

Jan. 10, 1928.

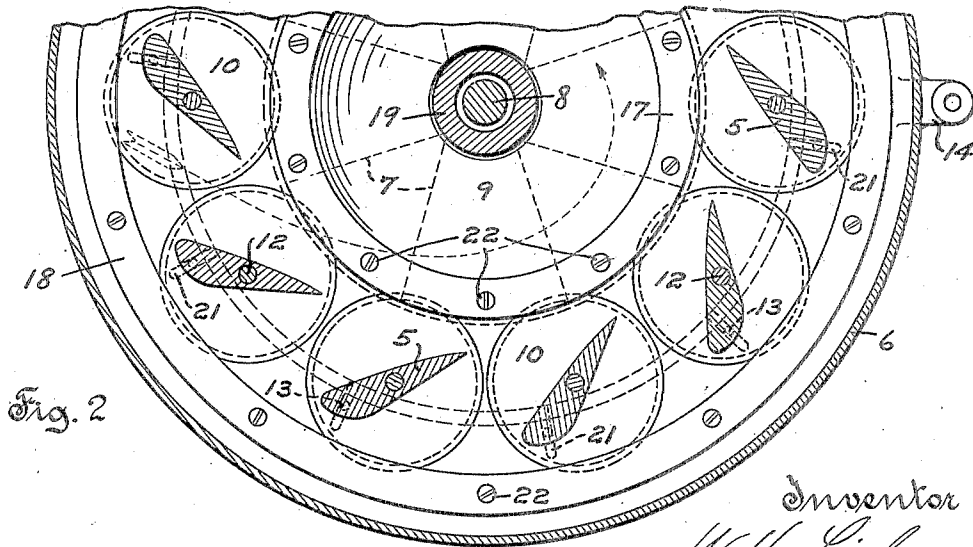
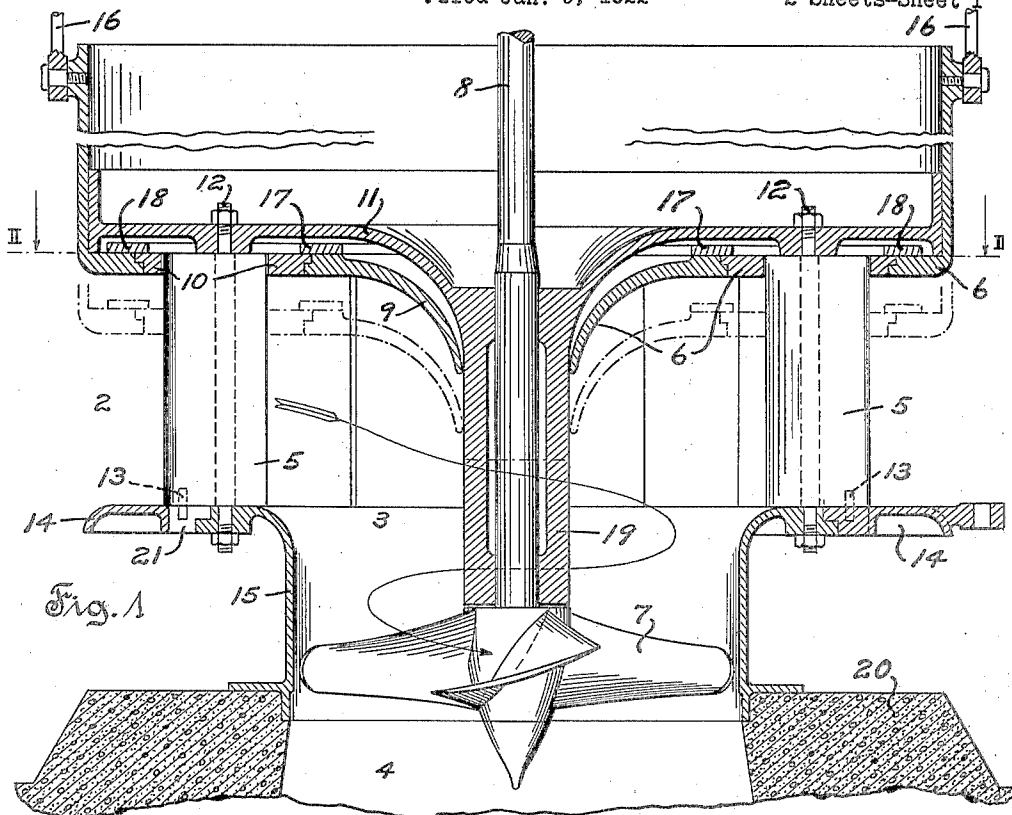
1,656,006

