

Feb. 10, 1970

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3,494,704

HYDRAULIC MACHINE

Filed Nov. 15, 1967

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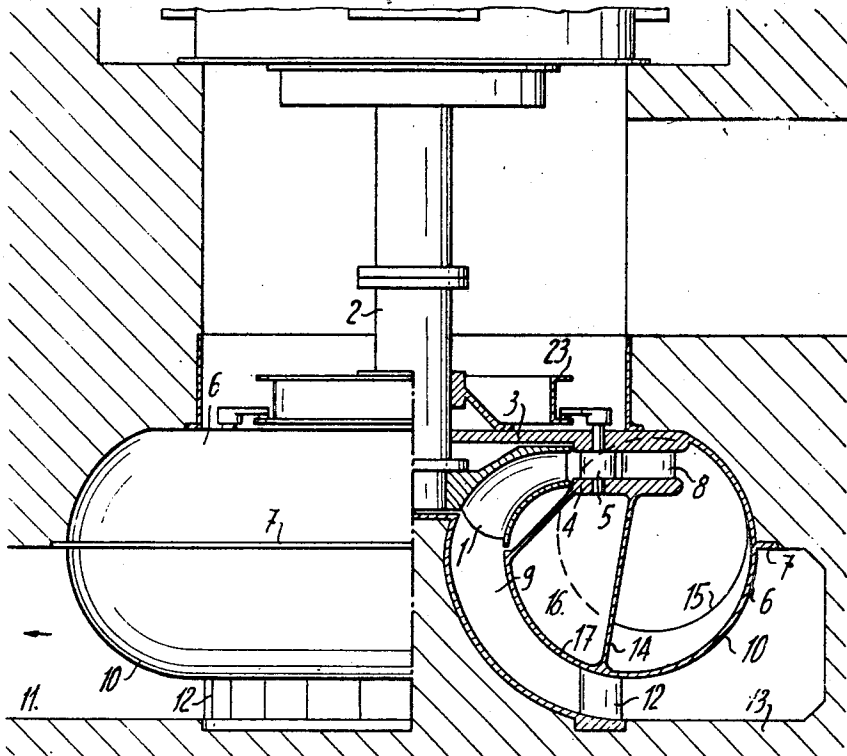


