Aug. 3, 1954 L. SAIVES 2,685,169

ROTARY HYDRAULIC TORQUE CONVERTER

Filed April 25, 1951 2 Sheets-Sheet 1

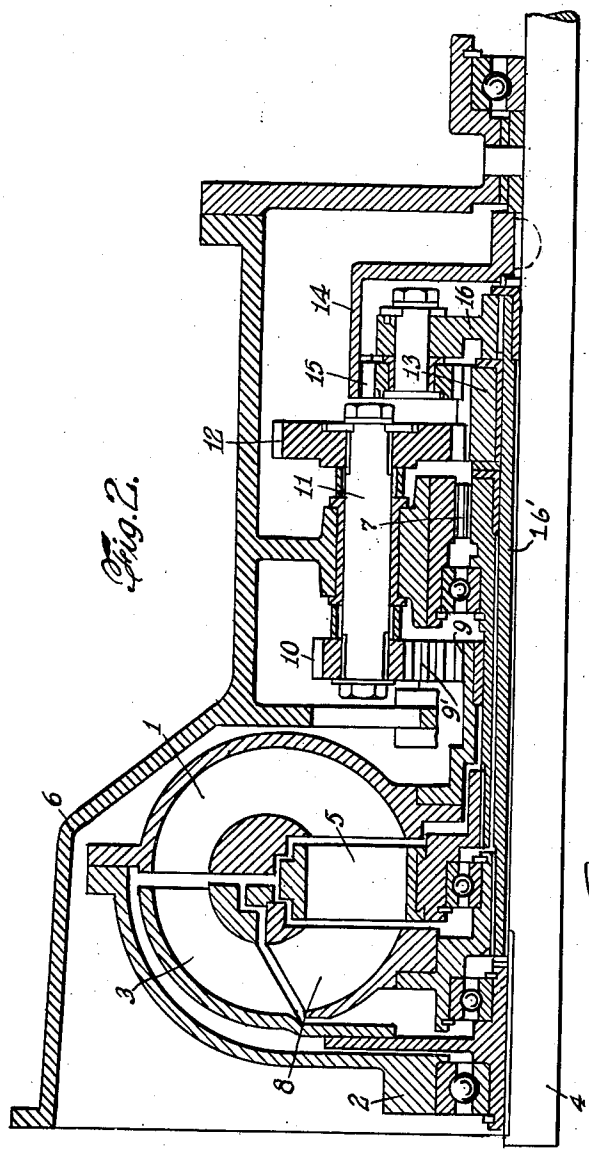


Fig. 2.

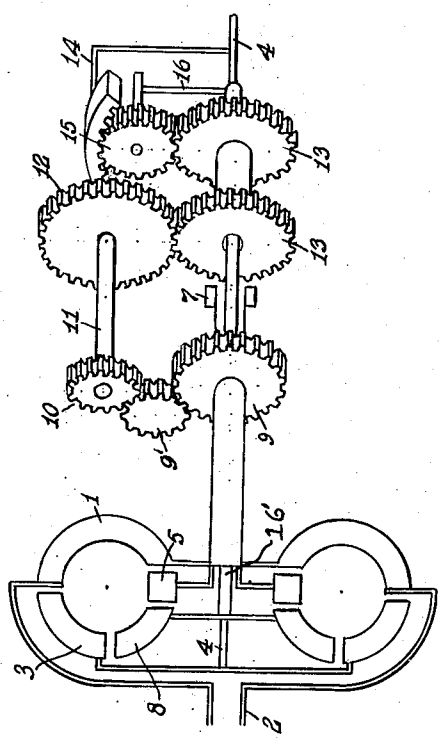


Fig. 3.

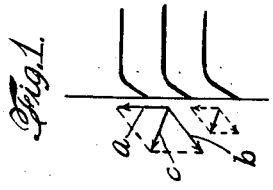


Fig. 1.

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Fig. 4.

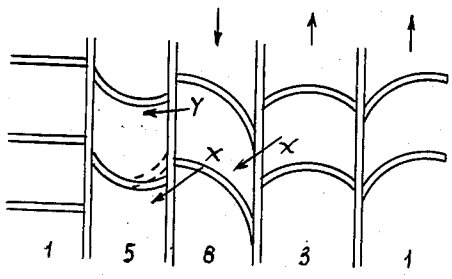


Fig. 4a.

