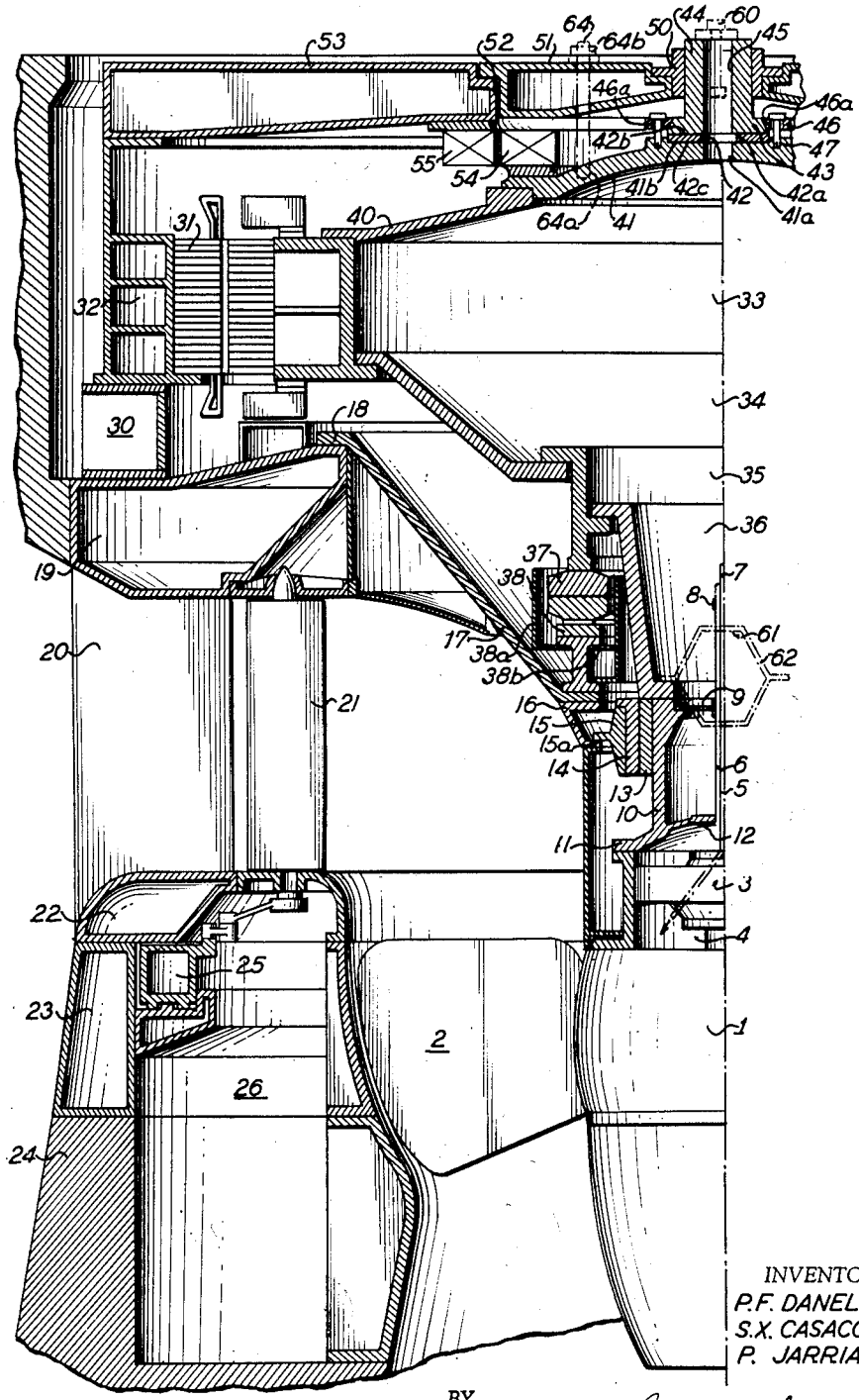
Oct. 16, 1956 P. F. DANEL ET AL 2,767,328

ROTATABLE ASSEMBLY IN A VERTICAL HYDRAULIC TURBO-GENERATOR

Filed Sept. 4, 1953



INVENTORS
P.F. DANEL
S.X. CASACCI
P. JARRIAN

BY

George W. Berry
ATTORNEY

United States Patent Office 2,767,328 Patented Oct. 16, 1956

2,767,328

ROTATABLE ASSEMBLY IN A VERTICAL HYDRAULIC TURBO-GENERATOR

Pierre F. Danel and Severin X. Casacci, Grenoble, and Paul Jarrian, Allevard-les-Bains, France, assignors to Etablissements Neyrpic, Grenoble, France, a corporation of France

Application September 4, 1953, Serial No. 383,815

(Filed under Rule 47(a) and 35 U. S. C. 116)

Claims priority, application France September 5, 1952

19 Claims. (Cl. 290—52)

This invention relates to vertically disposed hydroelectric turbo-generator installations and more especially to such hydroelectric turbo-generator installations having an improved construction and arrangement of the rotating parts thereof. More particularly this invention relates to an improved construction of the mechanical connection between the turbine runner and the generator rotor of a vertical hydroelectric turbo-generator.

