May 6, 1924. 1,493,154

L. F. HARZA

HYDRAULIC POWER STATION

Filed May 10, 1920 2 Sheets-Sheet 1

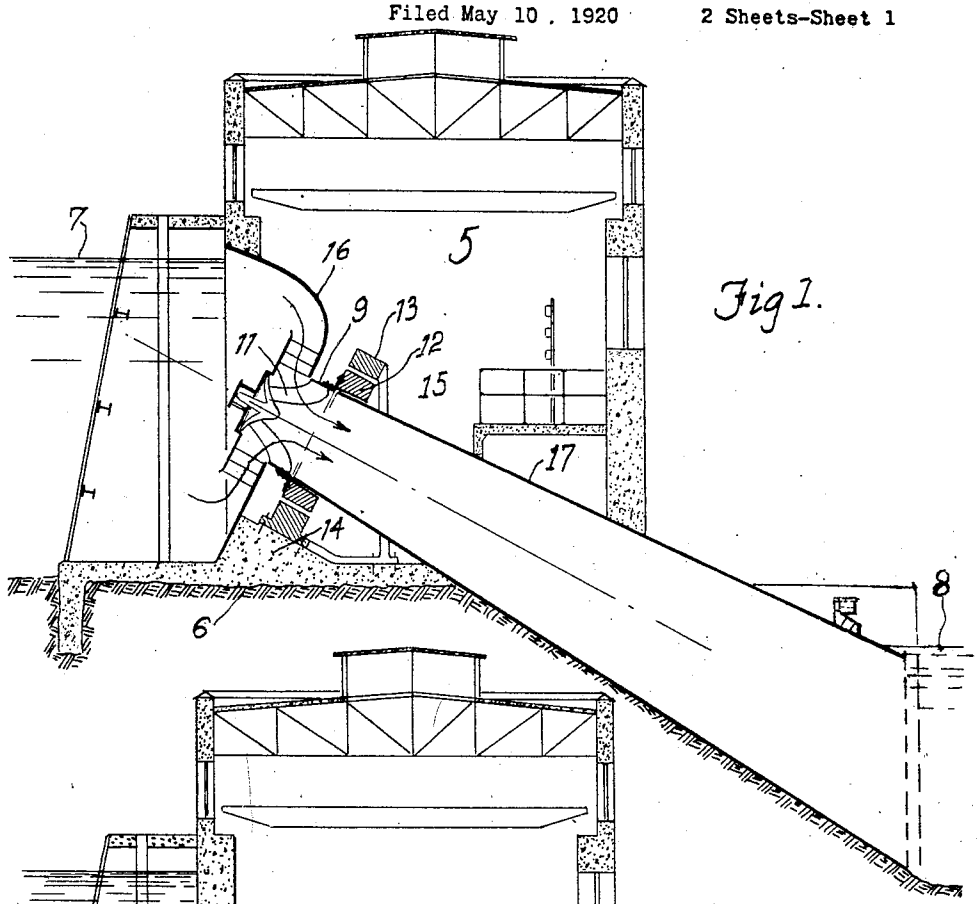


Fig 1.