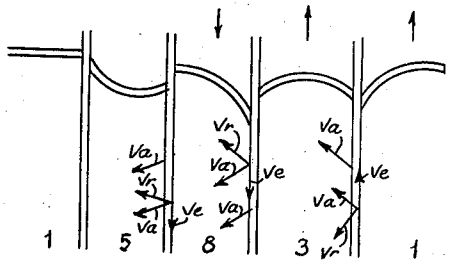


Fig. 5.

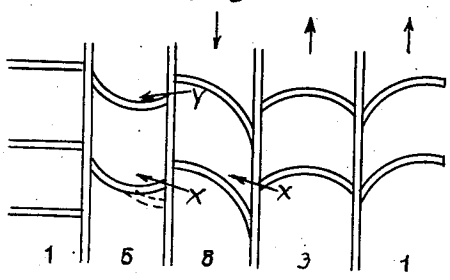


Fig. 5a.

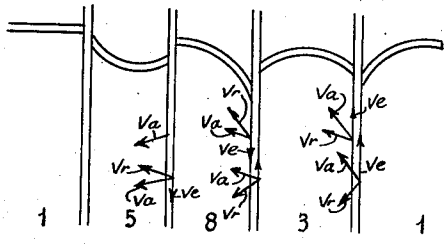


Fig. 6.

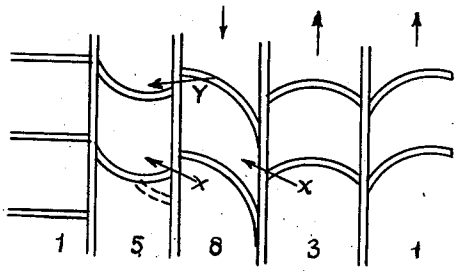
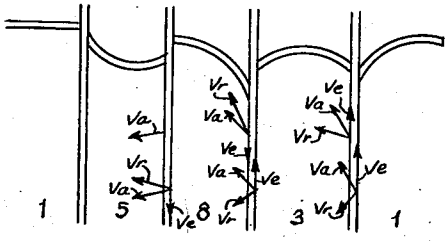


Fig. 6a.



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ROTARY HYDRAULIC TORQUE CONVERTER

Léon Saives, Billancourt, France, assignor to Regie Nationale des Usines Renault, Billancourt, France

Application April 25, 1951, Serial No. 222,846

Claims priority, application France July 21, 1950

3 Claims. (Cl. 60—54)

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The invention relates to a hydraulic torque converter of the type in which the hydraulic circuit includes a pump connected to the engine, a turbine connected to the driven unit, and a reaction element connected to a fixed casing by means of a free wheel.

In known converter constructions of this type, the proper operating conditions can be achieved only for one operating speed and in practice the output is limited to a narrow range of speeds.

The direction of the fluid streams relative to the vane sets at the inlet of each element is, in fact, a function of the speed of the elements, while the inlet angles of the vane sets are fixed.

But it is known that at the inlet of the turbine, provided the ends of the pump blades are inclined backward, the direction of the fluid streams relative to the turbine vane set is susceptible to little variation.

The object of the present invention is to provide a construction in which there is reproduced at the inlet of the recation element conditions similar to those at the inlet of the turbine, that is, a direction of the fluid streams varies little with respect to the reaction vane set.

It has been found that such a result is obtained by adding to the conventional system of pump, turbine, and reaction element, a rectifying element disposed between the turbine and the reaction element. This element, being driven, has a speed which is proportional to the difference between the speed of the pump and the speed of the turbine and is driven in a direction which is opposite to that of the pump.

In the accompanying drawings, Fig. 1 is a diagram of the speed vectors at the outlet of the pump of a conventional torque converter;

Fig. 2 is a cross-sectional view of a torque converter embodying features of the present invention;

Fig. 3 is a diagrammatic view in perspective of the kinematic relationships of the converter of the invention;

Fig. 4 shows diagrammatically the arrangement of the sets of vanes of the various elements of the torque converter, and represents the development of the outer contour of the circuit with the relative speed vectors of the fluid striking the rectifying vanes when the turbine is started;

Fig. 4*a* shows the arrangement of Fig. 4 but shows the vector diagrams of the speeds at the inlet and at the outlet of the various vane sets upon starting;

Fig. 5 is a diagrammatic view similar to Fig. 4, but showing the speed vectors for half-speed operation of the turbine;

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Fig. 5*a* is like Fig. 4*a* but shows the vector diagram of the speeds at the inlet and at the outlet of the various vane sets for half-speed operation;

Fig. 6 is like Fig. 4, but the speed vectors are shown for maximum speed of the turbine; and

Fig. 6*a* corresponds to Fig. 4*a*, but shows the vector diagram for maximum speed.