Various proposals have been made in connection with vertical hydroelectric turbo-generator installations in the endeavor to simplify the construction and to facilitate assembly and disassembly as well as the maintenance of such machines which may be of quite large dimensions because of the fact that they often are required to operate under relatively low hydraulic head. The construction thus is required to support large loads. It is desirable in particular to provide a compact economical construction, especially as to reducing the height of the unit which is an important factor in the matter of cost of construction as well as of the manufacturing operations.

In line with these endeavors the present invention is concerned especially with the construction and arrangement of the rotatable parts of the unit and with provisions in such construction for facilitating the assembly and disassembly of the rotatable parts and their removal from the space within the stationary members of the unit.

Accordingly, it is an object of this invention to provide a compact and economical construction in a vertical hydroelectric turbo-generator installation.

Another object of this invention is to provide a rigid and strong mechanical connection of improved design between the turbine runner and the generator rotor of a vertical hydroelectric turbo-generator.

Still another object of this invention is to provide a rotatable mechanical connection between the turbine runner and the generator rotor of a vertical hydroelectric turbo-generator whereby various accessory equipment employed therewith advantageously may be disposed in a space formed within this rotatable connection.

Yet another object of this invention is to provide a mechanical connection between the turbine runner and the generator rotor of a vertical hydroelectric turbo-generator installation whereby the several elements making up the connection readily may be disconnected and removed from the installation.

Another object of this invention is to provide a construction of this mechanical connection and of the enclosing casing of the machine which facilitates assembly and disassembly of and easy access to the sensitive parts of the unit.

These and other objects of this invention and how they are accomplished will become apparent by reference to the accompanying disclosure and drawing which shows a partial section taken through the vertical axis of a hydroelectric turbo-generator installation.

In accordance with this invention, the connection between the turbine runner and the generator rotor of a vertical hydroelectric turbo-generator comprise a hollow body concentrically disposed with respect to and intermediate the runner and the rotor and having an enlarged upper portion connected to the generator rotor and a lower small portion which may be cylindrical within a bearing of the unit connected to the turbine runner.

A vertical hydroelectric turbo-generator constructed in accordance with this invention is not provided with the conventional shaft which is replaced by a hollow body which may be of generally truncated conical form connecting the runner of the turbine with the rotor of the generator. This connecting body may comprise a plurality of superadjacent open-ended members or ferrules disposed coaxial with the axis of rotation of the runner and rotor and rigidly connected one to another and defining an inverted truncated generally conical assembly providing a relatively large unobstructed interior space which is advantageously utilized for locating and positioning the various accessory equipment as hereinafter further described. The ferrules of this assembly provide walls capable of transmitting the couple of the rotating forces to best advantage because of their disposition about the axis with economy of metal and of weight. The ferrules or connecting members preferably are flangedly connected one to another, the large upper end of one member being connected to the small lower end of the adjacent superposed member. These members or ferrules are so formed and disposed with respect to each other that when disconnected, a lower ferrule can be moved upwardly within the interior space defined by the walls of the adjacent superposed ferrule.

The hollow rotatable body provided by the assembly of ferrules is closed at its upper end or top by a covering member which is connected to the upper face of the annular generator rotor. An opening is provided in this covering member to allow access to the interior space within the assembly through the rotor annulus. The diameter of the opening in this covering member is greater than the outside diameter of one or several of the ferrules making up a connecting assembly that are supported by a ferrule which forms the load ring and carries the movable element of the thrust bearing. Preferably, the diameter of the opening is greater than the outside diameter of all of the connected ferrules except the uppermost ferrule which is directly connected at its upper end to the generator rotor, preferably to the lower face of the annulus of the rotor. This uppermost ferrule, however, is designed, when disconnected, to be moved upwardly within the generator rotor and out therefrom upon the removal of the top casing of the unit.

