April 28, 1942. K. J. VAN ERP 2,281,214

TURBO MACHINE

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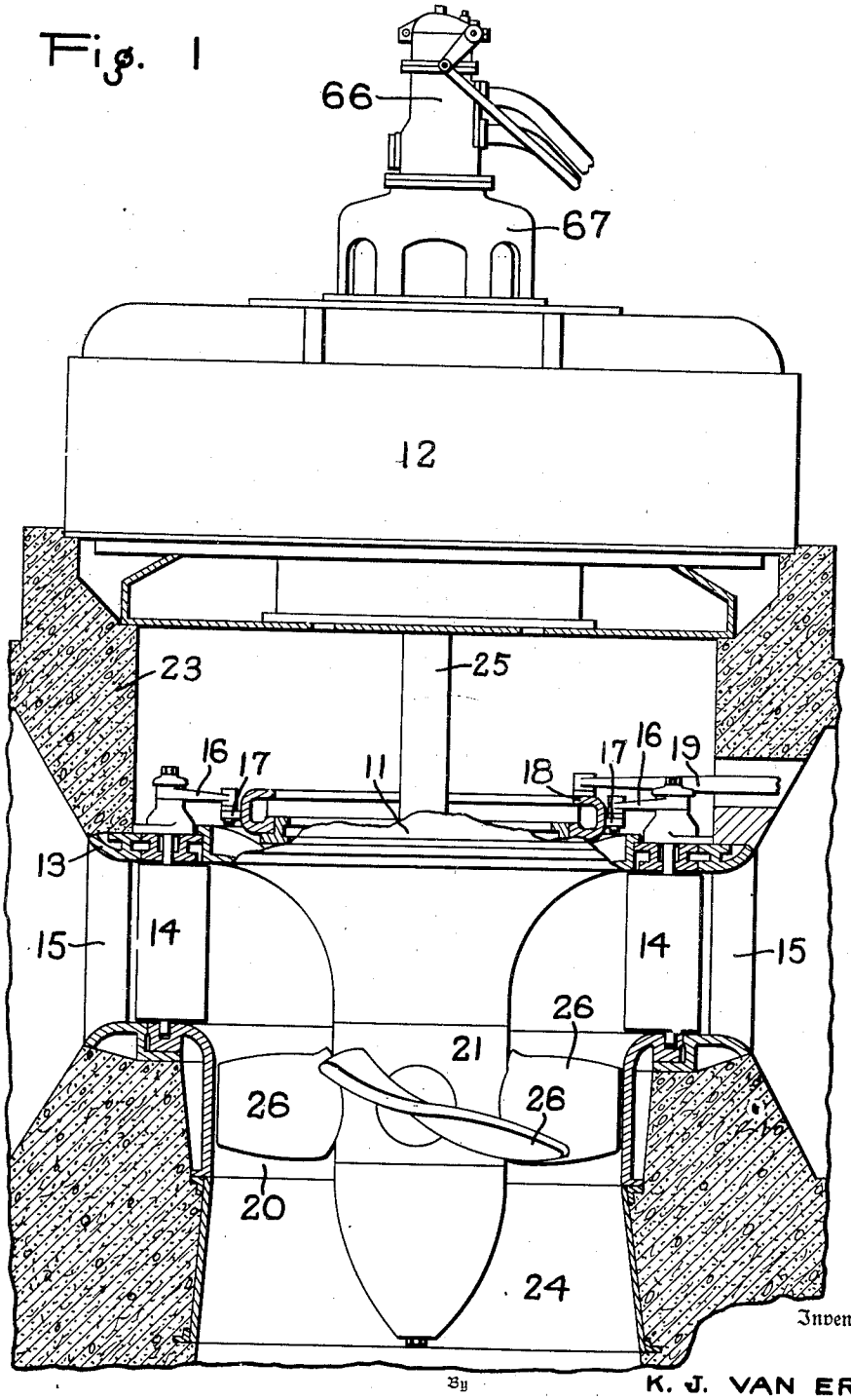
Fig. 1



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TURBO MACHINE

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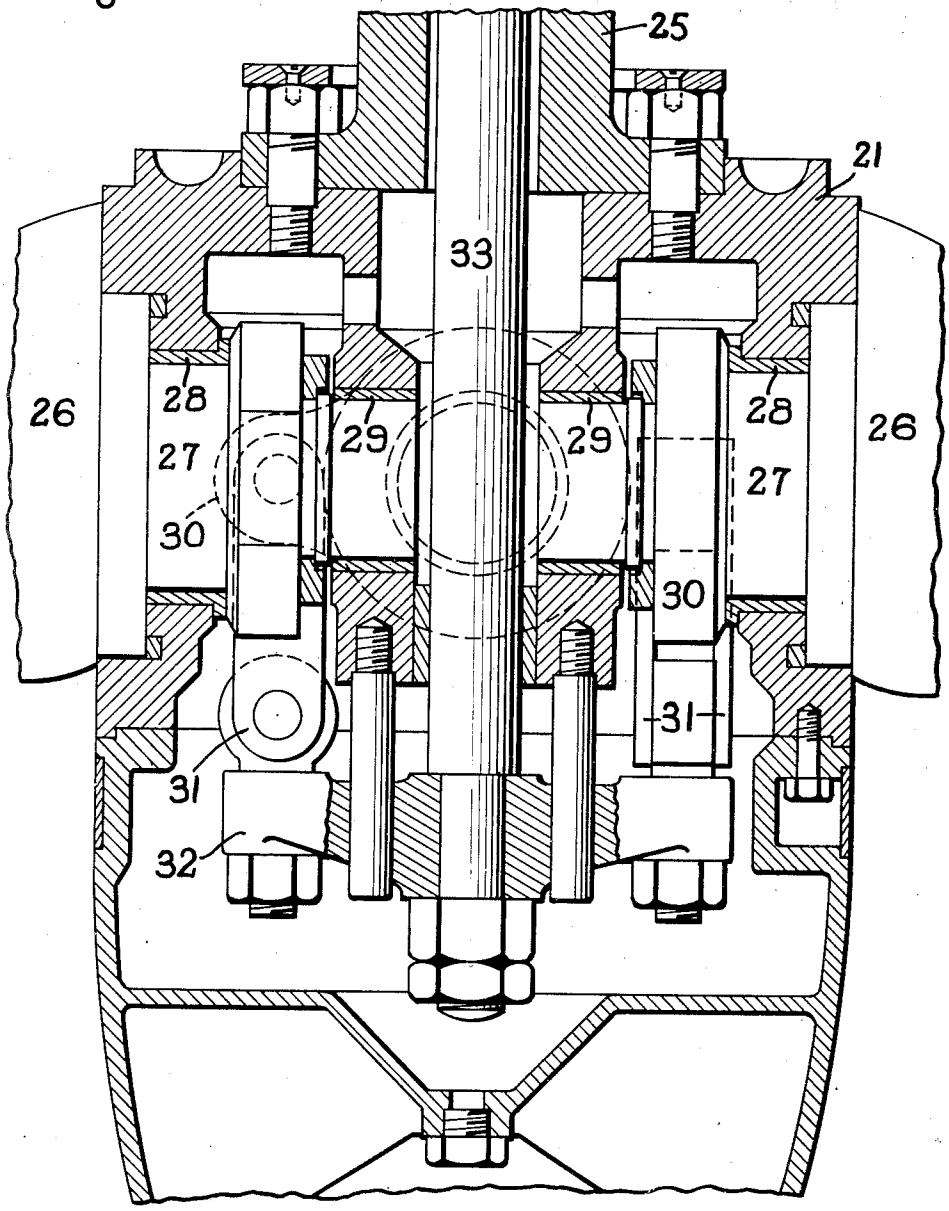
Fig. 2