FIG. 1

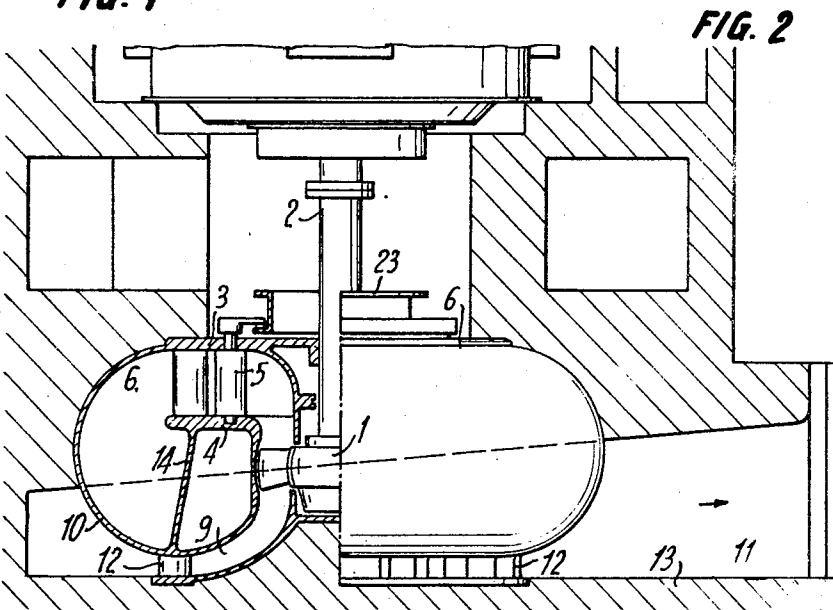


FIG. 2

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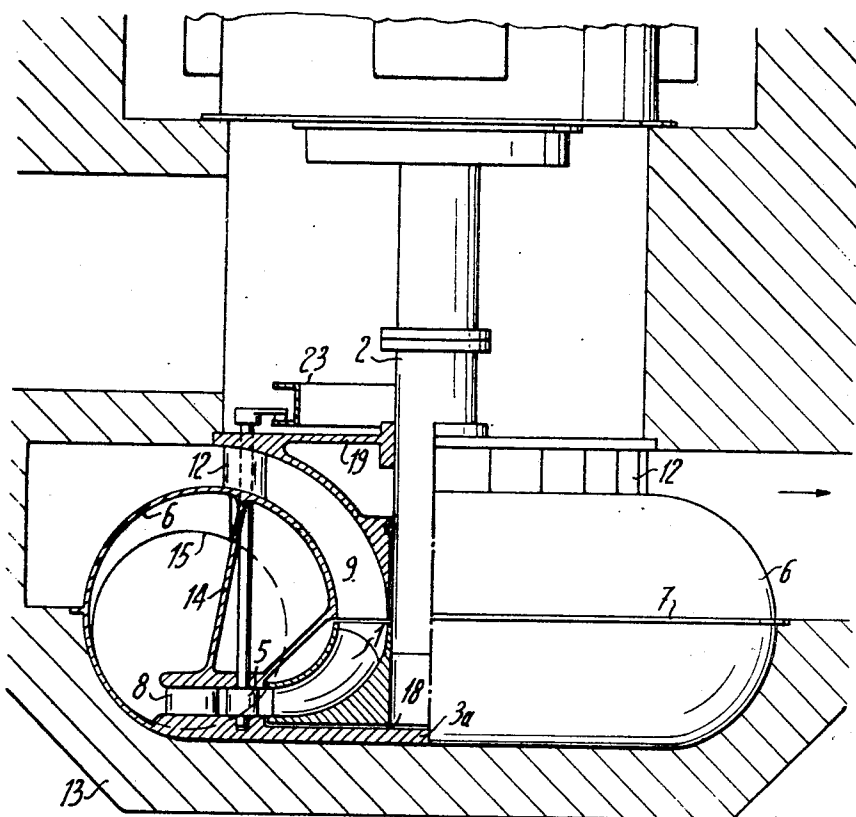
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5 Sheets-Sheet 2



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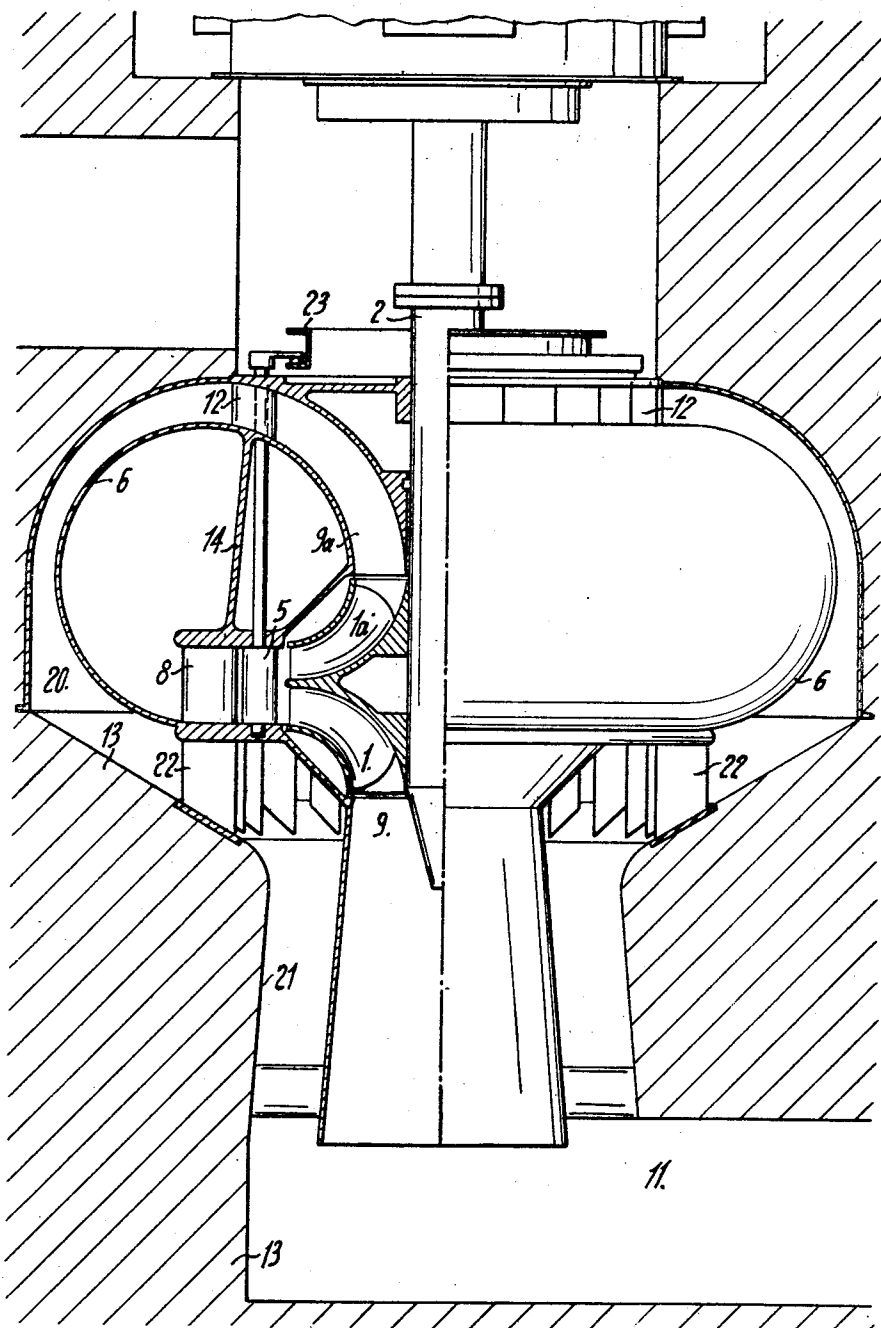