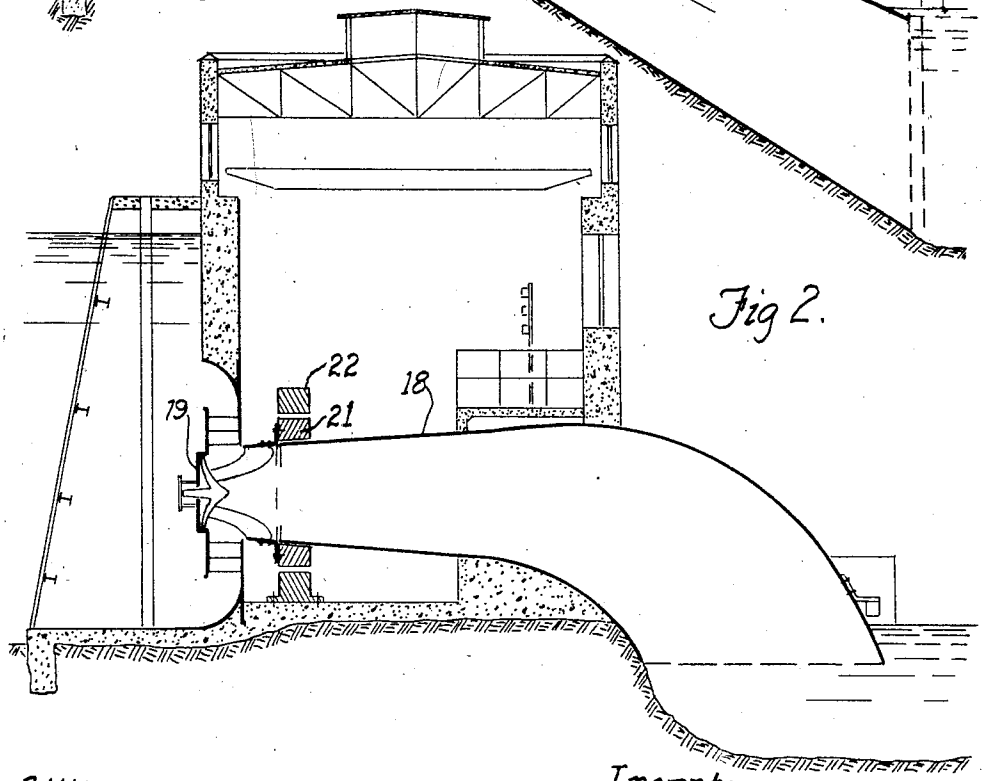


Fig 2.

Witness
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By Pond & Wilson, Attys

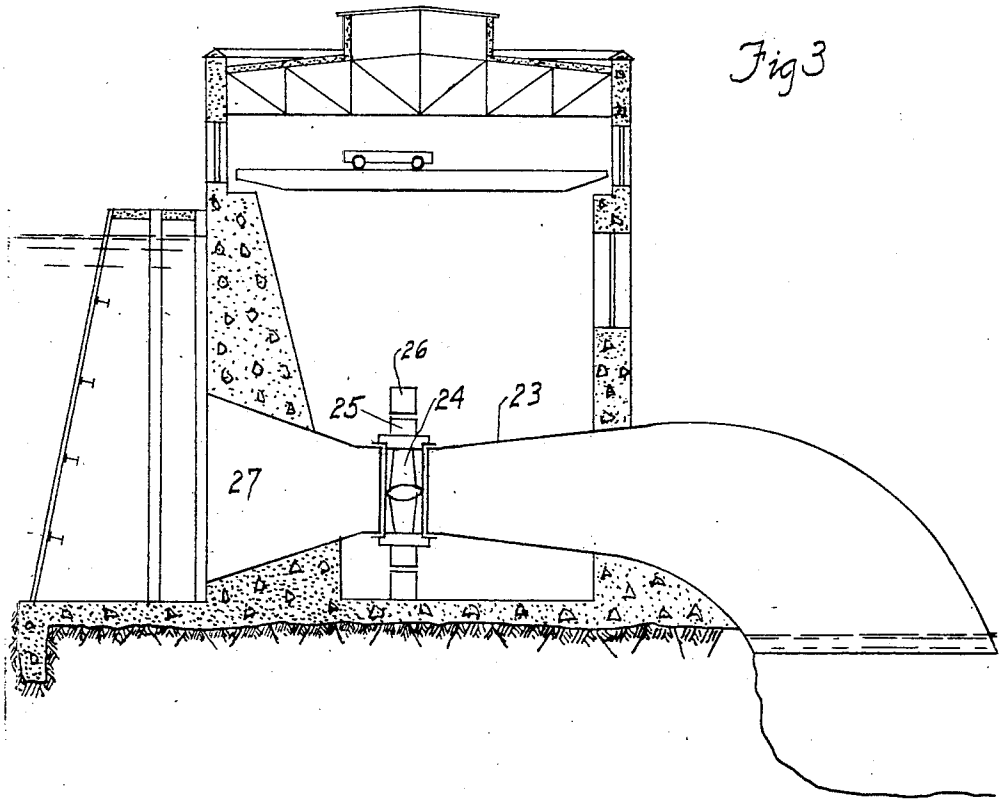
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Fig 3



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UNITED STATES PATENT OFFICE.

LEROY F. HARZA, OF CHICAGO, ILLINOIS.