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TURBO MACHINE

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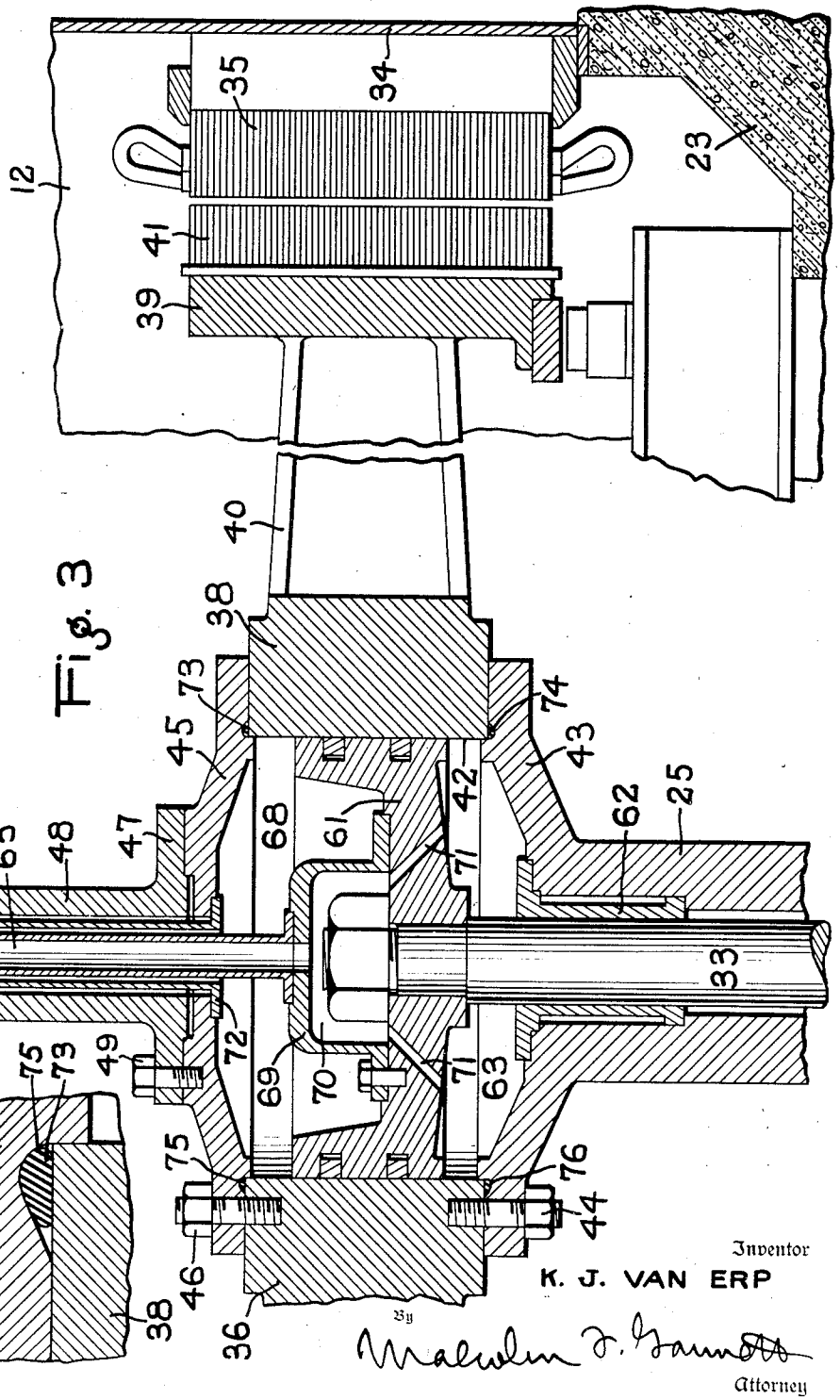