The torque converter of the invention (Figs. 2 and 3) includes a pump 1 connected to the engine shaft 2, a turbine 3 integral with the driven shaft 4, and a reaction member 5 connected to the casing 6 of the machine by a free wheel 7. There is also provided a rectifying turbine element 8 disposed between the turbine 3 and the reaction member 5.

The engine shaft 2 is integral with a pinion 9 which meshes with a loose pinion 9' having a shaft secured to casing 6. Pinion 9' in turn meshes with pinion 10, which is integral with a shaft 11 to which is cottered a pinion 12. Shaft 11 rotates in a bearing mounted in casing 6.

Pinion 12 is in engagement with a pinion 13, which is the sun pinion of a transmission having a crown wheel 14 and satellite 15, the sun pinion 13 being freely rotatable on its shaft. The satellite holder or support 16 is connected for rotation with rectifying element 8 through the medium of a hollow shaft 16'. Crown wheel 14 is connected to the driven shaft 4.

From the kinematic point of view, it is seen that the sun pinion 13 rotates in the direction opposite to that of the engine shaft 2 at a speed proportional to that of the latter and in relation to the number of teeth on the gears 9, 9', 10, 12 and 13. The satellite-holder 16 connected for rotation with the rectifying element 8 rotates at a speed proportional to the difference in speed between pump 1 and turbine 3 and in a direction opposite to that of the pump.

As an example, if the total ratio between pinion 9 and pinion 13 is 2, the rectifying element has a speed given by the formula:

$$\text{Speed of rectifier in opposite direction to that of the pump} = \frac{2\,(\text{pump speed} - \text{turbine speed})}{3}$$

Looking at the machine from the outlet end of the driven shaft 4, the clockwise direction of rotation is considered to be the positive or forward direction. In the developed views 4, 4*a*, 5, 5*a*, 6, 6*a*, this direction corresponds to a displace-

ment of the vane sets toward the top of the drawing. In these views 1 is the pump, 3 is the turbine, 5 is the reaction member and 8 is the rectifying element.

The opposite direction is the negative or reverse direction. In the developed views, this direction corresponds to a displacement of the vane sets toward the bottom of the drawing. The engine is assumed to rotate in the positive direction. If we give to the various speed vectors the following symbols:

a=absolute movement of the fluid relative to the vehicle,

e=movement of the vane sets relative to the vehicle,

r=movement of the fluid relative to the vane sets,

we always have the known relation of the velocities corresponding to these three factors:

$$\vec{V}a=\vec{V}e+\vec{V}r$$

In Fig. 1, a designates the circumferential speed of the pump relative to the turbine; b, the relative speed of the fluid with respect to the pump; and c, the relative speed with respect to the turbine.

In Fig. 1 it is seen that, with a pump having blades which extend backward, the direction of the fluid streams relative to the turbine vanes is only slightly variable. The flow of the fluid decreases with the difference in speed between turbine and pump.

It is seen that the relative speed vector of the fluid at the inlet of the turbine is the diagonal of a parallelogram having sides which shorten as the speed of the turbine increases with respect to the speed of the pump. In Figs. 4a, 5a and 6a the velocity vectors are shown for the conditions existing at the exit of the pump and at the entrance of the turbine 3, at the exit of the turbine and at the entrance of the reaction member 8, and at the exit of the reaction member and at the entrance of the rectifying element 5. Thus, the conditions at the exit of the pump are indicated by the arrows originating at the vertical line furthest to the right and the conditions at the entrance to the turbine 3 by the arrows originating at the next vertical line. The velocity conditions existing at the exit from the turbine are shown by the arrows originating at the next vertical line to the left, and so forth.