FIG. 4

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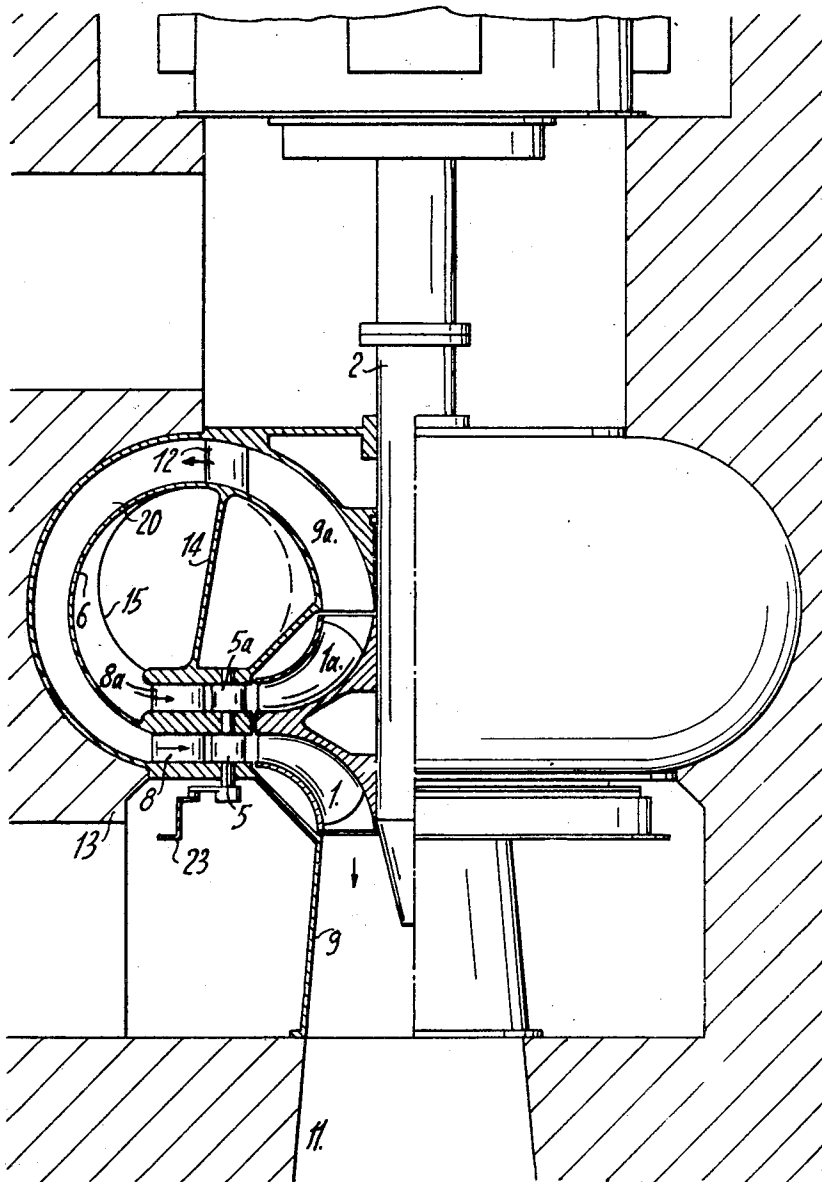