Fig. 3

Fig. 8

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TURBO MACHINE

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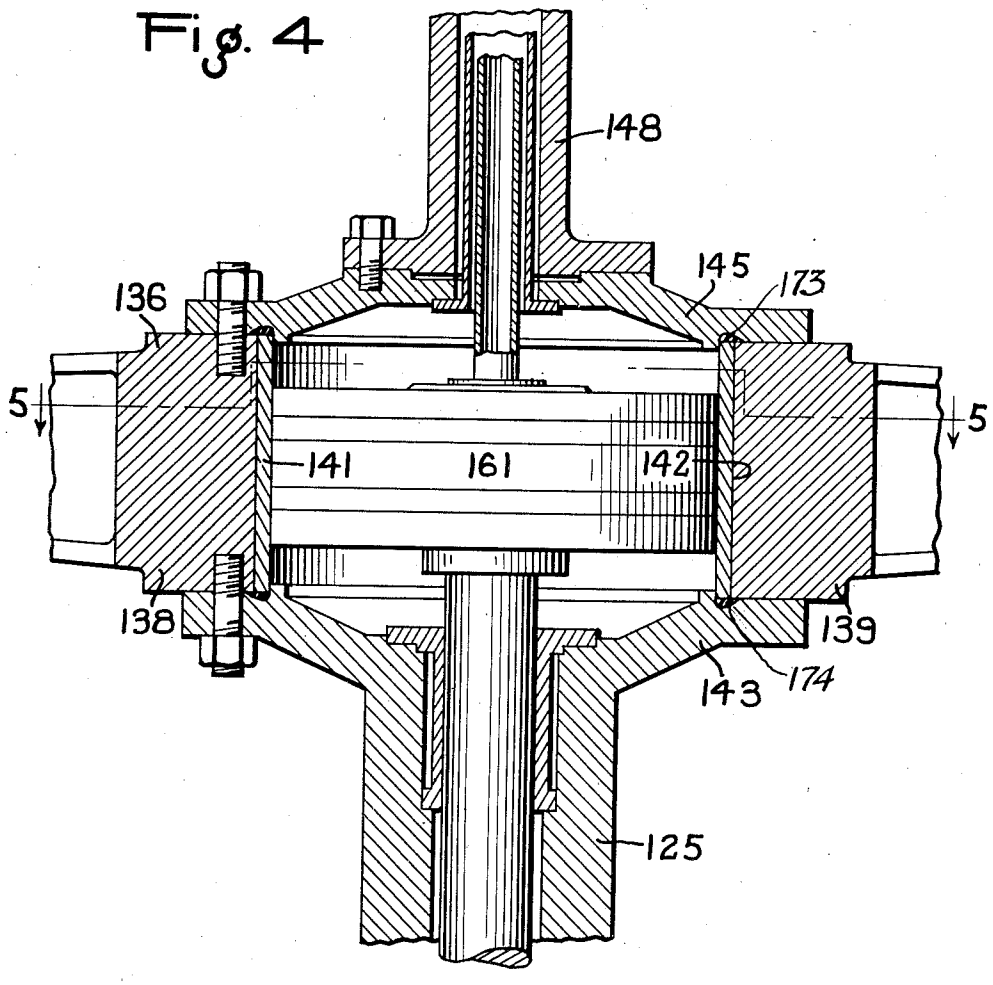
Fig. 4



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TURBO MACHINE

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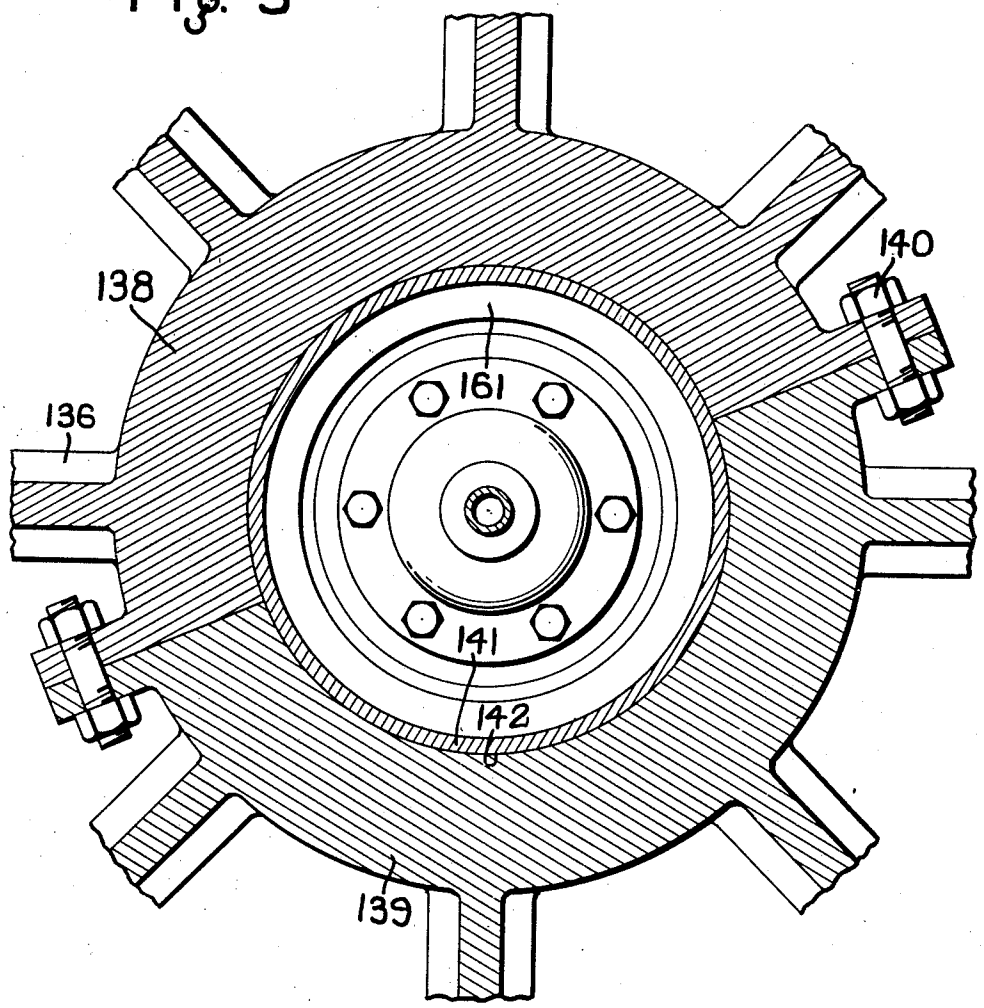
Fig. 5