W. H. LIEBER

HYDRAULIC MACHINE

Filed Jan. 9, 1922

2 Sheets-Sheet 1



Inventor
W. H. Lieber
by *[Signature]*
Attorney

Jan. 10, 1928.

1,656,006

W. H. LIEBER
HYDRAULIC MACHINE

Filed Jan. 9, 1922

2 Sheets-Sheet 2

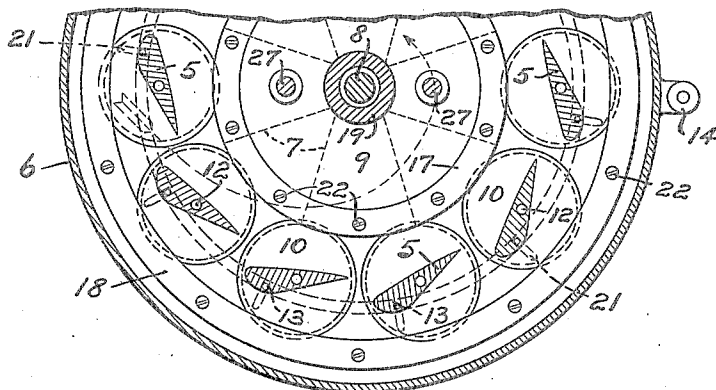
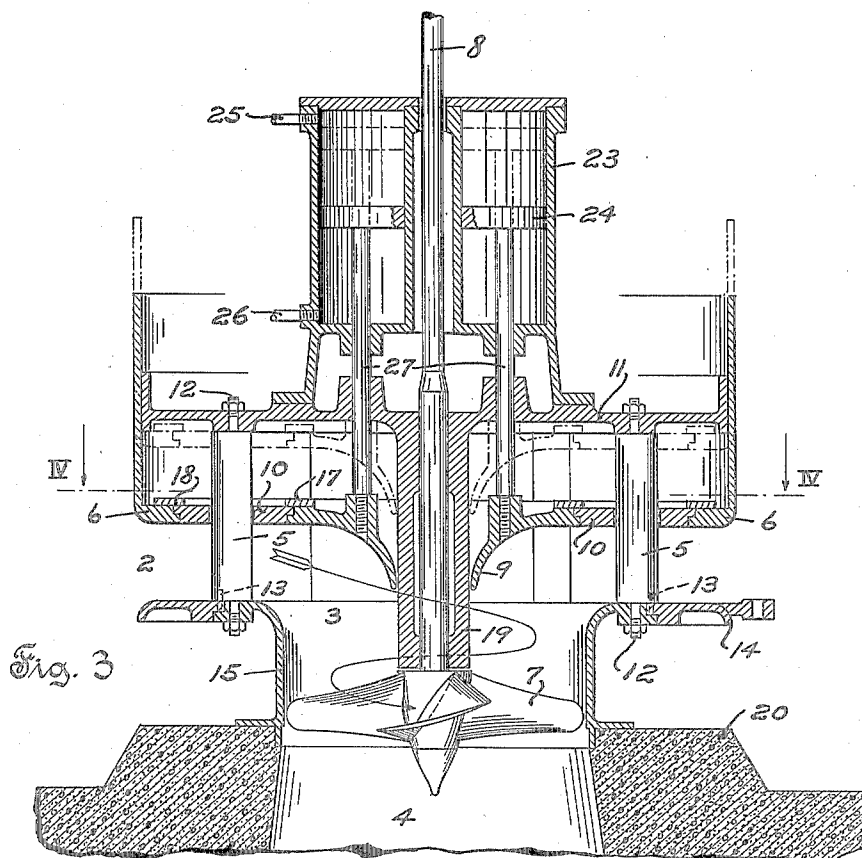


Fig. 4

Inventor
W. H. Lieber
by *G. J. G. Wein*
Attorneys

UNITED STATES PATENT OFFICE.