The opening in the top of the covering member provides access to the interior space within the connecting assembly wherein the various accessory equipment of the installation advantageously may be disposed. After disconnecting one or more of the connecting members or ferrules it is possible to remove each of these members upwardly through the opening in the covering member and to gain access to the thrust bearing assembly and to the lower guide bearing of the unit which are located intermediate the turbine runner and the generator rotor as well as to the exterior of the connecting assembly, in order to do any work required upon these parts.

The opening in the covering member thus supported on the rotor with a lid adapted to cover said opening and which may be rigidly connected to the cover member. The lid carries a trunnion concentrically with re-

spect to the axis of the turbine runner and generator rotor. Located above the rotor lid is a top cover covering an opening in the top casing of the unit having a slightly larger diameter than the outside diameter of the rotor lid. The top cover is supported on the stationary top which extends over the unit. Concentrically fixed to the top cover is a stationary upper guide bearing to receive the trunnion carried by the rotor lid. Means are provided for suspending the rotor lid from the top cover to provide for dismounting the assembly thereof without disengaging the rotor trunnion from the upper guide bearing. This means permits the disassembly of the rotor lid together with the rotor trunnion and its upper guide bearing without disturbing the alignment of the trunnion within the upper guide bearing. By employing this means the long and delicate operation of realigning the upper guide bearing and the rotor trunnion after each partial disassembly of the installation which may be required for inspection of the connecting assembly and the thrust and lower guide bearings is avoided.

The invention also provides for this operation means for setting the parts and for controlling the alignment which may be carried out in a convenient and precise manner.

In accordance with the above described arrangement and construction, means also are provided for permitting inspection of and maintenance work on the thrust bearing assembly and lower guide bearing without necessitating the removal of the top casing disposed above the generator rotor.

The invention further contemplates that the space available between the generator rotor, together with its covering member, and the top casing and its top cover be utilized for locating various pieces of accessory equipment. For example, the exciter for the generator is advantageously located within this space with the exciter rotor advantageously mounted on the top of the rotor lid adjacent the outer periphery thereof and the exciter stator advantageously fixed beneath the stationary top casing about the opening therein which is closed by the top cover.

The raising of the two covers exposes at the same time the rotor of the exciter which thus easily may be reached and reduction of the height of the unit thus is effected to the maximum extent.

The invention will now be described with reference to the drawing which illustrates an embodiment of the invention in a vertical turbo-generator installation wherein the turbine is of the Kaplan-type. The invention is not restricted to any particular type of turbine but is applicable to any vertical hydroelectric turbo-generator installation. For purposes of simplicity and clarity, the various bolts and nuts connecting the flanges of the ferrules as well as the members of the water conveying conduits, the accessory equipment and pumps and certain of the conventional mechanical and electrical connections have been omitted. The disposition and employment of these elements will be understood by those skilled in the art.

Referring to the drawing, the turbine runner **1** is provided with adjustable blades **2**. A servo-motor which controls the pitch of the blades comprises a piston **3** operating in cylinder **4**. Oil under pressure is admitted to one side of the piston while being discharged at the other side through two concentric pipes **5** and **6** which are shown terminated at **7** and **8**, respectively, where they may be connected to a suitable distributing valve, not shown. The turbine runner **1** is connected to the generator rotor by means of a hollow connecting assembly as above generally described. The upper end of the turbine runner **1** is connected to the lower end of cylinder **4** of the servo-motor which forms one of the connecting members or ferrules of the rotatable assembly. Cylinder **4** is disposed beneath and connected to the lower end of a hollow cylindrical neck **10** which is provided at its lower end with an outwardly extending flange **11**. A partition **12** extends within and across the lower portion of the neck **10** and serves as the upper head of cylinder **4**. The partition **12** is provided with an axial opening for the pipes **5** and **6**. The outside pipe **6** is held in position by means of a bracket **9** mounted on the inside of the upper end of the cylindrical neck **10**.

The cylindrical neck **10** carries exteriorly thereof upon its upper part a bearing ring **13** which is disposed within the stationary bearing ring **14** of the lower guide bearing **15**. The lower guide bearing **15** is provided with a centrally disposed outwardly projecting flange **15***a* which rests on the inner lower flange of a stationary annular collar **16** of channel section. Because of the large diameter of neck **10**, the guide bearing **15** may be disposed closely adjacent annular collar **16**. The upper flange of annular collar **16** is connected to a flange at the lower, smaller end of a stationary hollow, inverted, open-ended truncated conical supporting member **17** which supports the whole assembly of rotating elements of the unit.

