July 21, 1953 W. FERRIS 2,646,003

VANE TRACK FOR HYDRODYNAMIC MACHINES

Original Filed Nov. 9, 1946

FIG. 1

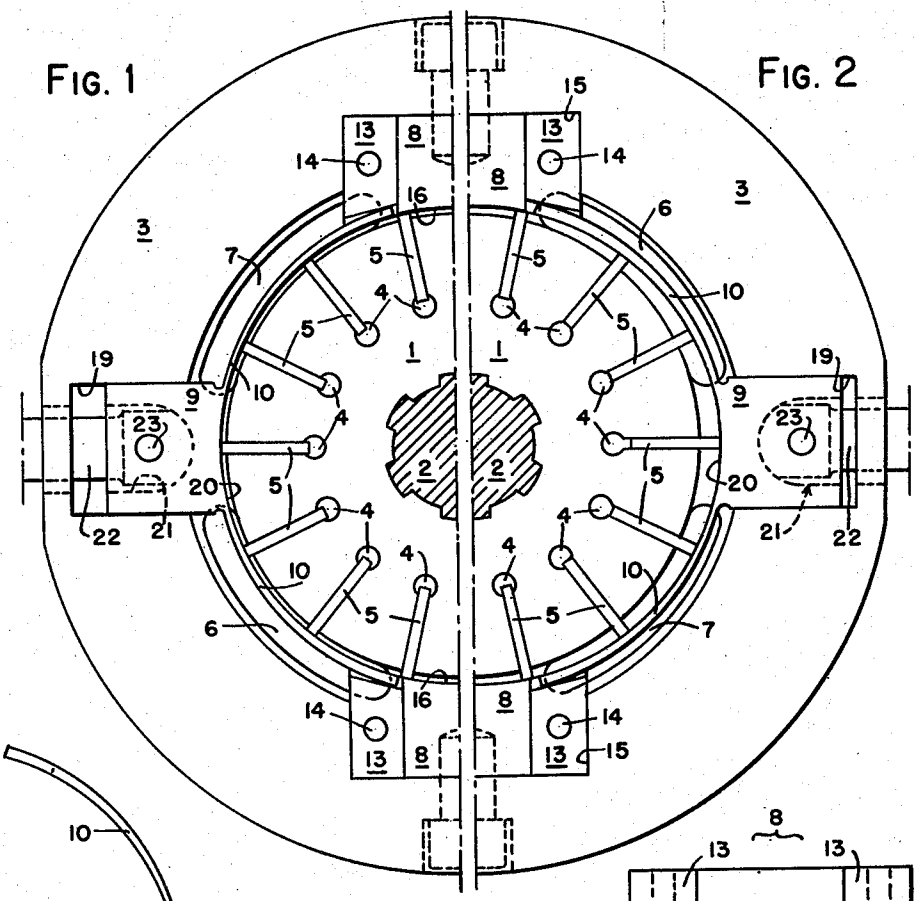


FIG. 2

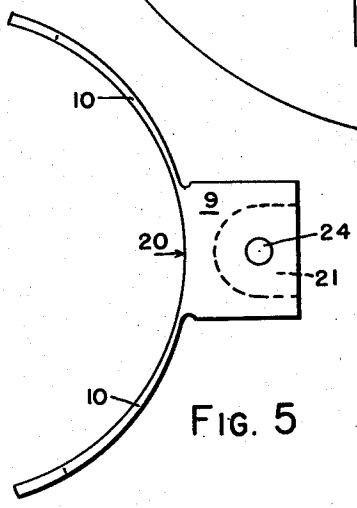


FIG. 5

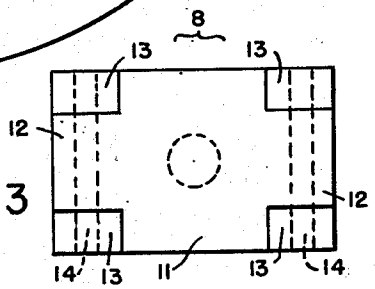


FIG. 3

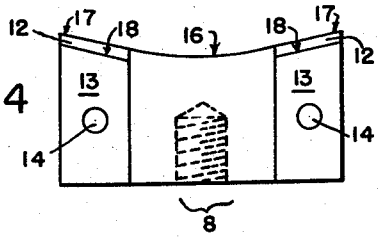


FIG. 4

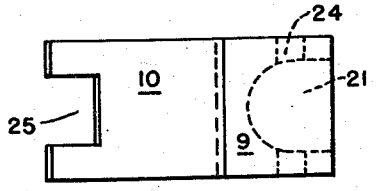


FIG. 6

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VANE TRACK FOR HYDRODYNAMIC MACHINES

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2 Claims. (Cl. 103—120)

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This application is a division of application Serial No. 709,019, filed November 9, 1946, now Patent No. 2,627,650. The invention relates to variable displacement hydrodynamic machines of the slidable vane type and more particularly to the vane track of such a machine.