WILLIAM H. LIEBER, OF WEST ALLIS, WISCONSIN, ASSIGNOR TO ALLIS-CHALMERS MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF DELAWARE.

HYDRAULIC MACHINE.

Application filed January 9, 1922. Serial No. 527,817.

This invention relates in general to improvements in the art of converting hydraulic energy, and relates more specifically to improvements in the construction and operation of hydraulic machines such as hydraulic turbines and pumps.

An object of the invention is to provide an improved hydraulic machine which is simple in construction and efficient in operation. Another object of the invention is to provide an improved method of controlling the flow of liquid to or from a hydraulic energy converting machine. A further object of the invention is to provide a structure whereby liquid may be more efficiently delivered to or from a hydraulic rotor, than has heretofore been possible. These and other objects and advantages of the present invention will be apparent in the course of the following description.

It has heretofore been proposed to convert hydraulic potential energy into kinetic energy appearing as torque on a rotating shaft, by causing liquid to whirl and by subsequently passing the whirling mass of liquid through a rotor or impeller. In the prior machines for effecting conversion of energy in this manner, it has been customary to utilize several types of gate mechanism for controlling the quantity of liquid delivered to the rotor. One of the prior types of gate mechanism comprises an annular series of adjustable guide vanes adapted to simultaneously throttle the flow and to vary the degree of whirl of the entering liquid. Another of the prior types of gate mechanism comprises a plunger gate movable axially of the turbine rotor in order to throttle the flow thereto, but in this latter type no means are provided for varying the degree of whirl of the entering liquid.

In energy converting installations of this type, there are numerous conditions which affect the efficiency of the energy converting unit. These conditions are frequently of variable nature, thus making it impossible to construct a unit in accordance with the prior art, in which maximum efficiency is maintainable for all variations in the operating conditions. It is desirable in order to maintain maximum efficiency, to vary the degree of whirl of the entering liquid independently of the quantity of

liquid admitted to the rotor. The prior gate mechanism in which the quantity of flow and the degree of whirl are simultaneously altered, is objectionable since such simultaneous variation of these two characteristics of the entering liquid is seldom desirable. In the prior gate mechanism in which the degree of whirl of the entering liquid cannot be varied at all, is inefficient for that reason.

The present invention contemplates the provision of means whereby the quantity of liquid admitted and the degree of whirl of the entering liquid may be varied independently of each other, thereby enabling operation of the apparatus at maximum efficiency under all conditions. While the invention has been illustrated herein as applied to a hydraulic turbine of the reaction type, it will be obvious that the principles involved are applicable to other hydraulic machines such as centrifugal pumps wherein it is sometimes desirable to accommodate or to produce varying characteristics of the discharge flow.

A clear conception of several embodiments of the invention and of the method of operating machines constructed in accordance therewith, may be had by referring to the drawings accompanying and forming a part of this specification, in which like reference characters designate the same or similar parts in the various views.

Fig. 1 is a central vertical section through a hydraulic machine embodying one form of gate mechanism constructed in accordance with the invention.

Fig. 2 is a fragmentary transverse section through the unit disclosed in Fig. 1, the section being taken along the irregular line II—II of Fig. 1 looking in the direction of the arrows.

Fig. 3 is a central vertical section through a hydraulic machine embodying another form of gate mechanism constructed in accordance with the present invention.

Fig. 4 is a fragmentary transverse section through the unit disclosed in Fig. 3, the section being taken along the line IV—IV of Fig. 3, looking in the direction of the arrows.