The conical supporting member **17** is provided at its upper end with an outwardly projecting flange **18** which is carried by and connected to an upper stationary annular hollow supporting member **19** which forms the upper cover of the stay vane ring assembly extending about distribution wickets **21**. The annular supporting member **19** is directly supported by the stay vanes **20**, which in turn are supported by a lower hollow annular supporting ring **22** which is carried upon an annular hollow bench ring **23** which rests on the concrete foundation **24** of the unit. This general arrangement of the distributor is described in greater detail in our copending patent application Serial No. 383,814 filed September 4, 1953. The control mechanism **25** for the wickets **21** is disposed within gallery **26** which encompasses the turbine runner **1** below the distributor.

The upper annular supporting member **19** also supports an annular block **30** which carries the generator stator **31**. The exterior generator stator ring **32**, moreover advantageously may be anchored to the surrounding concrete foundation in order better to absorb the reaction of the stator.

The generator rotor **33** is connected to the cylindrical neck **10** and to the turbine runner **1** by means of a plurality of endwise connected, hollow, open-ended connecting members or ferrules **34**, **35** and **36** of conical or cylindrical form. The connected ferrules **34**, **35** and **36** are flangedly connected one to another, the outwardly projecting flange at the upper end of a ferrule being connected to the inwardly projecting flange at the lower end of the adjacent ferrule disposed thereabove. As illustrated, the ferrule **35** is connected to the rotatable parts of the thrust bearing assembly and carries at its lower end the rotating element or ring **37** of the thrust bearing. The stationary element or ring **38** of the thrust bearing is disposed directly beneath and takes the bearing of the rotating ring **37**. The stationary ring **38** is supported on the lower flange of the conical supporting member **17**. Partitions **38***a* and **38***b* extend above the bearing elements **37** and **38** and define a reservoir for the lubricating oil for the thrust bearing assembly.

In accordance with this invention, as indicated hereinabove, a hollow connecting assembly between the generator rotor **33** and the turbine runner **1** thus is secured which provides a large interior space which is increased toward its upper end and easy access to which is made possible, in which space accessory equipment for the operation of the installation, such as the servo-motor and control equipment, the lubrication equipment, the various pumps and conduits, etc. advantageously may be disposed. The invention is not restricted to the arrangement of accessory equipment within this interior space of the hollow connecting assembly, the significant feature being the form and the fitted relation of the several elements which make up the connecting assembly which provide a kind of stepped arrangement which permits the successive disengagement and demounting of these elements from the

assembly proceeding in the direction from the bottom of the assembly to the top.

The upper end of the connecting assembly is closed by means of a covering member **40** which is connected by a flange to the upper face of the generator rotor **33**. The covering member **40** is provided with a large central opening therethrough which is covered by the rotor lid **41**. The opening through the covering member **40** has a diameter larger than the outside diameter of the ferrule **35** carrying the thrust bearing and larger than rings **37** and **38** of this bearing. The rotor lid **41** is provided with a relatively small centrally disposed opening **41***a*. The upper side of the rotor lid **41** is provided with a recessed surface **41***b* about the opening **41***a* and adapted to receive a seating plate **42** which directly supports a centrally disposed trunnion **44**. The lower end of trunnion **44** is provided with an outwardly extending flange **43** the outside periphery of which is chamfered to conical form. An axial bore **45** is provided in trunnion **44** and is adapted to be centrally disposed with respect to the opening **41***a* of rotor lid **41** and with respect to the opening **42***a* in the seating plate **42**. A ring **46** provided with an inside conical surface adapted to engage the conical outside surface of flange **43** provides for tightening the flange **43** together with the trunnion **44** upon the seating plate **42**, stud bolts **47** passing through enlarged holes **46***a* which are provided in the ring **46**. The flange **43** has a planar bottom surface in contact with the upper planar surface **42***b* of the seating plate **42**, the plane of contact of these surfaces forming a dihedral angle greater than zero with the plane of contact between the lower surface **42***c* of the seating plate **42** and the surface of the recess **41***b* at the upper side of rotor lid **41**. The plane of contact of the flange **43** and the seating plate **42**, therefore, is slightly inclined with respect to the vertical axis of the opening **45** through the trunnion **44**. This arrangement is similar to that which is described in the French Patent No. 963,389, dated February 21, 1948.