HYDRAULIC-POWER STATION.

Application filed May 10, 1920. Serial No. 380,084.

To all whom it may concern:

Be it known that I, LEROY F. HARZA, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in a Hydraulic-Power Station, of which the following is a specification.

This invention relates in general to hydromotive power plants, and more particularly to hydraulic power plants or stations adapted for use in connection with relatively low water heads.

One of the principal sources of energy loss in hydraulic power stations is from inefficient draft tubes. The water leaves the turbine at high velocity and at suction pressure and by gradual retardation in an expanding draft tube, its kinetic energy becomes effective in increasing the suction on the discharge side of the turbine and therefore, in increasing the effective head on the turbine. But when water is flowing in an expanding channel, and especially under suction pressure and high velocity, it is very difficult to direct its flow.

If the channel, in this case a draft tube, expands too rapidly, the flowing water may not fill the expanding section, leaving either a void or a zone of disturbance between the forward moving column of water in the center of the tube and the draft tube surface.

It is therefore, very desirable that the power station be so designed as to permit of a long, slowly expanding draft tube.

Curves or elbows in a draft tube are the greatest source of loss, and much attention is now being given by hydraulicians to experiments leading to the development of elbow designs which will permit the water to follow the surface of the tube around the inside of the elbow where the chief difficulty occurs.

Where an elbow is necessary, it is very desirable to locate it as far as possible from the turbine in order that the velocity may be reduced to as low a value as practicable in the straight length of tube, preceding the elbow, for the loss is much greater if the turn is made while the water is flowing at high velocity.

The three general types of low head hydraulic power stations now in use are:

1. Horizontal shaft.
2. Open flume vertical shaft.
3. Scroll case, vertical shaft.

In a horizontal low head station, the machinery is set in an open flume and may consist of one turbine or of one or more pairs of turbines. In either case, a sharp elbow is necessitated in the draft tube immediately after discharge from the turbine and hence, at high velocity, and a second elbow to turn the water again into a horizontal direction under the generator floor. The first elbow surrounds the shaft, which is carried out through a stuffing box to the driven machinery, usually a generator. Moreover, the direction of approach of the water toward the turbine is not favorable to high efficiency. The open flume vertical and scroll case vertical types of power stations require only one ninety degree bend in the draft tube instead of two, and permit of a longer straight draft tube preceding the bend, in which respect they are greatly superior to, and have largely superseded the horizontal station.

In both vertical stations, however, the desirable length of straight draft tube preceding the bend can be realized only by expensive excavation and substructure construction behind the protection of a cofferdam and with the attendant high pumping and other costs as well as hazard. Moreover, the velocity of approach to the turbines in an open flume vertical station is not favorable to good efficiency, and the construction of a scroll case to utilize this velocity of approach is very expensive and not fully effective as it compels the water to flow at considerable velocity around the circle of the scroll case, an appreciably greater distance, to reach the turbine inlet. Thus in all existing types of low head hydraulic power stations, the water is compelled to follow a tortuous path, constructed at great expense, and neither approaches nor leaves the turbine in the ideal straight line flow which conduces to maximum efficiency. Moreover, existing types require the weight of machinery and of water in turbine pits, as well as the building superstructure and floor to be carried on arches or beams over the water passages, thus still further increasing the substructure expense.

An analysis of the reasons for the tortuous water passages and expensive construction of existing horizontal power stations,

will indicate that the generator or other driven machinery stands directly in the line of discharge of the turbine and the draft tube must therefore be diverted from a straight line in passing the generator by the use of two elbows.

The vertical power station requires only one elbow in the draft tube, which however, is inherently expensive in low heads for the reason that the turbine must be placed well below headwater level and sufficient length of straight vertical draft tube can be obtained only by deep excavation and expensive substructure. Moreover, even with a higher head, the available length of straight vertical tube is limited to about 20 or 22 feet above tailwater, because of the practical limit of utilization of atmospheric suction head.

The best curved draft tubes for vertical units which have thus far been designed recover only about 50 percent of the kinetic energy of the water as it leaves the turbine, which latter in modern low head units, is often 10 percent or more of the total initial energy of the water. The unrecovered energy thus reduces the efficiency of the station about one half of this, or 5 percent. On the contrary, a long straight conical draft tube tests about 80 percent efficiency and recovers about 8 percent of the kinetic energy, thus improving the station efficiency about 3 percent.