Each of the hydraulic turbine installations illustrated in the drawings comprises

in general an inward flow inlet conduit 2, a vane free transition space 3 for receiving liquid from the conduit 2 and for changing its general direction of flow from radial to axial, a draft tube 4 arranged to receive liquid from the transition space 3, and an axial flow impeller 7 located between the transition space 3 and the draft tube 4. The inlet conduit 2 is in open communication with the source of liquid supply and is bounded by relatively movable upper and lower walls which are adapted to vary the quantity of liquid admitted to the transition space 3. In the installations illustrated, the lower bounding wall of the inlet conduit 2 comprises a lower stationary casing 15 and a rotatable guide vane actuating ring 14, while the upper bounding wall comprises a vertically adjustable plunger gate 6 slidably mounted upon the upper stationary turbine casing 11. The upper stationary casing 11 is supported directly from the lower casing 15 by means of an annular series of parallel pivot bolts 12, and has a downwardly extending central bearing portion 19. Adjustable guide vanes 5 are pivotally supported by the pivot bolts 12, these guide vanes 5 being located in the inlet conduit 2, and being adapted to vary the degree of whirl of the liquid delivered from the conduit 2 into the transition space 3. Each of the guide vanes 5 is provided with a downwardly extending pin 13 extending into an adjacent radial slot 21 formed in the guide vane adjusting ring 14. The ring 14 which is rotatably supported upon the stationary lower casing 15 is provided with actuating projections such as shown, for manipulating the guide vanes 5.

In order to permit adjustment of the guide vanes 5 about their pivot bolts 12 without hindering adjustment of the plunger gate 6, the plunger gate is provided with a rotary portion or circular plate 10 loosely embracing each of the guide vanes 5. These plates 10 are retained in position in the gate 6 by means of removable rings 17, 18 attached to the gate 6 by means of removable fastenings such as screws 22. The inner portion of the gate 6 is provided with a circular deflecting wall 9 having a central opening penetrated by the bearing portion 19 of the stationary upper casing 11. The deflecting wall 9 is adapted to change the general direction of flow of the liquid delivered into the transition space 3 from the inlet conduit 2, from radial to axial and is of such length measured axially of the unit, that it will not interfere with the rotor 7 when the plunger gate 6 is fully closed. The transition space 3 is bounded by the deflecting wall 9, the stationary bearing portion 19 and the stationary lower casing 15, and communicates directly with the inlet side of the rotor 7.

The impeller or rotor 7 located between the transition space 3 and the draft tube 4, is of the high speed axial flow type and is attached to the lower extremity of a vertical main shaft 8 which is supported in the stationary bearing portion 19, and the upper extremity of which is associated with an energy absorbing device such as an electric generator. While the specific impeller or rotor 7 illustrated is of the axial flow type, it will be obvious that the present invention should not be limited by such disclosure and that the principles are also applicable to installations embodying other types of impellers. The outer extremity of the vanes of the rotor 7 closely approach the interior of the casing 15 and as illustrated have free outer ends and also have varying angularity throughout their lengths. This specific form of rotor is not a part of the present invention but forms the subject of a copending application filed by another party. The draft tube 4 may assume a variety of forms and is located within the main foundation 20 which provides a support for the lower stationary casing 15 and the elements resting thereon.

In the installation illustrated in Figs. 1 and 2, the plunger gate 6 is manipulable to regulate the quantity of liquid entering the rotor 7 through the inlet conduit 2 and the transition space 3, by means of the rods 16 which may be movable either manually or otherwise. These rods 16 are attached to the annular bearing flange of the gate 6 which engages an outer cylindrical surface of the upper stationary casing 11. This form of gate mechanism is preferably employed where the inlet pressures are low or where the diameter of the unit is small.

In cases where the inlet pressures are relatively high or where the diameters are large, it may be preferable to utilize fluid pressure gate actuating mechanism such as illustrated in Figs. 3 and 4. In this structure the plunger gate is manipulable by means of an annular piston 24 connected to the plunger 6 by means of parallel rods 27 and reciprocable within a cylinder 23. Fluid under pressure may be admitted to and delivered from the cylinder 23 through conduits 25, 26, the actuating fluid being derivable from any convenient source.