The trunnion **44** is guided in an upper stationary guide bearing **50** which is supported by means of a flange bearing on a shoulder formed on the central cover portion **51** of a stationary stator cover. The cover portion **51** closes off the opening **52** which is defined by the inside periphery of the stationary stator cover **53**. The diameter of the opening **52** is such as to allow the removal upwardly therethrough of the rotor lid **41** as well as the various ferrules and other parts of the connecting assembly or of the accessory equipment when disposed within the interior of the hollow connecting assembly.

The generator exciter and certain other apparatus may be supported within available space between the stator cover **53** and generator rotor **33** and its covering member **40**. As illustrated in the drawing, the rotor lid **41** supports at its periphery the exciter rotor **54**. The exciter stator **55** is secured to the underside of the stator cover **53** adjacent and extending about the opening **52**. Within the scope of the invention the disposition of the exciter stator and the exciter rotor may be varied while providing for support of the stator on the stator cover **53** and support of the exciter rotor on the members rotating with the rotor of the turbo-generator. The exciter also may be located in the conventional position above the stator cover **53** and the cover portion **51** and operatively connected to the trunnion **44**.

The rotatable assembly connected between the generator rotor and the turbine runner in accordance with this invention is very rigid and subject to very little deformation, thus requiring that the upper and lower guide bearings be very accurately aligned and that the bearing surface of the thrust bearing be precisely perpendicular to the vertical axis of the rotatable assembly. The assembly and the alignment of the lower guide bearing **15** and of the thrust bearing and its bearing rings **37** and **38** are effected in the usual manner and do not present any particular difficulty. The rotor trunnion **44**, on the other hand, since it is relatively far removed from the lower guide bearing, is subject to being substantially off center and more than is permissible with respect to the lower guide bearing and the vertical axis of cylindrical neck **10**. Such misalignment of the vertical axis of the trunnion **44** with respect to the lower guide bearing assembly may arise due to the misalignment of the successively connected ferrules constituting the connecting assembly, each of which can contribute and add to the error of alignment.

In order to provide for precisely positioning and aligning the trunnion **44** with respect to the vertical axis of the installation, in accordance with this invention means for setting and means for controlling the alignment of the trunnion **44** are provided. The means for setting the trunnion **44** comprises the seating plate **42** together with the trunnion flange **43** and the means for controlling the alignment of the trunnion **44** comprises in part a telescope **60** optically centered along the vertical axis of the bore **45** of the trunnion **44**, and in part a reticule or cross hair **61** which is mounted on a rigid conical support or tripod **62**, suitable bench marks being provided for the placing of this support or tripod **62** in two positions inverted with respect to each other and with respect to the upper opening of cylindrical neck **10**. The operation of alignment of the trunnion **44** with respect to the lower guide bearing assembly and the bearing cylinder **10** is carried out before installing the concentric conduits **5** and **6**. By means of these two positions of the reticule **61**, the reticule becomes located exactly along the vertical axis of the neck **10** and of the vertical axis of the turbine.

The inclination of the axis of the trunnion **44** is adjusted by adjusting the relative position of the trunnion **44** on the seating plate **42**. The lateral adjustment of the trunnion **44** relative to the seating plate **42** is effected by lateral sliding of the trunnion on the plate, utilizing the play between the bolts **47** in the enlarged holes **46***a* in the ring **46**. The trunnion **44** is so adjusted with respect to the seating plate **42** until the optical axis of the telescope **60** is aligned with the reticule **61** for both of its relatively inverted positions. By these means it is assured that the trunnion **44** is accurately aligned with the axis of the rotor **33** and of the lower guide bearing. The ring **46** then is clamped in place, the stationary upper guide bearing **50** is then set on the trunnion **44** and fastened in place in the removable cover portion **51** which in turn is connected and fixed to the stationary stator cover **53** and marked.

When these operations of alignment and setting of the trunnion **44** once have been carried out it is not necessary to repeat them, since it is possible to maintain the setting of the upper guide bearing including the trunnion **44** with respect to the vertical axis of the installation when access to the interior of the connecting assembly is desired. To this end means are provided for temporarily rigidly fixing the rotor lid **41** to the cover portion **51**. As illustrated in the drawing, this means comprises externally threaded tension bolts **64** which are screwed into internally threaded holes **64***a* in the rotor lid **41** and provided with nuts **64***b* at their upper ends. The assembly comprising the cover portion **51**, the guide bearing **50**, the rotor lid **41** and the trunnion **44** thus may be securely and rigidly tied together and can be removed as a unit with the several parts maintained in their operating relation. For reassembly of these rigidly connected elements it is only necessary to replace cover portion **51** in its original position on the stator cover **53**.