A slidable vane type hydrodynamic machine includes a rotor having a plurality of vane slots extending inward from its periphery, a vane slidable in each slot, two cheek plates which are closely fitted to opposite sides of the rotor and to opposite edges of the vanes, a spacer ring which extends around the rotor and forms with the cheek plates a chamber having a plurality of ports through which liquid flows to and from the space between the rotor and the spacer ring, and a vane track upon which the outer ends of the vanes slide during rotation of the rotor.

The vane track includes a plurality of abutments or bridges, with which the vanes coact to provide substantially liquid tight seals between the inlet and outlet ports of the machine, and a plurality of track sections which are arranged between the bridges and form therewith a continuous track. The bridges are ordinarily arranged in pairs with one bridge of each pair arranged close to the periphery of the rotor and with the other bridge spaced from the periphery of the rotor when the machine is performing useful work, the bridge which is close to the rotor being called the "sealing bridge" and the bridge which is spaced from the rotor being called the "pumping bridge" or the "working bridge." If all the bridges are stationary, the displacement of the machine is constant but the displacement may be varied by providing means to move the working bridge of each pair toward and from the rotor.

Vane type hydrodynamic machines are extensively used as pumps but a properly designed vane type hydrodynamic machine may function as a motor. When the machine is used as a pump, its rotor is ordinarily rotated at such a high speed that the centrifugal force is sufficient to keep the vanes in contact with the track and it is only necessary to hydrostatically balance the vanes. However, if the machine is operated at slow speeds, as by being used as a motor, the centrifugal force is insufficient to keep the vanes in contact with the track in which case the machine is provided with suitable means for positively moving the vanes outward such as means for supplying high pressure liquid to the inner ends of the outward moving vanes.

When the working bridges of a machine having two pairs of bridges are spaced from the rotor and the rotor is rotated, each vane will move inward as its outer end moves from a working bridge toward the adjacent sealing bridge, it will move outward as its outer end moves from the sealing bridge toward the next working bridge, it will move inward as its outer end moves from that bridge toward the next sealing bridge, and it will move outward as its outer end moves from that sealing bridge toward the first mentioned bridge. Each vane thus makes two reciprocations during each revolution of the rotor and, since the rotor is often driven at very high speeds, the reciprocations may be very rapid.

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If the track is so shaped that it forces each vane inward too rapidly, the vane will tend to dig into the track and thus cause excessive wear of the track or the vane or both. If the slope of the track at any point is so steep that an outward moving van cannot follow it, the vane may leave the track at that point and reengage the track at another point with an impact that tends to damage both the track and the vane. Consequently, the shape of the track must be such as to provide gradual accelerations and decelerations of the vanes.

A track having a surface so shaped as to cause uniform accelerations and decelerations of the vanes would provide an ideal condition which may be approached in a unitary rigid vane track for a constant displacement machine but in a variable displacement machine the contour of the track will vary as the movable bridges are moved inward and outward to vary the displacement.

It has heretofore been proposed to provide vane tracks having flexible track sections fixed to the movable bridges but such prior vane tracks are so expensive to make that they are impractical for commercial use.

The present invention has as an object to provide a vane track having a plurality of movable bridges, a plurality of stationary bridges and flexible track sections fixed to the movable bridges and so constructed and supported that in all positions of the movable bridges they will form with the bridges an endless track of a contour that will cause gradual accelerations and decelerations of the vanes in their radial movements.

Other objects and advantages will appear from the following description of the vane track shown in the accompanying drawings in which the views are as follows:

Fig. 1 is a transverse section through one half of a hydrodynamic machine having a vane track in which the invention is embodied, the view being

taken along the faces of the rotor and the spacer ring and showing the movable bridge in zero displacement position.