During normal operation of a unit embodying the present invention, the plunger gate 6 may be adjusted to produce admission of the quantity of liquid necessary to carry the load imposed upon the main shaft 8. The liquid then enters the turbine rotor 7 through the inlet conduit 2 and the transition space 3. As the efficiency of the rotor 7 is to some extent dependent upon the degree of whirl of the entering liquid, the guide vanes 5 may be adjusted to produce most efficient operation, by manipulating the actu-

ating ring 14. Such adjustment of the guide vanes 5 will produce any desired degree of whirl of the liquid admitted to the transition space 3 from the inlet conduit 2. In the transition space 3, the whirling mass of liquid has its course changed from inward to axial without destroying the whirling components of the flow, by the deflecting wall 9. As illustrated by the arrows in Figs. 1 and 3, the whirling liquid delivered from the transition space 3 passes directly through the rotor 7 and is discharged from the rotor into the draft tube 4.

It will be obvious that the setting of the plunger gate 6 may be varied at will without disturbing the setting of the guide vanes 5, such operation being permitted by the circular disks 10 which during adjustment of the guide vanes 5 rotate freely within the plunger gate 6. During adjustment of the plunger gate 6, the disks 10 slide freely along the guide vanes 5, without affecting the setting of the vanes. These plates 10 serve to maintain smooth hydraulic passages for the entering liquid, thereby maintaining maximum efficiency of entrance by avoiding disturbances in the flow. It will also be noted that in order to permit complete closing of the plunger gate 6, without interference between the deflecting wall 9 and the rotor 7, the rotor 7 is preferably located some distance below the lower ends of the guide vanes 5. Such location of the rotor is not, however, objectionable and is in fact desirable since the provision of an axial flow conduit immediately preceding the rotor 7 enables the whirling mass of liquid to enter the rotor without impact. It will also be noted that the guide vanes 5 while not intended primarily for the purpose of throttling the flow of liquid, may be utilized in case of emergency, as when the plunger gate 6 becomes inoperative, to throttle the flow. The adjustment of the vanes 5 is readily effected by the adjusting ring 14 having slots 21 coacting with the guide vane pins 13. As the ring 14 is rotated, the pins 13 advance along the slots 21 thereby swinging the vanes 5 about the pivot bolts 12.

The adjustment of the gate 6 and guide vanes 5 may be effected either automatically or manually in accordance with variations in any one or more characteristics, such as changes in load, speed or operating head. While the position of the gate 6 may be varied without necessarily varying the angularity of the guide vanes 5, it will be obvious that simultaneous adjustment of both the gate 6 and vanes 5 may be desirable at times, in order to secure the desired operation of the unit. It will also be apparent that the gate 6 and guide vanes 5 may be automatically adjustable in response to different or the same variable characteristics. The desirability of such adjustments of the gate 6

and guide vanes 5 and the manner of effecting them will be readily understood by those skilled in the art.

While the invention has been illustrated as applied to vertical turbine units, it will be apparent that the same is also applicable to horizontal units as well as to units of other than the open flume type. The specific means for manipulating the plunger gate 6 and the guide vanes 5 may also be varied considerably without in any manner affecting the scope of the present invention. It should be generally understood that it is not desired to limit the invention to the exact details of construction and of operation herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In combination, an impeller, conduit means forming a vane-free space in advance of said impeller, means for varying the quantity of fluid passing through said space to said impeller, and adjustable means functioning independently of said quantity varying means for varying the direction of flow of said fluid relatively to said impeller.

2. In combination, an axial flow impeller, conduit means for directing fluid inwardly and axially toward said impeller, a gate for varying the quantity of fluid passing through said conduit means, and a series of adjustable guide vanes for varying the degree of whirl of the fluid admitted to said impeller through said conduit means.

3. In combination, an axial flow impeller, conduit means for admitting fluid axially toward said impeller, a gate movable axially of said impeller for controlling the quantity of fluid admitted through said conduit means, and adjustable means functioning independently of said gate for varying the degree of whirl of the fluid admitted to said impeller through said conduit means.

4. In combination, an impeller, a plunger gate for varying the quantity of fluid admitted to said impeller, and a series of guide vanes movable independently of said gate for merely varying the direction of flow of the fluid admitted to said impeller, said gate spanning the passages between said guide vanes.