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TURBO MACHINE

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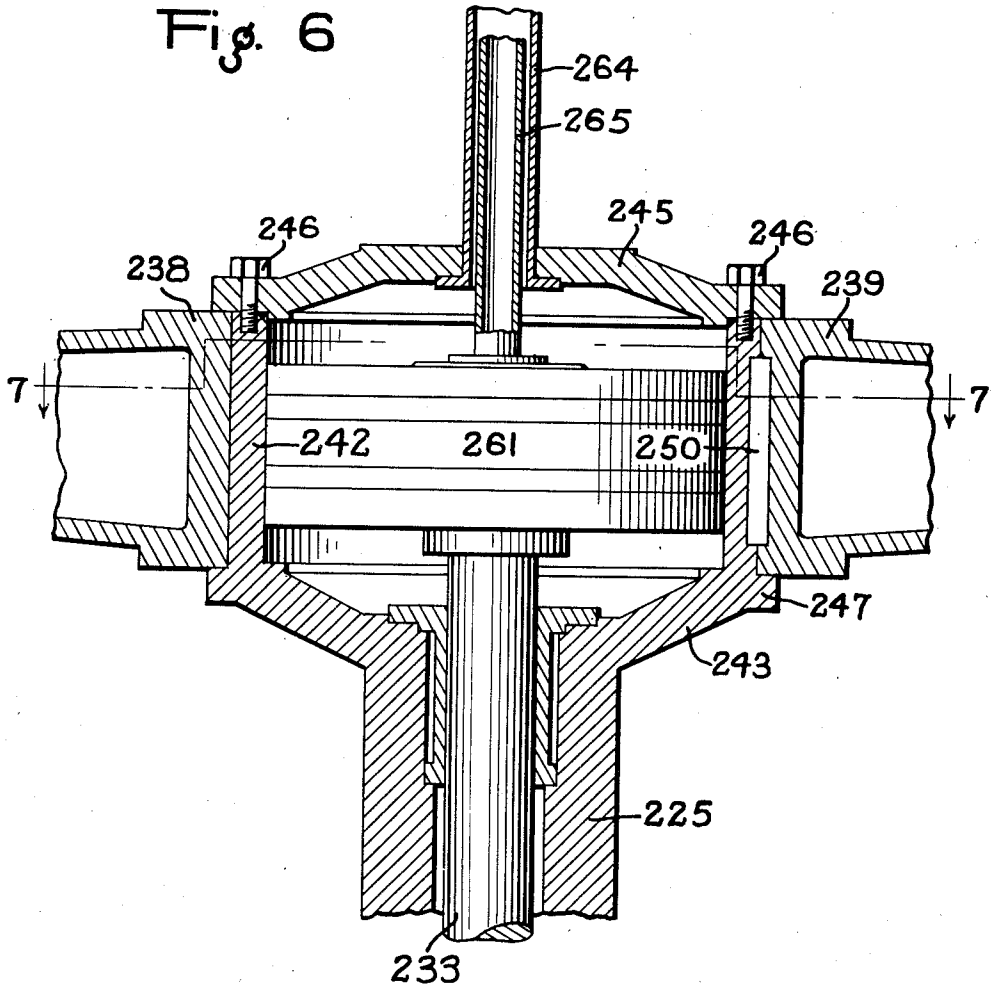
Fig. 6



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TURBO MACHINE

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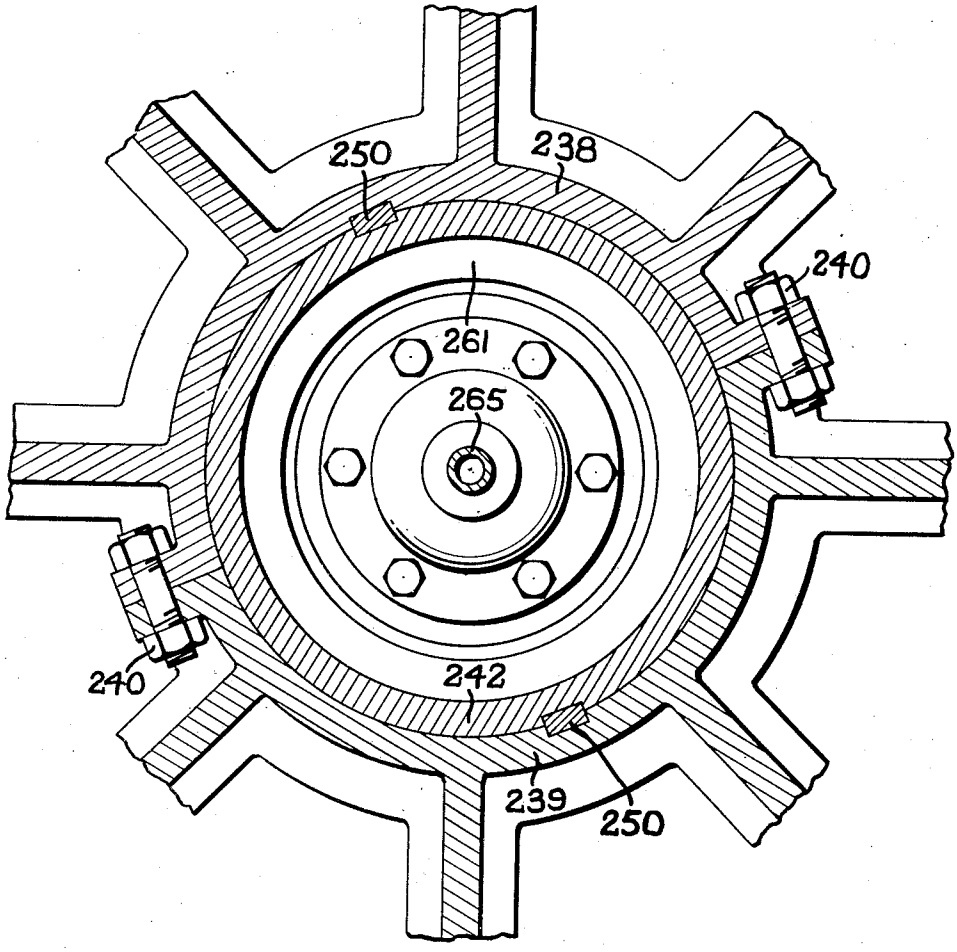
Fig. 7