The means which I propose, therefore, for obtaining a rectilinear flow throughout the power station and for keeping the design of the draft tube under control in the interest of maximum efficiency and without the expensive construction required for vertical units, is to utilize a horizontal single runner turbine, but discharge the water therefrom axially through the generator rotor or other driven machinery instead of diverting it through two elbows around the generator. Moreover, the single horizontal runner permits water to enter it equally as well as the scroll case and without the expensive construction incident to the latter.

The primary object of my present invention is to provide a hydraulic power station which shall be extremely simple in construction, cheap to build, and through which the water will flow in a direction as nearly rectilinear as possible, such curves as necessary being made only where the velocity is low, and which will therefore be more efficient in operation, and with these ends in view, my invention contemplates a construction in which the water approaches the turbine in such a direction that its kinetic energy of approach will add to the effective head without expensive construction such as a scroll case, in which the draft tube is continued in a straight line from the turbine runner any desirable distance without important increase in cost until the water is reduced to low velocity, the draft tube being of gradually increasing cross-sectional area, so that the water is permitted to gradually retard and thereby its kinetic energy be largely recovered. While any preferred type of turbine suitable for my installation may be utilized, I have shown upon the accompanying drawings, for purposes of illustration merely, two inward flow or Francis type turbines differently set, and one axial flow turbine. It will be manifest, however, that the particular type of turbine is of secondary importance and that my invention is capable of association with turbines of any suitable construction.

Referring to the drawings:

Fig. 1 is a sectional view of a hydraulic power station embodying my invention, the draft tube and turbine being inclined to the horizontal;

Fig. 2 is a similar view showing the turbine and the expansive portion of the draft tube as disposed horizontally; and

Fig. 3 is a similar view showing my invention associated with an axial flow turbine.

Referring to the drawings more in detail, and particularly Fig. 1 thereof, reference character 5 indicates generally a power station structure built preferably of concrete directly upon bed rock or other foundation material 6. The normal head water level above the dam is indicated by reference character 7 and the tail water level by reference character 8.

The turbine runner in this instance is of the inward flow type, commercially known as the Francis type. The minor details of construction of this turbine are not disclosed in the drawings, as they are well known in the trade, but instead of employing a central shaft for the runner, and by which power is customarily transmitted to the generator, I contemplate connecting to the perimeter of the runner, or in other words, to the band 9, which embraces the inner ends of the blades 11, a rotor 12 of an electric generator, a belt pulley, gear, chain sprocket, grinding stone, or other means of power transmission or utilization. The stator of this generator, designated by reference character 13 surrounds the rotor, the base of the stator being mounted directly upon concrete, or a base as indicated at 14, and the upper part being supported by a suitable arch like frame 15 extending upwardly on each side of the draft tube. It will be observed that both the turbine runner and the generator are mounted on an axis inclined to the horizontal, and a suitably shaped casing 16 is employed to direct the water to the turbine runner.

The draft tube, designated by reference character 17 is co-axial with the turbine runner and generator and extends in a

straight line at an inclination to the horizontal from the turbine to the tail water level. It is only essential, however, that this draft tube extend in a straight line for a distance which will secure maximum economical expansion of the water in a straight line flow, instead of in a tortuous passage, thus facilitating its flow and expansion so that the kinetic energy may be more fully recovered. This draft tube, as will be apparent from the drawings, is of gradually increasing cross-sectional area from the runner toward its discharge end so that the water may expand gradually without producing eddies and back currents, which would interfere with its flow. Although this draft tube is shown to be a truncated cone, the diameter increasing at uniform rate, it may, however, be built to expand at a non-uniform rate.

In the construction shown in Fig. 2, the draft tube 18 is extended in a horizontal direction instead of being inclined, as shown in Fig. 1, and turbine runner 19, also the rotor 21 and stator 22 of the generator are arranged upon a horizontal axis co-axial with the draft tube. The rotor 21 in this instance is also directly connected to the rim of the turbine runner and as in the construction shown in Fig. 1, surrounds the draft tube. Any details of the bearings for the runner and generator and the means for preventing leakage at the joints are not disclosed herein, as they form no part of my present invention, but these features will constitute subject matter of other applications.