5. In combination, an impeller, conduit means for delivering fluid inwardly and axially toward said impeller, a gate for controlling the flow of fluid through said conduit means, said gate being formed to change the direction of flow of the entering fluid from inward to axial, and means functioning independently of said gate for varying the degree of whirl of the fluid admitted to said impeller.

6. In combination, an impeller, conduit means for delivering fluid inwardly and

axially toward said impeller, a gate for controlling the flow of fluid through said conduit means, said gate being formed to change the direction of flow of the entering
5 fluid from inward to axial, and an annular series of adjustable guide vanes for varying the degree of whirl of the fluid admitted to said impeller.

7. In combination, an impeller having a
10 vane-free transition space in advance thereof, means for varying the quantity of fluid delivered to said impeller through said space, and adjustable means functioning independently of said quantity varying means
15 for varying the degree of whirl of said fluid relatively to said impeller.

8. In combination, an impeller, conduit means forming a vane-free space in advance of said impeller, means for varying the
20 quantity of fluid admitted to said impeller through said space, and adjustable means operable independently of said quantity varying means for varying the direction of flow of the fluid admitted to said impeller
25 through said space.

9. In combination, an impeller, conduit means forming a vane-free transition space directly in advance of said impeller, means for varying the quantity of fluid admitted
30 to said impeller through said space, and adjustable means located closely adjacent to said quantity varying means for varying the direction of flow of fluid admitted to said impeller through said space, said di-
35 rection varying means functioning independently of said quantity varying means.

10. In combination, an impeller, conduit means forming a vane-free transition space for conducting fluid along the axis of said
40 impeller, means for varying the quantity of fluid flowing through said space, and adjustable means located in advance of said space and closely adjacent to said quantity varying means for varying the direction of
45 flow of fluid admitted to said space, said direction varying means functioning independently of said quantity varying means.

11. In combination, an impeller having a vane-free space adjacent thereto, a gate
50 movable axially of said impeller to vary the quantity of fluid passing through said space, and a series of adjustable guide vanes for varying the direction of flow of said fluid, said gate functioning independently of said
55 guide vanes.

12. In combination, an impeller having a vane-free transition space directly in advance thereof, a gate movable axially of said

impeller to vary the quantity of fluid admitted thereto through said space, and an
60 annular series of adjustable guide vanes surrounding the axis of said impeller for varying the degree of whirl of the said fluid.

13. In combination, an impeller, means forming a passage comprising radial and
65 axial flow portions connected by a transition space for conducting fluid to said impeller, means for relatively moving the bounding surfaces of said passage to control the quantity of fluid admitted to said
70 impeller, and means functioning independently of said quantity controlling means for varying the degree of whirl of the entering fluid.

14. In combination, an impeller, conduit
75 means for delivering fluid inwardly and axially toward said impeller, said conduit means comprising a movable wall forming a surface curving from the radial to the axial
80 direction and said wall being movable to control the quantity of fluid delivered to said impeller, and means functioning independently of said quantity varying means for varying the degree of whirl of the fluid
85 delivered to said impeller.

15. In combination, an impeller, conduit means for delivering fluid toward said im-
90 peller, said conduit means comprising a wall movable along the axis of said impeller to control the quantity of fluid admitted to said impeller, and means functioning in-
95 dependently of said quantity varying means for varying the degree of whirl of the fluid delivered to said impeller.

16. In combination, an impeller, conduit
95 means for delivering fluid to said impeller, said conduit means comprising a wall movable along the axis of said impeller to vary the quantity of fluid admitted to said im-
100 peller, and means movable about axes parallel to the axis of said impeller and functioning independently of said quantity varying means for varying the degree of
105 whirl of the fluid delivered to said impeller.

17. In combination, an axial flow im-
105 peller, conduit means for delivering fluid axially with respect to said impeller, means movable along the axis of said impeller to vary the quantity of fluid passing through
110 said conduit means, and means movable about axes parallel to the axis of said impeller for independently varying the degree of whirl of said fluid.

In testimony whereof, the signature of the inventor is affixed hereto.

WILLIAM H. LIEBER.