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TURBO MACHINE

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Fig. 9

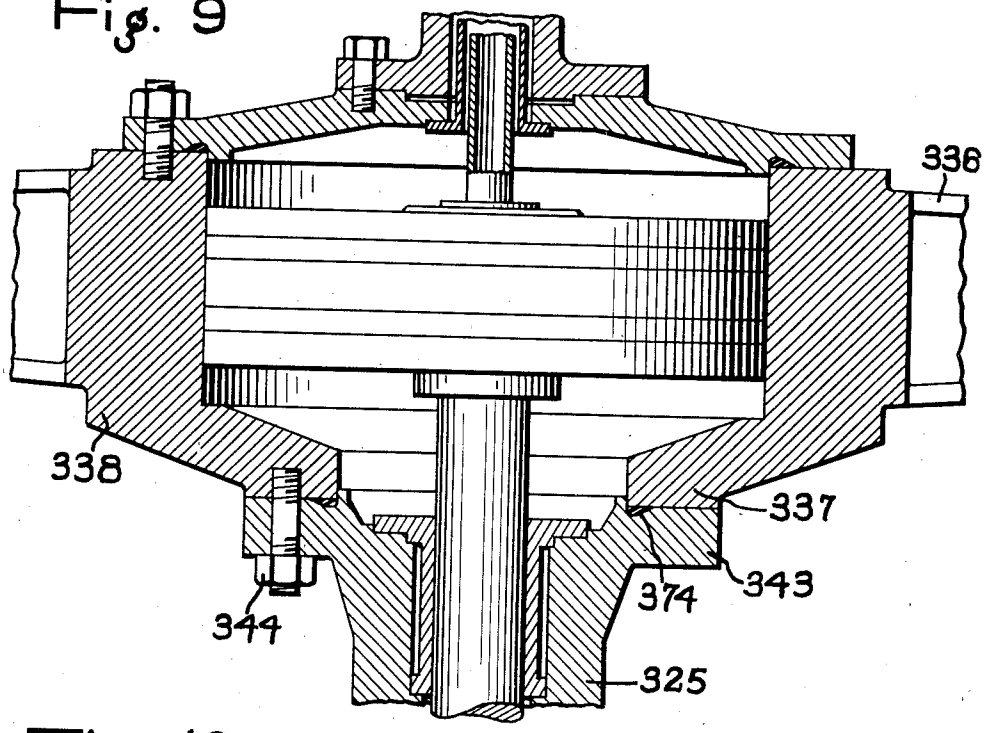
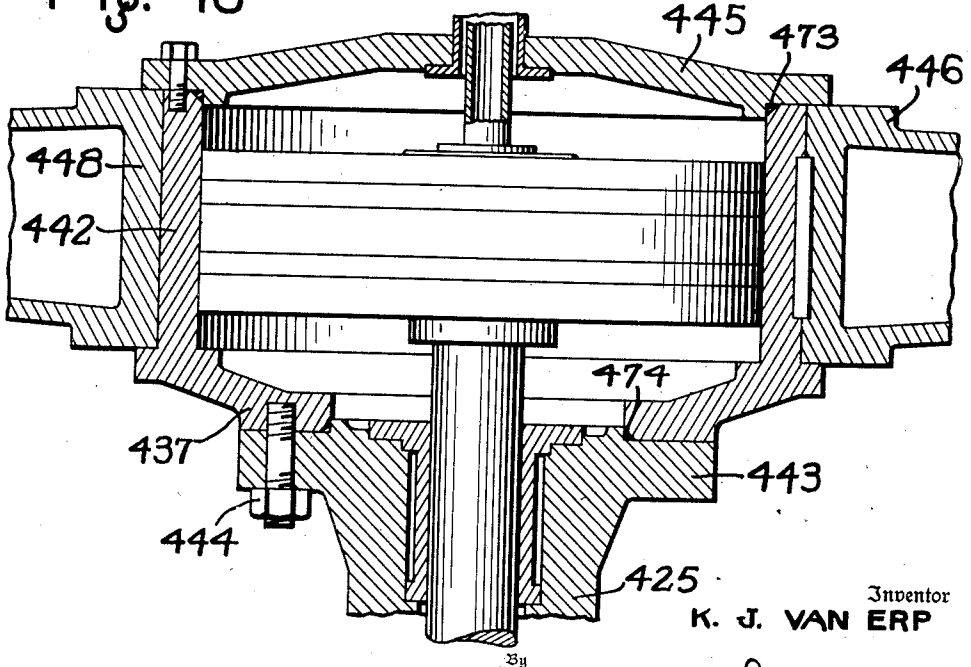


Fig. 10



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Patented Apr. 28, 1942 2,281,214

UNITED STATES PATENT OFFICE

2,281,214

TURBO MACHINE

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Application August 1, 1940, Serial No. 349,276

10 Claims. (Cl. 290—52)

This invention relates generally to turbo machines with adjustable runner blades, such as hydraulic turbines, pumps, blowers, wind machines, air propellers, and the like, either driving an electric generator or being driven by an electric motor, as the case may be. More particularly the invention relates to machines of the above type in which the runner blades are automatically adjustable by means including a fluid pressure power cylinder.

