeller-turbine-reactor type constituting per se a drive transmitter adapted to afford torque increase above unity under high loads at zero or intermediate speed conditions, with the liquid mass circulating about the general axis, within a closed toroidal circuit, centrifugally through the ducts defined by the impeller vanes thence centripetally through the turbine ducts and thence into and through the reactor ducts and outlets to the impeller, the reactor being located at the part of the circuit nearest to the general axis; said transmitter being characterized as to the reactor and its cooperative actions in that each of its vanes has along its marginal outlet portion a progressively warped or twisted form throughout its extent radial to the general axis by reason of said outlet portion having at a median radial extent a mean outlet angle at a substantial incline to a radial plane touching the vane tip end, and at a greater radial extent a greater outlet angle and at a lesser radial extent a lesser outlet angle; whereby to improve the cooperative action of the reactor in the transmitter combination in the manner and for the purposes set forth and the vanes being of such structure that the width of the outlet between each pair of vanes is substantially constant thereby obviating undue constriction at any point.

8. The torque converter as in claim 7 and wherein the maximum outlet angle of the reactor vanes is between about 70 and 75 degrees and the minimum outlet angle thereof between about 60 and 65 degrees.

9. The torque converter as in claim 7 and wherein the maximum outlet angle is of the order of 74 degrees and the minimum of the order of 62 degrees.

10. A hydraulic rotary torque converter apparatus of the vaned impeller-turbine-reactor type constituting per se a drive transmitter adapted to afford torque increase above unity under high loads at zero or intermediate speed conditions, with the liquid mass circulating about the general axis, within a closed toroidal circuit, centrifugally through the ducts defined by the impeller vanes thence centripetally through the turbine ducts and thence into and through the reactor ducts and outlets to the impeller, the reactor being located at the part of the circuit nearest to the general axis; the reactor vanes having their inlet ends roundly enlarged; and said transmitter being characterized as to the reactor and its cooperative actions in that each of its vanes has along its marginal outlet portion a progressively varied and twisted form throughout its extent radial to the general axis by reason of said outlet portion having at a median radial extent a mean outlet angle at a substantial incline to a radial plane touching the vane tip end, and at a more remote radial extent a greater outlet angle and at a less remote radial extent a lesser outlet angle; said maximum greater outlet angle and said minimum lesser outlet angle being both well within their enclosing quadrant and each of the order of 10 degrees removed from said mean outlet angle.

11. The torque converter as in claim 10 and wherein the maximum outlet angle of the reactor vanes is between about 70 and 75 degrees and the minimum outlet angle thereof between about 60 and 65 degrees.

12. The torque converter as in claim 10 and wherein the maximum outlet angle is of the order of 74 degrees and the minimum of the order of 62 degrees.

13. The torque converter as in claim 12 and wherein the mean or midway outlet angle is of the order of 70 degrees.

14. A vaned reaction member for use in hydraulic power transmission apparatus of the kind whereby transmission of power can be effected by liquid circulating in a closed circuit through an impeller, a turbine and a reaction member at a torque ratio greater than 1:1 independently of any mechanical gearing, the reaction member having vanes the mean outlet angle of which is not less than 65°, the inlet ends of the vanes being formed with bulbous heads, the number and construction of the vanes being such that every plane containing the axis intersects at least one vane, the outlet angle being greater in a part of each vane more remote from such axis than in a part nearer to such axis, and the width of the outlet between each pair of consecutive vanes being substantially uniform.

15. A vaned reaction member for use in hydraulic power transmission apparatus of the kind whereby transmission of power can be effected by liquid circulating in a closed circuit through an impeller, a turbine and a reactor at a torque ratio greater than 1:1 independently of any mechanical gearing; the reactor having vanes the outlet angle of which varies from a minimum between about 60 and 65 degrees to a maximum between about 70 and 75 degrees, increasing progressively with the radial distance from the axis; the inlet ends of the vanes being formed with bulbous heads, the number and construction of the vanes being such that every plane containing the axis intersects at least one vane, and the width of the outlet portion of the duct between each pair of consecutive vanes being substantially uniform throughout the extent of outlet from minimum to maximum radial distance from the general axis.

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