Fig. 2 is a similar section through the other half of the same machine and shows the movable bridge in maximum displacement position.

Fig. 3 is an enlarged view of the inner face of one of the stationary bridges shown in Figs. 1 and 2.

Fig. 4 is an end view of the bridge shown in Fig. 3.

Fig. 5 is a side view of one of the movable bridges and the two flexible track sections formed integral therewith.

Fig. 6 is an end view of the parts shown in Fig. 5.

The hydrodynamic machine shown in Figs. 1 and 2 is of the general type of the machine shown in Patent No. 2,141,170 to which reference may be had for details of construction. It is deemed sufficient to state herein that the machine has a rotor 1 fixed for rotation with a shaft 2 and arranged within a spacer ring 3, that rotor 1 has a plurality of vane slots 4 extending inward from its periphery and a vane 5 slidable in each slot with its edges flush with the faces of rotor 1, that two cheek plates (not shown) engage opposite faces of spacer ring 3 which is just enough thicker than rotor 1 to provide running clearance between rotor 1 and the inner faces of the cheek plates, and that two diametrically opposed ports 6 and two diametrically opposed ports 7 communicate with the spaces between rotor 1 and the inner periphery of spacer ring 3.

The outer ends of vanes 5 ride upon an endless vane track comprising two stationary sealing bridges 8 which are fixed in spacer ring 3 diametrically opposite each other and have their inner faces arranged close to the periphery of rotor 1, two movable working bridges 9 which are spaced 90° from bridges 8 and are slidable in spacer ring 3 toward and from rotor 1, and four flexible arcuate track sections 10 each of which is formed integral with a movable bridge 9 and extends therefrom to the adjacent stationary bridge 8.

As shown in Figs. 3 and 4, each bridge 8 includes a body portion 11 having two integral extensions 12 on each end thereof and four abutments 13 each of which is closely fitted against an end face of body portion 11 and against a side face of an extension 12. Abutments 13 are rigidly secured in position by two pins 14 each of which is closely fitted in an extension 12 and in the two adjacent abutments 13 and which may be fixed in position by slightly upsetting its ends. Each bridge 8, including its abutments 13, is exactly the same thickness as spacer ring 3 and is tightly fitted in a recess 15 formed in the spacer ring 3.

The inner face 16 of body portion 11 is accurately and smoothly finished to a radius which preferably is equal to the distance between face 16 and the center of rotor 1. The inner faces 17 of extensions 12 are straight, smooth and tangent to face 16. The inner end face 18 on each abutment 13 is straight, smooth and parallel to the adjacent face 17.

Each bridge 9 is slidably fitted in a recess 19, which is formed in spacer ring 3, and it is accurately and smoothly finished to such dimensions that it forms substantially liquid tight joints with the walls of recess 19 and with the inner faces of the cheek plates.

The inner face 20 of each bridge 9 is smoothly finished to a radius which may be equal to the distance between face 20 and the center of rotor 1 when bridge 9 is either in its zero displacement position, in its maximum displacement position or in an intermediate position but, for simplicity and economy in manufacture, it ordinarily is finished to the same radius to which the faces 16 on bridges 8 are finished.

Bridges 9 may be shifted to and held in adjusted positions in any suitable manner. As shown, each bridge 9 is provided with a recess 21 to receive the inner end of a control rod 22 which is fixed to bridge 9 by a pin 23 and extends radially outward through spacer ring 3, a hole 24 being provided in each bridge 9 to receive a pin 23. Control rods 22 are operated in unison by mechanism not shown.

Each track section 10 is integral at one end with a bridge 9, as previously explained, and its inner face is smooth and forms a continuation of the face 20 on bridge 9. The other or free end of each track section 10 is provided with a notch 25 (Fig. 6) to enable it to straddle an extension 12 on a bridge 8 and to be supported upon the faces 18 of the adjacent abutments 13 as shown in Figs. 1 and 2. Track sections 10 ordinarily are initially bent to a radius enough greater than the radius of face 20 to cause the free ends thereof to remain in contact with faces 18 in all positions of bridge 9.

The free end of each section 10 is of a thickness exactly equal to the distance between a face 17 and the adjacent face 18. Therefore, since faces 17 and 18 are parallel to each other, face 17 is substantially tangent to the inner face of track section 10 at all positions of bridge 9, thereby providing a smooth path for each vane 5 as it passes from a bridge 8 onto a track section 10 and from a track section 10 onto a bridge 8.