The removal of the cover portion **51** and the rotor lid **41** so connected together affords ready access to the interior of the rotatable connecting assembly so as to carry out the necessary maintenance work on the equipment installed therein under the best conditions. Immediate access is provided to the accessory equipment disposed within the interior of the rotor assembly. The

ferrules 36, 35 then can be disconnected and removed through opening 52, provision having been made in the usual manner for temporarily supporting the turbine runner, on the one hand, and the rotor of the generator, on the other hand. Upon removal of the connecting member 36, the lower guide bearing assembly is exposed. Upon removal of the ferrule 33, the thrust bearing and the bearing rings 37 and 38 are exposed and may be removed. If desired, the various elements making up the lower guide bearing assembly and the thrust bearing support also may be removed, as well as the neck piece 19 and the cylinder 4 and piston 3 of the blade operation.

This invention is not limited to the embodiment illustrated in the drawing which is presented merely by way of example. Moreover, the invention is applicable to turbines with fixed blades or to any other type of vertical turbine or vertical hydroelectric turbo-generator installation.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many modifications, changes and alterations are possible without departing from the spirit or scope of this invention.

We claim:

1. In a hydroelectric turbo-generator having a turbine runner and a generator rotor rotatable on a common axis, means connecting said runner and said rotor for rotation together on said axis comprising a hollow connecting member having a wall extending about and along said axis and defining a hollow space within said member open at the two ends thereof spaced along said axis, the cross section of said space being sufficient for withdrawing therethrough members of said connecting means disposed adjacent said runner, said generator rotor extending about said axis and about an open space having a cross section providing for withdrawing said hollow connecting member through said rotor space.

2. In a vertical hydroelectric turbo-generator having a turbine runner and a generator rotor rotatable on a common vertical axis, said generator rotor being disposed above said turbine runner, means connecting said runner and said rotor for rotation together on said vertical axis comprising a plurality of hollow connecting members open at both ends thereof and arranged in end to end relation along the axis of rotation of said runner and said rotor, each of said hollow members having a wall extending about and along said vertical axis and defining the hollow space within the respective member, an upper portion of a given member being connected to a lower portion of a superadjacent member, the cross section of the space of said superadjacent member being at least sufficient for withdrawal of said given member upwardly through said space of said superadjacent member, said generator rotor extending about said vertical axis and about an open space having a cross section providing for withdrawing said hollow connecting members vertically through said rotor space.

3. In a vertical hydroelectric turbo-generator as defined in claim 2, a cover connected to said rotor at the upper side thereof for rotation therewith on said axis and provided with an opening therein generally concentric with said axis of rotation and at least of sufficient size to provide for removal of said given member therethrough.

4. In a vertical hydroelectric turbo-generator as defined in claim 19, a thrust bearing having a stationary bearing element supported in said turbo-generator, and a rotatable bearing element carried by said connecting member in bearing relation to said stationary bearing element for supporting on said thrust bearing thrust resulting from the weight of said runner and said rotor and of said connecting means and the thrust of said runner.

5. In a vertical hydroelectric turbo-generator as defined in claim 19, a guide bearing having a stationary bearing element supported in said turbo-generator, and a rotatable bearing element carried by said connecting member in bearing relation to said stationary bearing element for guiding in rotation said runner and said rotor and said connecting means.

6. In a vertical hydroelectric turbo-generator having a turbine runner and a generator rotor rotatable on a common vertical axis, said generator rotor being disposed above said turbine runner, means connecting said runner and said rotor for rotation together on said vertical axis comprising a ferrule having a wall extending about and along said vertical axis and defining a hollow space within said ferrule co-axial with said vertical axis, said ferrule being open at the ends thereof spaced along said vertical axis, said wall sloping with respect to said axis to form said ferrule with its upper open cross section greater than the lower open cross section thereof, a second ferrule having a wall extending about and along said vertical axis and defining a hollow space within said second ferrule co-axial with said vertical axis, the upper portion of said wall of said second ferrule being connected to the lower portion of said wall of said first ferrule at the inner side of said wall of said first ferrule for rotation of said second ferrule with said first ferrule and so that said second ferrule is capable of being withdrawn upwardly from engagement with said first ferrule through said upper open cross section of said first ferrule, said generator rotor extending about said vertical axis and about an open space having a cross section providing for withdrawing said first ferrule vertically through said rotor space, means connecting said first ferrule to said generator rotor for rotation therewith, and means connecting said second ferrule to said runner for rotation therewith.