FIG. 5

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5 Sheets-Sheet 5

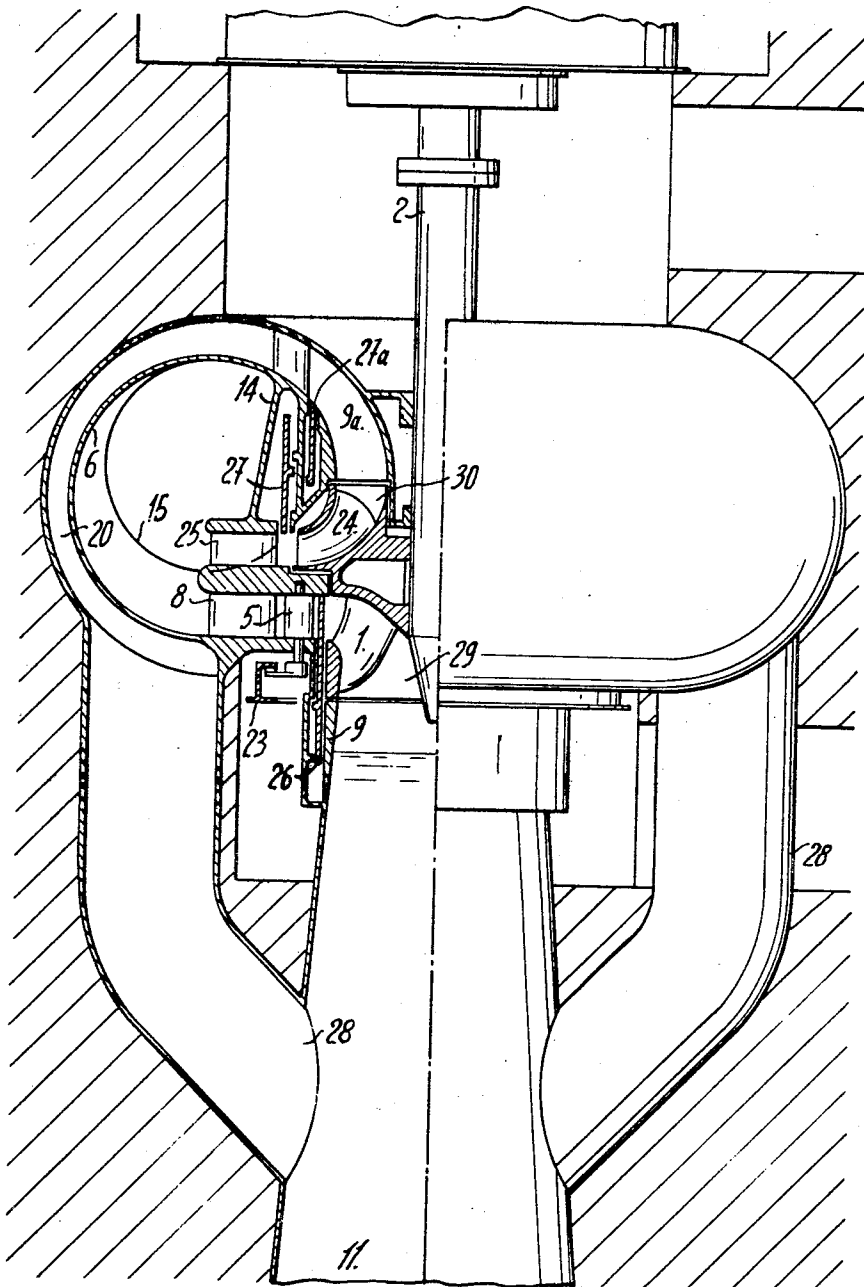


FIG. 6

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3,494,704

HYDRAULIC MACHINE

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Filed Nov. 15, 1967, Ser. No. 683,346

Claims priority, application Switzerland, Nov. 21, 1966, 16,662/66

Int. Cl. F02d 1/00; F03b 13/12

U.S. Cl. 415—95

6 Claims 10

ABSTRACT OF THE DISCLOSURE

A hydraulic machine, such as a turbine and/or a pump, has a suction channel communicating with a rotor and the suction channel partially surrounds a feed tank connected with said rotor. The tank is adapted to feed water into the rotor or to collect water therefrom. The suction channel preferably extends at its other end in an outward radial direction. The tank has its transverse medial plane axially shifted with reference to the end of the rotor facing away from said channel, this arrangement permits reducing the bulk of the machine in a transverse direction as well as vertically when the outer end of the suction channel is directed radially and outwardly.