In the construction shown in Fig. 3, the draft tube 23 is similar to the draft tube 18 of Fig. 2 but in this instance, instead of employing a Francis type turbine, I have shown an axial flow turbine 24 having the rotor 25 of the generator mounted directly upon the rim of the runner, the stator 26 being disposed around the rotor in the manner previously explained. In this instance, a penstock 27 of suitable shape and length is utilized to direct the water to the runner of the turbine.

While I have shown in each instance a power house constructed over and around the hydro-motive unit, it should be understood that this building may be of any preferred type or construction and in some instances, may be entirely dispensed with, as it is becoming the practice to employ out-of-door type generators and other machinery, thus saving the expensive building construction, and this type of installation may be utilized with my invention, which lends itself readily to such construction.

Irrespective of the type of protection afforded to the mechanism, my invention is very cheap to install for the reason that no expensive substructure for supporting the generator over the water passages is required, and no expensive excavation to take care of the water discharged from the turbine is necessary. Moreover, this type of power station, especially as shown in Figs. 2 and 3, may be constructed without the need of a cofferdam, with its attendant pumping expense and hazard, by prefabricating the last length of draft tube as a unit and riveting same to the remainder of the draft tube along a seam above the water level.

In this type of power station, the water flows in a straight line from the turbine until the expansion of the draft tube has reduced its velocity to any desired minimum, the important fact being that there is no inherent difficulty or restriction in this type of development to prevent the design of the draft tube for maximum efficiency without important increase in cost.

It is largely because my generator is mountd on a horizontal or inclined axis and around instead of above, or at one side of the draft tube, as has heretofore been customary, which permits this rectilinear flow type of water passages including draft-tube construction and at the same time, affords a cheap mounting for the generator and entirely eliminates the customary power shaft between the runner and the generator.

The advantages of my rectilinear flow type of power station become especially apparent when applied to an axial flow turbine, as in Fig. 3, which may also be inclined similarly to Fig. 1, for when thus applied, the entire kinetic energy of approach of the water in river or canal becomes effective on the turbine without change of direction. My construction, as in Figs. 1 and 2 approaches as nearly to this ideal hydraulic condition as is possible with an inward flow turbine and much more nearly than present practice in horizontal or vertical open flume or scroll case installations makes possible.

It will be manifest, therefore, that I have provided a construction which is very cheap to install, and which is extremely efficient in operation, and while I have shown and described preferred embodiments thereof, it should be understood that the invention is capable of embodiment in structures differing materially from those illustrated and described, without departing from the spirit of invention as defined in the following claims.

I claim:

1. In a hydraulic power station the combination of a power house, a conduit for conducting water in a substantially right line through said house, a hydraulic turbine adapted to be actuated by the flowing water, and power transmitting mechanism connected with the periphery of said turbine, said conduit being of increasing diameter

from the turbine toward its delivery end to permit the expansion of the stream flowing therethrough.

2. In a hydraulic power station the combination of a power house, a conduit for conducting water in a substantially straight line thru said power house, a turbine disposed in the path of the flowing water, power transmitting mechanism connected to the periphery of said turbine and means for supporting part of said mechanism from beneath the conduit, said conduit being of gradually increasing cross-sectional area with its minimum diameter in proximity to the delivery side of the turbine.

3. In a hydraulic power station, the combination of a power house, a conduit arranged to conduct water through said power house in a substantially right line, power transmitting mechanism, a hydraulic turbine disposed in the path of the flowing water, the periphery of said turbine being connected with said power transmitting mechanism to actuate the same, and means beneath the conduit for supporting the stationary part of said mechanism, said conduit being of gradually increasing cross-sectional area from the turbine to the delivery end thereof.

4. In a hydraulic power station, the combination of a power house, a conduit for conducting water in a substantially right line through said house, a hydraulic turbine associated with the conduit for actuation by the water flowing therethrough, and power transmitting mechanism surrounding the conduit and carried by the turbine, said conduit being of increasing diameter from the turbine towards the delivery end of the conduit to permit the expansion of the stream of water flowing therethrough.

LEROY F. HARZA.