7. In a vertical hydroelectric turbo-generator as defined in claim 6, said first ferrule providing an inwardly extending annular flange at its lower open end, said second ferrule comprising an outwardly extending annular flange disposed above and bearing on said flange of said first ferrule.

8. In a vertical hydroelectric turbo-generator having a turbine runner and a generator rotor rotatable on a common vertical axis, said generator being disposed above said turbine runner, means connecting said runner and said rotor for rotation together on said vertical axis comprising two ferrules each having a wall extending about and along said vertical axis and defining a hollow space within said ferrule co-axial with said vertical axis, said ferrules each being open at the ends thereof spaced along said vertical axis and being disposed in end to end relation one above the other, the wall of at least a given one of said ferrules sloping with respect to said axis to form said given ferrule with its upper open cross section greater than the lower open cross section thereof, the upper ferrule having an inwardly extending annular flange co-axial with said vertical axis and extending about said lower ferrule, the lower ferrule having an outwardly extending annular flange co-axial with said vertical axis and disposed above and bearing on said inwardly extending flange of said upper ferrule so as to provide for withdrawing said lower ferrule upwardly through said upper ferrule, said generator rotor extending about said vertical axis and about an open space having a cross section providing for withdrawing said ferrules vertically through said rotor space, means connecting said upper ferrule adjacent its upper open cross section to said generator rotor, and means connecting said lower ferrule adjacent its lower open cross section to said turbine runner.

9. In a vertical hydroelectric turbo-generator as defined in claim 19, said generator having a stator extending about said vertical axis and about said rotor, and a stationary stator cover disposed above said stator and said rotor and provided with an opening therein generally concentric with the axis of rotation and at least of sufficient cross section to provide for removal of said member therethrough.

10. In a vertical hydroelectric turbo-generator having a turbine runner and a generator rotor rotatable on a

common vertical axis, said rotor being disposed above said runner, means connecting said runner and said rotor for rotation together on said vertical axis and having a cover connected to said rotor at the upper side thereof for rotation therewith on said axis, said rotor cover carrying a trunnion upwardly projecting therefrom and disposed generally coaxially with said axis of rotation of said runner and said rotor, and means supported in said turbo-generator and providing a stationary guide bearing engaging said trunnion in bearing relation thereto.

11. In a vertical hydroelectric turbo-generator having a turbine runner and a generator rotor rotatable on a common vertical axis, said rotor being disposed above said runner, means connecting said runner and said rotor for rotation together on said vertical axis comprising a hollow connecting member disposed between said runner and said rotor, a cover connected to said rotor at the upper side thereof for rotation therewith, said rotor cover having an opening therein generally concentric with said axis of rotation and providing access to the interior space of said hollow connecting member, said rotor cover carrying a trunnion upwardly projecting therefrom and disposed generally coaxially with said axis of rotation of said runner and said rotor, and means supported in said turbo-generator and providing a stationary guide bearing engaging said trunnion in guiding bearing relation thereto.

12. In a vertical hydroelectric turbo-generator as defined in claim 11, said generator having a stator extending about said rotor, said means supporting said guide bearing comprising a stationary stator cover disposed above said generator stator and supported thereby and having an opening therein concentric with the said axis of rotation of said runner and said rotor, a central cover portion engaging said stator cover and supported thereby to cover said opening, said guide bearing being carried by said central cover portion and engaging said trunnion in guiding bearing relation thereto.

13. In a vertical hydroelectric turbo-generator having a turbine runner and a generator rotor, and means connecting said runner and said rotor for rotation together on a common vertical axis, said rotor being disposed above said runner, said generator having a stator extending about said vertical axis in generating relation to said rotor, a stationary stator cover supported in said hydroelectric turbo-generator above said stator and rotor and having a central opening therein coaxially with the axis of said runner and said rotor, an exciter for said generator having the stator element thereof supported by said stationary stator cover adjacent and extending peripherally about said opening in said stator cover, the rotatable element of said exciter being supported by said means connecting said runner and said rotor for rotation therewith and disposed adjacent and inwardly of the periphery of said opening toward said axis of rotation with respect to said stator element of said exciter and extending about said axis.

14. In a vertical hydroelectric turbo-generator as defined in claim 13, a central cover portion supported by said stationary stator cover so as to cover said opening in said stator cover and so as to be removable therefrom to provide for removal of said rotatable exciter element through said central opening.