The present invention has for its object a hydraulic machine including at least one turbine and/or pump or pump-turbine rotor, a toroidal shaped tank feeding water into said rotor or receiving the water passing out of said rotor and a transfer channel.

According to the invention, the improved machine is provided with a transfer channel of which at least a portion extends radially along the tank and partially encloses the tank. Said channel will be termed hereinafter the suction channel for sake of clarity, whether the machine operates as a turbine or as a pump.

The accompanying drawings illustrate diagrammatically and by way of example several embodiments of said invention. In said drawings:

FIG. 1 is an elevational view, partly in section, along the vertical axis of a first embodiment of such a hydraulic machine known as a Francis turbine.

FIG. 2 is an elevational view, partly in section along the vertical axis of a second embodiment of said hydraulic machine, known as a Kaplan turbine.

FIG. 3 is an elevational view, partly in section, along the vertical axis of a third embodiment of such a hydraulic machine, which in this instance is an inverted flow Francis turbine.

FIG. 4 is an elevational view, partly in section, along the vertical axis of a fourth embodiment of the improved hydraulic machine, which in this case comprises a double Francis turbine.

FIG. 5 is an elevational view, partly in section, along the axis of a fifth embodiment of the improved hydraulic machine, which in this case comprises a two stage pump or turbine.

FIG. 6 is an elevational view, partly in section, along the axis of a sixth embodiment of the improved hydraulic machine, which in this case comprises a turbine coupled with a pump.

Referring to FIG. 1, the hydraulic machine includes a runner or wheel 1 of the Francis type, forming the rotor secured to the lower end of a vertical shaft 2. Said rotor is fed by a distributor 5 extending between an upper cover 3 and a lower cover 4, which covers hold the rotor in position. An annular tank 6 is adapted to feed water into said turbine. As apparent from inspection of the drawing,

the medial plane of said tank 6 as defined by the flange 7, is shifted downwardly with reference to the axis of the input of the water streams entering the preliminary distributor 8 lying ahead of the distributor 5. Said arrangement allows giving the suction channel 9 a shape partially matching that of the tank. Said channel, instead of extending in a conventional manner downwardly, radially surrounds a portion of the periphery of the tank 6, so as to enclose the latter at least partly. As a matter of fact and as illustrated in FIG. 1, the section 10 of the outer wall of said tank 6 forms also a portion of the inner guiding wall of the suction channel 9. Said suction channel 9 opens into an exhaust channel 11. Stationary guiding stays 12 provide for the transmission of the load formed by the parts of the machines including the tank 6, the covers 3 and 4 and the distributor 5 onto the masonry 13. A supporting partition 14 transmits directly across the tank 6 the load of the covers 3 and 4 and of the distributor 5 to said stays 12. The input channel feeding water into the tank 6 has been drawn diagrammatically at 15. As to the tank compartment 16 extending between the lower cover 4, the supporting partition 14 and a section 17 of the wall of the suction channel 9, it may be kept empty and contain no water in the case of a comparatively low head of water acting on the rotor. In contradistinction, in the case of a high water head, it is preferable to provide an equilibrium between said compartment 16 and the main compartment forming the actual tank 6, which is obtained by forming openings through the partition 14. The arrangement described hereinabove with reference to FIG. 1 shows that it is possible to fit a hydraulic machine within a space which is much lower than a conventional arrangement according to which the suction channel extends vertically underneath the machine.

The second embodiment illustrated in FIG. 2 shows a hydraulic machine the arrangement of which is similar to that of the first embodiment and including the same main components, to wit: a runner or rotor 1 carried by a vertical shaft 2, an upper cover 3, a lower cover 4, a distributor 5, a feed tank 6 and a suction channel 9 extending radially along the periphery of the tank 6 so as to close said tank at least partly along a section of its outer wall 10. In this second embodiment the turbine is of the Kaplan type, and it is apparent that with such a type of turbine, it is possible to provide without any difficulty a suction channel 9 enclosing at least partly the tank 6. Said suction channel 9 opens also across the stays 12 into an exhaust channel 11 surrounding the lower part of the annular tank 6.