An object of the present invention is to provide an improved turbo machine in which the arrangement of the power cylinder is such that the total axial length of the machine is reduced to a minimum.

Another object of the invention is to provide an improved turbo machine in which the power cylinder is so arranged in the machine that it may be conveniently inspected without the necessity of disturbing the vital parts of the machine, particularly the bearings and the rotor of the electrical unit, thereby reducing the time for inspection to a minimum.

Another object of the invention is to provide an improved turbo machine of the type having an adjustable blade runner connected to the rotor of an electrical unit, in which the power means for the runner blade operating mechanism is disposed within the hub of the rotor of the electrical unit.

Another object of the invention is to provide an improved turbo machine of the character mentioned, which is simple in construction, and reliable and exact in function under all conditions of service.

The invention also comprises certain new and useful improvements in the construction, arrangement and combination of the several parts of which it is composed, as will be hereinafter more fully described and claimed.

In the accompanying drawings:

Fig. 1 is a side elevation, partly in section, of a turbo machine constructed according to the present invention;

Fig. 2 is an enlarged vertical section of a portion of the runner, showing the construction of the parts within the hub of the runner;

Fig. 3 is an enlarged vertical section of a portion of the electrical generator, showing the construction of the parts within the rotor;

Fig. 4 is a vertical section of the hub of the generator rotor showing another form of the invention;

Fig. 5 is a horizontal section taken on the line 5—5 of Fig. 4;

Fig. 6 is a section similar to Fig. 4 showing another form of the invention;

Fig. 7 is a horizontal section taken on the line 7—7 of Fig. 6;

Fig. 8 is an enlarged detail section of the sealing means shown in Fig. 3;

Fig. 9 is a view similar to Fig. 4 showing another form of the invention, and

Fig. 10 is a view similar to Fig. 6 showing another form of the invention.

Referring to the drawings and especially to Fig. 1, the turbo machine may be in the form of a hydraulic turbine 11 adapted to operate an electrical generator 12.

The turbine 11 comprises a casing 13 which forms a peripheral water inlet in which are mounted an annular series of movable wicket gates 14 and stationary guide vanes 15.

The wicket gates 14 are adapted to be rotated simultaneously into different angular positions to control the flow of water into the turbine in the usual manner, and for this purpose said wicket gates have operatively connected thereto gate operating arms 16 which are connected by links 17 to a gate adjusting ring 18.

The gate adjusting ring 18 is connected by link means 19 to the controlling member of a governor (not shown).

The lower portion of the turbine casing 13 forms an axially directed chamber 20 in which the runner 21 operates.

Any suitable type of setting may be used for the installation of the apparatus, a concrete setting 23 being shown in the present instance.

The portion of the setting 23 below the turbine forms a draft tube 24 into which the water is discharged from the runner.

The electrical generator 12 may rest on top of the setting 23.

Referring to Fig. 2, the hub of the runner 21 is bolted or otherwise fixed to the lower end of a hollow or tubular shaft 25.

The shaft 25 extends upwardly and its upper end is secured to the hub of the rotor of the generator 12 in the manner to be hereinafter more fully described.

A suitable number of blades 26 are rotatably supported in the hub of the runner 21 and project radially therefrom.

The inner end of each blade 26 is formed with a trunnion 27 which is journalled in bearings 28 and 29 supported in the hub. The construction is such that the blades are rotatable into different angular relationships with the axis of the runner.

Means are provided for simultaneously rotating all of the blades 26 and for maintaining them in equal angular relationship, such means comprising preferably an arm 30 rigidly fixed on the trunnion 27 of each blade, and links 31 which pivotally connect the arms on the different blades to a cross head 32, guided to reciprocate in a direction axially of the runner.

It will be understood that the relative positions of the blades 26 govern the area of the water passages or openings between the blades, and that when the blades are rotated, the area of the water passages is increased or decreased depending upon the direction in which the blades are moved.

The cross head 32 is bolted or otherwise fixed to the lower end of an operating rod 33 which extends upwardly through the hollow runner shaft 25.

Referring to Fig. 3, the electric generator 12 comprises a cylindrical housing 34 in which the stator structure 35 of the generator is mounted.

Operatively associated with the stator 35, is a rotor 36.

The rotor 36 comprises a spider having a central portion or hub 38 and a peripheral portion 39 which is connected to the hub 38 by a plurality of spokes or arms 40.

The peripheral portion 39 of the rotor 36 supports a field winding 41.

In the form of the invention shown in Figs. 1, 2 and 3, the hub 38 may be constructed of a one-piece casting. In this event the hub 38 is constructed of a diameter of such dimensions as to provide a cylindrical bore 42 which functions as the side wall of a power cylinder arranged within the hub of the rotor 36.

The upper end of the runner shaft 25 is flared outwardly, as indicated at 43, Fig. 3, so as to provide means for closing the lower end of the cylinder 42.

The flanged portion 43 of the shaft 25 is bolted or otherwise fastened to the hub 38, as indicated at 44.

The upper end of the cylinder 42 is closed by means of a flanged plate 45, which plate may be detachably secured to the hub 38 by means of bolts 46, as shown in Fig. 3.

The plate 45 has the lower flanged end 47 of a tubular shaft 48 secured thereto, as indicated at 49.

The upper end of the operating rod 33 is fixed to the piston 61 of the power cylinder 42.

The upper portion of the rod 33 passes through a bushing 62 mounted in the runner shaft 25, and this bushing besides forming a bearing for the operating rod 33, provides means for closing the chamber 63 on the lower side of the piston 61.

The piston 61 is double acting, and in order to supply oil to both sides thereof for the purpose of operating the same in either direction, two tubes or pipes 64 and 65 are employed.