In Fig. 4a are shown the various speed diagrams at the time of starting up. Upon starting, the vehicle, the driven shaft 4, and the turbine 3 are at rest. The engine and the pump are set in motion at the desired speed. At the outlet of the pump we have the diagram shown in this figure. The fluid is projected against the turbine 3 with the velocity Va as indicated by the uppermost arrow at the right. As a consequence, there is a high torque on the turbine, that is, on the driven shaft 4.

At the outlet of the turbine vanes, the fluid is directed rearwardly due to the shape of the vane set, substantially along the tangent to the middle line of the vane set of the turbine 3 at the outlet.

In this example, the vane set of rectifying element 8 rotates at the time of starting at two-thirds the speed of the pump and in the opposite direction. Fig. 4a shows that the vane set meets the fluid issuing from the turbine at the speed Vr.

At the outlet of the vane set of element 8, the relative velocity of the fluid is slightly increased due to the contraction of the cross-section of the fluid stream since the diameter of the vane set of element 8 is smaller at the outlet than at the inlet, as seen in Fig. 2. The driving velocity is decreased because of the decrease in diameter of the vane set of element 8 from the inlet to the outlet.

At the outlet of vane set of element 8, it is seen that these various factors acting jointly with the vanes of element 8, impart to the fluid an absolute speed Va.

If the rectifying element 8 did not exist, the fluid issuing from the turbine would act directly along arrow X of Fig. 4 on the vanes of reactor 5, and if we wanted to limit the losses by shock at the inlet, we would have to give to the blades of the reactor the form indicated by the broken lines in Fig. 4.

The purpose of the rectifier during this phase of the operation is to change the direction of the fluid streams at the inlet of the reactor, so that it will correspond to the solid lines of Fig. 4 (arrival along arrow Y).

At the outlet of rectifier 8, the fluid is deflected in the reactor as in an ordinary converter comprising pump, turbine, and reactor.

Under the effect of the torque received on the driven shaft 4, the vehicle picks up speed.

Due to the relative forward velocity imposed on it by the turbine, the fluid at the outlet thereof has an absolute velocity which is less and less directed backwardly. The rotational velocity of the element 8 also decreases due to the rotation of the crown wheel 14.

When the turbine has reached a velocity of rotation about half that of the pump vanes (Figs. 5 and 5a), at the outlet of pump 1, Ve has not varied (assuming that the speed of the engine is constant). Due to the decrease in the flow of fluid in circulation observed as the torque converter picks up speed, Vr has decreased so that Va, the resultant of Ve and Vr, has decreased in magnitude and is now directed forwardly.

At the inlet of the vane set of turbine 3, with the driving velocity Ve of the turbine equal to half the velocity of rotation Ve of the wheel, the velocity Vr is directed rearwardly in such manner that the turbine vane set is still suitably struck by the fluid of the converter, but the circulation velocity of the fluid in relation to the vane set is less than when starting.

At the outlet of the vane set of turbine 3, the combination of the velocity Vr with the velocity Ve results in the absolute outlet velocity Va. We see that the velocity Va, which had at the start a strong inclination rearwardly, is now slightly inclined forwardly.

At the inlet of the vane set of rectifier 8, the velocity of rotation Ve of vane set 8 is maintained at its reduced value; in the example being discussed, Ve equals ⅓ the speed of the pump and has an opposite direction. It is seen from the drawing that despite the variation of direction of the speed at the inlet between the starting speed and the speed considered, the vane set 8 suitably strikes the fluid.

At the outlet of the vane set of rectifier 8, the driving velocity Ve is, as we have seen, less than the corresponding speed at the inlet because of the smaller-radius of the vane set at the inlet than at the outlet. The velocity relative to the vane set Vr is increased and the absolute velocity Va is substantially as upon starting so that the fixed vane set 5 is still correctly adapted to the fluid current.

From Fig. 5 it is seen that without vane set 8 the reactor vane set 5 would be attacked by the fluid along arrow X, which would make it necessary to form this vane set 5 as shown by the broken lines, while with the rectifying vane set 8 the reactor 5 is attacked along arrow Y, that is, the shape shown in solid lines is still suitable.

Beyond this speed, the relative forward velocity due to the rotation of turbine 3 is increasingly greater. The absolute speed of the fluid streams, for example, extends along arrow X of Fig. 6 for a given operating speed.