FIG. 3 shows a hydraulic machine comprising a Francis turbine wherein the runner or rotor 1 is turned upside down to provide an inverted flow along its vertical shaft 2. Consequently, the suction channel 9 is directed upwardly and extends radially around the tank 6. The preliminary guiding stays 8 and also the distributor 5 are located at the lower end of the machine and a flat cover 3a corresponding to the upper cover 3 of the machine illustrated in FIG. 1 is housed underneath the rotor 1. The gap 18 extending between said lower cover 3a and the rotor 1 is connected with the high pressure side of the machine, so that the pressure thus acting underneath the rotor has a tendency to relieve the pivot subjected to the axial load formed by the rotary parts of the machine. In this embodiment, the stays 12 located at the output end of the suction channel 9 transmit through the partition 14 and through the preliminary guiding stays 8 the load of the upper components 19 of the machine frame to the masonry 13.

FIG. 4 illustrates a double hydraulic machine including two adjacent Francis rotors 1 and 1a carried by the same vertical shaft 2. The suction channel 9a for the upper

rotor 1a is directed upwardly along the shaft 2, whereas the suction channel 9 for the rotor 1 is directed downwardly and is in the shape of a conventional suction cone opening into the exhaust channel 11. The preliminary guiding stays 8 of said machine and also the distributor 5 feed the two rotors 1 and 1a out of the same tank 6. The suction channel 9a for the upper rotor 1a completely encloses the tank 6 through its bent extension 20 and opens coaxially with the suction channel 9 as a coaxial annular frusto-cone 21 opening into said exhaust channel 11. The stationary stays 12 and also the further stationary stays 22 are adapted to transmit to the masonry work 13 the load formed by the stationary parts of the machine by means of the partition 14 and of the preliminary guiding stays 8.

FIG. 5 shows a two stage pump or turbine including two superposed rotors 1 and 1a carried by the same vertical shaft 2. In the case where the hydraulic machine operates as a two stage turbine, the feed tank 6 feeds across the preliminary guiding stays 8a and the distributor 5a the first rotor 1a of which the suction channel 9a extends upwardly and then radially outwardly so as to enclose the tank 6 through its bent extension 20. Said suction channel 9a for the first stage of the turbine extends across the preliminary guiding stays 8 and the distributor 5 of the second stage 1 of the turbine out of which water flows into the corresponding suction channel 9 of a conventional frusto-conical shape directed downwardly towards an exhaust channel 11.

Said machine includes also stationary stays 12 and a partition 14 for the transmission of the load of the stationary sections of the machine to the masonry 13. In said embodiment, the annular blading system 23 is located underneath the distributor 5, whereas in the four first embodiments disclosed, said blading system 23 was located in the upper part of the machine. The arrangement illustrated in FIG. 5 is of particular interest when it is desired to make use of a water head of a considerable height, of a magnitude say of 1,000 m., and to use turbines of the Francis type with which the maximum height which may be used for operation with a proper yield is of a magnitude of about 500 to 600 m. for each stage.

FIG. 6 illustrates a hydraulic machine of the so-called turbine-pump type, that is a hydraulic machine including a turbine rotor 1 coupled with a pump rotor 24. A common tank 6 serves on the one hand for feeding water to the turbine rotor 1, when operative, across the front guiding stays 8 and the distributor 5 controlled by the blading system 23 and on the other hand for receiving the water passing out of the diffuser 25 of the pump 24 in the case of the machine operating as a pump. A sleeve valve 26 illustrated in its closed position in FIG. 6 allows cutting off the chamber 29, inside which the turbine rotor revolves, with reference to the tank 6. Two further sleeve valves 27 and 27a illustrated in their open positions allow cutting off the chamber 30, inside which the pump rotor 24 revolves, with reference to the tank 6 and the suction channel 9a opening into the latter.

In this embodiment, the suction channel 9 of the turbine of a conventional frusto-conical shape extends downwardly. As to the suction channel 9a of the pump 24, it includes a section 20 surrounding the tank 6. Pipes 28 provide for the feed of water into the pump 24 out of the lower channel 11, through which water is exhausted out of the turbine 1 or else through which water is fed into the pump 24. Said pipes 28 which may be distributed around the suction cone 9 open thus into the section 20 of the suction channel 9a so as to feed the pump rotor 24.