The pipes 64 and 65 are mounted within the hollow shaft 48 and rotate therewith, said pipes extending from the hub of the rotor 36 upwardly through the shaft 48 to a head 66 which is mounted on top of the exciter housing 67 of the generator 12, as shown in Fig. 1.

It is to be understood that the shaft 48 is operatively connected to the rotor of an exciter for the generator mounted within the housing 67. Since the exciter has a well known function which is no part of the present invention, no further description thereof is deemed necessary herein.

In mechanisms falling within the scope of the present invention, the operating fluid is generally oil, and the oil is supplied from the usual pressure tank (not shown) which is installed in the power house as a part of the equipment. The oil pressure tank is connected with the turbine governor and also with the head 66, means being provided for controlling the oil in such a manner that when the governor operates in either direction to adjust the angles of the wicket gates, the runner blades will be caused to turn in a similar direction so as to effect a corresponding adjustment in the angles or positions thereof. In this way the parts of the machine will be simultaneously adjusted, so that all of the parts will at all times retain their correct relationship with each other, and the machine will operate with maximum efficiency and smoothness and with minimum vibration. The manner in which the operating oil is controlled is fully described in United States Letters Patent No. 1,937,772, granted December 5, 1933, to Daniel J. McCormack for Turbine.

As shown in Fig. 3, the pipes 64 and 65 may be concentrically disposed. The lower end of the pipe 65 is in communication with the chamber 63 on the lower side of the piston 61 and the lower end of the pipe 64 is in communication with chamber 68 on the upper side of said piston.

The lower end of the pipe 65 is fixed to a cap 69 carried by the piston 61, and, therefore, the pipe 65 will be moved rectilinearly in the shaft 48 when the piston operates.

A chamber 70 is provided within the cap 69, said chamber being connected to the piston chamber 63 by means of passages or ports 71 formed in the piston 61, so that oil supplied through the pipe 65 will flow into the chamber 63.

The lower end of the pipe 64 terminates above the cap 69, so as to be in communication with the chamber 68. The lower end of the pipe 64 may be secured to the underside of the plate 45, by means of a member 72. The member 72 provides means for closing the lower end of the hollow shaft 48 and thereby cuts off communication from the chamber 68 to the space within said shaft exteriorly of the pipes 64 and 65.

In order to seal the joints between the hub 38 and the flange 43 and the plate 45, respectively, sealing means may be provided, as shown in Figs. 3 and 8. These sealing means may comprise annular rubber gaskets 73 and 74 mounted in grooves 75 and 76, formed, respectively, in the members 45 and 43.

In operation, the runner absorbs energy of the water passing into the casing 15 and transforms same into rotational energy which is transmitted by the shaft 25 to the rotor 36 of the generator. Electrical energy is, then, produced in the stator 35 in well known manner.

When the load on the machines varies, the pressure fluid supplied through the pipes 64 and 65 to the chambers 68 and 63, respectively, of the power cylinder 42 will be varied so as to effect actuation of the piston 61 in well known manner. In this way the runner blades 26 will be moved to the position in which the machine operates at the maximum efficiency.

As will be seen from the embodiment of the invention shown in Fig. 3, the power cylinder or servo motor for operating the runner blades 26 is

a part of the hub 38 of the generator rotor 36. By constructing the rotor 36 in this manner the total axial length of the machine is reduced to a minimum, so that the cost of the machine is decreased and the cost of the structure in which the machine is housed is also decreased in comparison with other similar machines heretofore constructed, which machines had their power cylinders or servo motors arranged in the runner shafts between the runners and the generators.

Furthermore it will readily be seen that with the power cylinder arrangement according to my invention as compared with the above mentioned old design, inspection and, for instance, an exchange of piston rings of the power means will be greatly facilitated with a resultant saving in time and expense. The old construction necessitated removal of the generator rotor to get at the power cylinder, requiring major dismantling operations, while with my design, removal of only the upper part of the generator structure is required to get access to the power cylinder, leaving the rotor itself and the alignment of the machine undisturbed.

Usually in large turbo machines it is the practice to construct the hub of the generator rotor of two or more sections. In other words, the hub of the generator rotor is made split.

Referring now to Figs. 4 and 5, the rotor 136 is shown as having a hub formed of substantially semi-cylindrical sections 138 and 139, which sections are detachably connected by means of bolts 140 or other suitable fastening means.

In order to provide a smooth surface for the piston 161, a one-piece cylindrical sleeve 141 is mounted in the bore 142 of the hub, said sleeve being clamped between the flanged portion 143 of the runner shaft 125 and the upper flanged plate 145 of the exciter shaft 148.

In other respects the construction of the power cylinder is the same as that heretofore described.

It will be readily understood that the purpose of the sleeve 141 is to prevent leakage through the joints of the sections of the rotor hub, and consequently the sealing means 173 and 174 are so arranged at the joints between said sleeve and the other parts 138, 139, 143 and 145 of the hub as to seal such joints.

In the form of the invention illustrated by Figs. 6 and 7, the generator rotor may be formed of two semi-cylindrical hub sections 238 and 239, which sections are detachably connected by means of bolts 240 or other suitable fastening means.

The runner shaft 225 has its upper enlarged portion 243 formed with an upstanding cylindrical portion 242 which constitutes the side wall of the power cylinder of the machine.

A top plate 245, secured to the top of the cylinder 242 by bolts 246 provides means for closing the top of the power cylinder and also means for supporting the pipe 264.

The pipe 265 is connected to the piston 261 and said piston is connected to the operating rod 233 in the same manner as shown in Fig. 3.

The hub sections 238 and 239 are clamped between the flange of the top plate 245 and the flange 247 of the shaft 225.

In order to further interlock the runner shaft 225 with the generator rotor, keys 250 may be mounted in suitable grooves formed respectively in the abutting walls of the cylinder 242 and the hub sections 238 and 239.

In Fig. 6 the exciter shaft has been omitted, since this form of the invention may be used, when desired, in the construction of hydro electric machines having the generator exciters located elsewhere than directly above the generator.