In Fig. 6a there is shown the flow of the fluid in the machine at a speed of the turbine such that the reactor 5 is ready for free-wheel rotation. As is known, the velocity of the fluid in the turbine has still decreased, but remains correctly oriented at the inlet. At the outlet of the turbine the absolute velocity is oriented forward to a great extent, and the rectifying vane set 8, which now rotates at very low velocity, brings the fluid back so that the fixed vane set 5 remains suitably attacked.

If the rectifying element 8 did not exist, the fluid, issuing from the turbine 3, would act directly on the vane set of the reactor 5 and in order to limit the shocks at the inlet of the latter, I would have to draw the vane set along the dotted line in Fig. 6. It is the task of the rectifier in this range, due to the shape of the vane set and its velocity toward the rear, to bring toward the rear the fluid which passes through it (arrow Y, Fig. 6) in such a way that the vane set of the reactor can be drawn along the unbroken line of Fig. 6 (the same as the solid lines in Figs. 4 and 5).

Calculations and experience have shown that if the rectifier is to play its role effectively in all ranges, the law of the variation of its velocity has to be as outlined above. It is the function of the rectifier 8 to maintain as constant as possible the direction of the fluid at the inlet of the reactor, that is, to exercise control over the behavior of the fluid.

Above a certain range the rectifier is no longer adapted to compensate the tendency of the fluid to drive the reactor forwardly. The reactor which is mounted on a free wheel does not take the torque any more and the apparatus operates as a clutch.

The study of the functioning of the apparatus of the invention shows that in the course of starting up the absolute velocity of the fluid at the outlet of the turbine, at first strongly directed forwardly, becomes gradually directed rearwardly. A rectifier blade set actuated by a rotating motion opposite to that of the vane set and proportional to the difference of the velocities between the pump and the turbine, picks up the fluid at the outlet of the turbine and throws it with an almost constant absolute velocity in its direction of rotation. The reactor is then suitably attacked by the fluid at all speeds and the converter operates with a good output in a wide range of velocities.

I claim:

1. In a rotary hydraulic torque converter having an input structure and an output structure, a vaned pump wheel carried by said input structure, a vaned turbine wheel connected to said output structure and positioned to receive the discharge from said pump wheel, a vaned reaction wheel spaced from said turbine wheel, and a vaned rectifying wheel disposed to receive the discharge from said vaned turbine wheel and to direct the discharge toward said reaction wheel, a gear train for driving said rectifying wheel in a direction opposite to that of said turbine wheel, said gear train including gear means rotated by the input structure and gear means rotated by the output structure, whereby said rectifying wheel is driven differentially by said gear train at a speed proportional to the difference in speeds between said pump wheel and said turbine wheel.

2. A rotary hydraulic torque converter as defined in claim 1, wherein said gear means rotated by said output structure comprises a planet pinion support connected for rotation with said rectifying wheel and supporting a plurality of planet pinions, a sun gear and a ring gear in meshing engagement with said planet pinions, said sun gear being connected for rotation with said pump wheel in the opposite direction thereto, and said output structure including a driven shaft connected to said ring gear.

3. In a rotary hydraulic torque converter having an input structure and an output structure, a vaned pump wheel carried by said input structure, a vaned turbine wheel connected to said output structure and positioned to receive the discharge from said pump wheel, a vaned reaction wheel spaced from said turbine wheel, and a vaned rectifying wheel disposed to receive the discharge from said vaned turbine wheel and to direct the discharge toward said reaction wheel, a gear train for driving said rectifying wheel in a direction opposite to that of said turbine wheel, said gear train including gear means rotated by the input structure and gear means rotated by the output structure, whereby said rectifying wheel is driven differentially by said gear train at a speed proportional to the difference in speeds between said pump wheel and said turbine wheel, a speed reducing gear having a fixed casing, one gear of said speed reducing gear being connected with said vaned pump wheel, a free wheel mechanism connecting said vaned reaction wheel with said casing, said gear means rotated by said output structure comprising a planet pinion support connected for rotation with said rectifying wheel and supporting a plurality of planet pinions, a sun gear and a ring gear in meshing engagement with said planet pinions, said sun gear meshing with a second gear of said speed reducing gear and thereby being connected for rotation with said pump wheel in the opposite direction thereto, and said output structure including a driven shaft connected to said ring gear.

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