When the hydraulic machine is operating as a pump, the chamber 29 inside which the turbine rotor 1 revolves is no longer filled with water since the water has been expelled from said chamber, for instance by compressed air.

When the hydraulic machine is to operate as a turbine, the sleeve valve 26 is open, while the sleeve valves 27

and 27a are closed. The chamber 30 inside which the pump rotor 24 revolves is then no longer filled with water so as to reduce the frictional losses arising during operation, whereby the machine may operate as a turbine with a good efficiency. As a modification of the arrangement illustrated in FIG. 6, it is possible to set the turbine rotor 1 above the pump rotor 24, instead of the reverse as in the case illustrated.

The different embodiments of a hydraulic machine disclosed hereinabove with reference to FIGS. 1 to 6 all show the novel arrangement, wherein at least a portion of the suction channel encloses at least part of the feed tank or the water collecting tank to permit reducing the general radial bulk of the machine. This is ascribable to the fact that the medial plane 7 of the tank 6 is shifted vertically with reference to the horizontal plane in which water enters the turbine out of the tank or passes out of the pump into said tank. This provides means for shifting the volume occupied by the tank into an area of a diameter less than that of the front guiding stays 8 for instance. On the other hand, the arrangement illustrated in FIGS. 1 to 3 also permits a substantial reduction in the height occupied by the hydraulic machine since the suction pipe, instead of extending vertically in a downward direction, flares in a horizontal radial direction towards the exhaust channel 11.

In all the embodiments disclosed, the cross-sectional area of the tank 6 instead of decreasing between the input opening 15 and the opposite end of the tank as is usual, is constant so that the tank is in the general shape of a toroid. However, in order to retain with such a tank a constant speed of flow, it is possible to provide it internally with a partition guiding the water so as to gradually reduce the cross-section of the tank 6 between the input opening 15 and the opposite end of the tank.

All the embodiments disclosed and illustrated have been shown as having a vertical rotary axis. Of course, said axis may as well be horizontal.

What is claimed is:

1. A hydraulic machine comprising a rotor, the ends of which are subjected respectively to high and low pressure, a water-carrying toroidal shaped tank opening into the high pressure end of said rotor, a channel into which the low pressure end of the rotor opens, at least the initial portion of said channel adjacent the rotor disposed along and in direct contacting relationship with a portion of said tank, said channel extending radially around said tank and surrounding the major portion of the outer periphery of said tank, the wall of said initial portion of the channel also forming the wall of the corresponding portion of the tank, and water conveying means into which the lower pressure end of the channel opens radially.

2. A hydraulic machine as claimed in claim 1, subjected to a head of water and wherein the channel is directed upwardly over the corresponding portion of the tank, said machine including a vertical rotor-carrying shaft, a pivot supporting said shaft and means where through the water pressure at the high pressure end of the rotor is applied to said pivot against the weight applied to said shaft.

3. A hydraulic machine as claimed in claim 1, including a second rotor arranged in juxtaposed axial relationship with reference to the first-mentioned rotor and the high pressure end of which communicates with said tank, a second channel connected with the low pressure end of said second rotor and extending axially away from the first-mentioned channel and water conveying means into which both channels open at their ends opposite the corresponding rotors.

4. A hydraulic machine as claimed in claim 1, functioning selectively as a two stage pump and as a two stage turbine, said machine including a second rotor arranged

5

in juxtaposed axial relationship with reference to the first-mentioned rotor, the high pressure end of which is connected with the end of the first-mentioned channel facing away from the first-mentioned rotor, a second channel connected with the low pressure end of the second rotor and extending axially away from the first-mentioned channel and water conveying means into which the second channel opens through its end opposite the second rotor.

5. A hydraulic machine as claimed in claim 1, functioning selectively as a pump and as a turbine said machine including a second rotor arranged in axial juxtaposed relationship with reference to the first-mentioned rotor and the high pressure end of which communicates with said tank, said rotors serving respectively for turbine and for pump operation, a second channel connected with the low pressure end of said second rotor and extending axially away from the first-mentioned channel, water conveying means into which both channels open and dual means adapted to close the connection of the tank with each of the rotors respectively.

6. A hydraulic machine, as claimed in claim 1, wherein

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the transverse medial cross-section of the tank is axially shifted with reference to the high pressure end of the rotor.

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