In order to keep the radial accelerations and decelerations of the vanes well within the permissible limits, each track section 10 is gradually tapered from a maximum thickness at its free end to a minimum thickness adjacent bridge 9 to thereby cause the portion of track section 10 adjacent bridge 9 to flex more than the free end portion thereof as bridge 9 is moved toward and from rotor 1.

The accelerations and decelerations of the vanes are greatest when bridges 9 are in their maximum displacement positions but, if track sections 10 are properly proportioned, there will be no abrupt changes in the rates of acceleration and deceleration. For example, if the rotor is about three and one-half inches in diameter, the thickness of a track section at its thinnest part may be about sixty per cent of the thickness at the free end.

The arrangement is such that the vane track will be substantially concentric with the rotor and no significant radial movement of the vanes will occur when bridges 9 are in their zero displacement positions as shown in Fig. 1 but, when bridges 9 are moved outward from their zero displacement positions, each vane will start to move gradually outward as it passes from a face 16 onto a face 17, it will gradually accelerate as it passes from that face 17 onto the adjacent track section 10, it will continue to gradually accelerate until it reaches a point intermediate bridges 8 and 9 and then it will gradually decelerate until it passes onto the face 20 of the adjacent bridge 9. It will then have substantially no radial movement until it passes onto the next track section 10 and then it will start to move inward. It will gradually accelerate as it continues to move along track section 10, it will continue to gradually ac-

celerate until it reaches a point intermediate the ends of section 10 and then it will gradually decelerate until it passes onto face 16 of the next bridge 8 and then radial movement of the vane will cease as the vane moves across face 16. There are thus no abrupt changes in rates of radial acceleration and deceleration of the vanes and, consequently, abrasion of the ends of the vanes and of the vane track is negligible.

The vane track illustrated and described herein may be modified without departing from the scope of the invention which is hereby claimed as follows:

1. An endless vane track of variable length comprising a plurality of alternate fixed and movable bridges spaced around a common center and having arcuate inner faces, two arcuate flexible vane track sections formed integral with each movable bridge and extending from opposite ends of the inner face thereof to the adjacent fixed bridges and having their inner faces forming continuations of the arcuate inner face on said movable bridge, extensions arranged upon opposite ends of each fixed bridge and having the inner faces thereof tangent to the arcuate inner face of that fixed bridge, and abutments fixed to said extensions to support the free ends of the adjacent track sections and having the inner face of each abutment approximately parallel to the inner face of the adjacent extension and spaced radially outward therefrom a distance substantially equal to but not less than the thickness of the end portion of the track section supported thereon to thereby enable that abutment to hold the inner face of the track section thereon flush at one point with the inner face of said adjacent extension in all positions of the movable bridge with which that track section is formed integral, said flexible track sections being relatively thin adjacent said movable bridges and gradually increasing in thickness toward their free ends to thereby maintain proper curvatures of said sections in all positions of said movable bridges.

2. In a hydrodynamic machine having a rotor and a plurality of vanes slidable radially in said

rotor, the combination of two movable bridges and two fixed bridges spaced alternately around a common center and having arcuate inner faces, an extension arranged upon each end of each fixed bridge and having the inner face thereof tangent to the arcuate inner face of that fixed bridge, four flexible track sections arranged alternately with said bridges and forming therewith and with said extensions an endless vane track of variable length upon which the outer ends of said vanes ride during rotation of said rotor, each track section being formed integral at one end with a movable bridge and having its inner face forming a continuation of the inner face of that bridge and its other end bifurcated, and two abutments fixed to opposite sides of each of said extensions to support the bifurcated end of the adjacent track section, the abutments fixed to each extension having the inner faces thereof arranged approximately parallel to the inner face of that extension and spaced radially outward therefrom a distance substantially equal to but not less than the thickness of the bifurcated end of the track section supported thereon to thereby enable said abutments to hold the inner face of that track section flush at one point with the inner face of that extension in all positions of the movable bridge with which that track section is formed integral, and said flexible track sections being relatively thin adjacent said movable bridges and gradually increasing in thickness toward their free ends to thereby maintain proper curvatures of said sections in all positions of said movable bridges.

WALTER FERRIS.

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