15. In a vertical hydroelectric turbo-generator having a turbine runner and generator rotor rotatable on a common vertical axis, said rotor being disposed above said runner and extending about said vertical axis and about an open space therewithin, an open end hollow connecting member connecting said runner and said rotor for rotation of said rotor upon rotation of said runner, said hollow connecting member having a wall extending about and along the vertical axis of rotation of said runner and said rotor and defining the hollow space within said member, a rotor cover connected to said rotor at the upper side thereof for rotation therewith on said axis and provided with an opening therein generally concentric with said axis of rotation to provide access to the space within said rotor and to said space within said hollow member, a rotor lid carried by said rotor cover and covering said opening of said rotor cover and removable therefrom, said generator having a stator extending about said vertical axis and about said rotor, a stationary stator cover disposed above the stator of said generator and supported thereby and having an opening therein concentric with said axis of rotation of said runner and said rotor, the cross section of said opening of said stationary stator cover being sufficient for removal therethrough of said rotor cover lid, a central cover portion supported by said stator cover so as to cover said opening in said stator cover, a trunnion carried by said rotor cover lid and upwardly projecting therefrom generally coaxially with said axis of rotation of said runner and said rotor, a guide bearing carried by said central cover portion and engaging said trunnion in guiding bearing relation thereto, and means connectible to said rotor cover lid and to said central cover portion for rigidly connecting said rotor cover lid and said central cover portion to hold said trunnion and said guide bearing in fixed relation to each other for removal with said rotor cover lid and said central cover portion and for replacement therewith said rotor cover lid and said central cover portion in the respective operating positions on said rotor cover and said stationary stator cover.

16. In a vertical hydroelectric turbo-generator having a turbine runner and generator rotor rotatable on a common vertical axis, said rotor being disposed above said runner and extending about said vertical axis and about an open space therewithin, an open end hollow connecting member connecting said runner and said rotor for rotation of said rotor upon rotation of said runner, said hollow connecting member having a wall extending about and along the vertical axis of rotation of said runner and said rotor and defining the hollow space within said member, a rotor cover connected to said rotor at the upper side thereof for rotation therewith on said axis and provided with an opening therein generally concentric with said axis of rotation to provide access to the space within said rotor and to said space within said hollow member, a rotor lid carried by said rotor cover and covering said opening of said rotor cover and removable therefrom, said generator having a stator extending about said vertical axis and about said rotor, a stationary stator cover disposed above the stator of said generator and supported thereby and having an opening therein concentric with said axis of rotation of said runner and said rotor, the cross section of said opening of said stationary stator cover being sufficient for removal therethrough of said rotor cover lid, a central cover portion supported by said stator cover so as to cover said opening in said stator cover, a trunnion carried by said rotor cover lid and upwardly projecting therefrom generally coaxially with said axis of rotation of said runner and said rotor, a guide bearing carried by said central cover portion and engaging said trunnion in guiding bearing relation thereto, and means for adjusting the position of said trunnion with respect to said rotor cover lid to adjust the alignment of the axis of said trunnion with respect to said axis of rotation of said runner and said rotor.

17. In a vertical hydroelectric turbo-generator as defined in claim 16, said adjusting means comprising a wedge shaped plate bearing on a surface provided on said rotor cover lid perpendicular to said axis of rotation, said plate having an upper surface inclined to said axis, said trunnion providing a surface inclined to the axis of said trunnion and bearing on said upper inclined surface of said plate, whereby upon rotation of said plate relative to said trunnion the axis of said trunnion may be aligned with said axis of rotation of said runner and said rotor.

18. In a vertical hydroelectric turbo-generator as defined in claim 17, said trunnion and said plate having cen-

tral openings therethrough, said trunnion being adapted to support a telescope in optical alignment with the axis of the trunnion, whereby said trunnion axis may be aligned with the axis of rotation of said runner and said rotor.

19. In a vertical hydroelectric turbo-generator having a turbine runner and a generator rotor rotatable on a common vertical axis, said generator being disposed above said turbine runner, means connecting said runner and said rotor for rotation together on said vertical axis comprising a hollow connecting member having a wall extending about and along said axis and defining a hollow space within said member open at the two ends thereof spaced along said axis, the cross section of said space being sufficient for withdrawing therethrough members

of said connecting means disposed adjacent said runner, said generator rotor extending about said axis and about an open space having a cross section providing for withdrawing said hollow connecting member through said rotor space.

References Cited in the file of this patent

UNITED STATES PATENTS

7,412	Fisher	June 4, 1850
754,400	Westinghouse	Mar. 8, 1904
1,813,107	Allner	July 7, 1931
1,860,618	Nagler	May 31, 1932
1,919,376	Moody	July 25, 1933
2,628,766	Rydmark et al.	Feb. 17, 1953