It will further be noted that in this form of the invention the connection between the runner shaft and the rotor hub has been simplified, since the bolts 44, Fig. 3, have been eliminated.

Referring to Fig. 9, the upper end of the runnershaft 325 is formed with an enlarged flanged portion 343 which is adapted to be connected to the lower inwardly extending flanged portion 337 of the hub 338 of the rotor 336 by means of bolts 344, or other suitable fastening elements.

A sealing means 374, generally of the type of sealing means shown in Fig. 8 may be provided at the joint between the flanges 337 and 343.

In other respects all other elements of this form of the invention are substantially the same as those shown in Fig. 3.

In the form of the invention shown in Fig. 10, the construction shown in Fig. 6 is modified so as to construct the part of the power cylinder 442 which is inserted within the hub 448 of the rotor 446 of a separate piece adapted to be detachably connected to the upper end of the runner shaft 425.

The upper end of the shaft 425 is formed with a flanged portion 443 substantially similar to the upper end of the shaft 325.

The power cylinder insert piece 442 is formed with a lower inwardly extending flanged portion 437 which is connected to the flange 443 by means of bolts 444, or other suitable fastening elements.

A sealing means 474 is provided at the joint between the flanges 437 and 443, and a similar sealing means 473 is provided at the joint between the upper end of the cylinder 442 and the plate 445.

In other respects all other elements of this form of the invention are substantially the same as those shown in Fig. 6.

The modifications shown in Figs. 9 and 10 are useful in installations where only a relatively low oil pressure is available for working the power cylinder, or in installations embodying a very large turbine, or if the operating head of the turbine is relatively high, or if two or all of these conditions would have to be met simultaneously and the power cylinder has a large diameter. Under such conditions it may be undesirable or uneconomical to use the designs illustrated in Figs. 3 and 6, due to limitations in forging the runner shafts with flanges of unusually large size.

Having thus described my invention, what I claim is:

1. In a turbo machine comprising a runner having blades movable into different angular positions and an electric machine having a rotor connected by a shaft to said runner, of fluid pressure means mounted within the hub of the rotor and operatively connected to said runner blades for actuating the same.

2. In a turbo machine, a runner having blades movable into different angular positions, mechanism within the hub of the runner for moving said blades, a hollow runner shaft connected to the hub of the runner, a rod mounted within said shaft and connected to the runner blade operating mechanism, an electric machine having a rotor connected to said runner shaft, a chamber formed in the hub of the rotor, and

power means mounted in said chamber and connected to said rod for actuating the same.

3. In combination, a turbo machine having a runner formed with adjustable blades and an electric generator having a rotor connected to said runner and operated thereby, and fluid pressure mechanism contained within the generator rotor for operating said runner blades.

4. In a hydraulic machine having a runner hub with adjustable blades, an electric generator having a rotor, a shaft connected with the hub and with said rotor so as to be driven by the runner for communicating power to the rotor, fluid pressure means mounted within the hub of said rotor, and means operatively connecting said fluid pressure means with said runner blades for communicating movements of said fluid pressure means to said runner blades.

5. In a hydraulic machine having a runner hub with blades turning in bearings, a shaft connected with the hub so as to be driven thereby for communicating power from the hub, an electric generator having a rotor connected to said shaft, a power cylinder and piston mounted within the hub of said rotor, and means connecting said piston with said runner blades for actuating the same.

6. In a turbo machine, a runner having blades movable into different angular positions, mechanism within the hub of the runner for moving said blades, a hollow runner shaft connected to the hub of the runner, an electric generator having a rotor connected to said runner shaft, a cylinder formed in the hub of said rotor, a piston mounted within the cylinder, a rod mounted within said shaft and connected at one end to the runner blade operating mechanism and connected at the other end to said piston, and means for supplying pressure fluid to said cylinder for operating said piston.

7. In a turbo machine, a runner having blades movable into different angular positions, mechanism within the hub of the runner for moving said blades, a hollow runner shaft connected to the hub of the runner, an electric generator having a rotor, the hub of said rotor being formed with an enlarged bore, an enlarged cylindrical portion formed on the end of said runner shaft opposite to the end connected to the runner hub, said cylindrical portion being disposed within the hub of said rotor, keys connecting the enlarged cylindrical portion of said shaft with said rotor hub for communicating power from said shaft to said rotor, means enclosing said cylindrical portion so as to provide a power cylinder, a piston mounted within the cylinder, a rod mounted within said shaft and connected at one end to the runner blade operating mechanism and connected at the other end to said piston, and means for supplying pressure fluid to said cylinder for operating said piston.

8. In a turbo machine, a runner having blades movable into different angular positions, mechanism within the hub of the runner for moving said blades, a hollow runner shaft connected to the hub of the runner, an electric generator having a rotor formed of a plurality of detachable sections, the hub of said rotor being formed with an enlarged bore, a one-piece cylindrical sleeve mounted within said bore, an enlarged flanged portion formed on the end of said runner shaft opposite to the end connected to the runner hub and detachably connected to the rotor hub for closing one end of said sleeve, a top plate detachably connected to the opposite side of the rotor hub for closing the other end of said sleeve, means for sealing the joint between said sleeve and said hub, a piston mounted within said sleeve, a rod mounted within said runner shaft and connected at one end to the runner blade operating mechanism and connected at the other end to said piston, and means for supplying pressure fluid through said top plate to the chambers on the opposite sides of the piston for operating said piston.

9. In a turbo machine, a runner having blades movable into different angular positions, mechanism within the hub of the runner for moving said blades, a hollow runner shaft connected to the hub of the runner, an electric generator having a rotor, the hub of said rotor being formed with a bore for a power piston connected with said runner blade operating mechanism, an inwardly extending flange formed on the hub of said rotor around the periphery of said bore, and a flange formed on said runner shaft and adapted to be connected to the flanged portion of said rotor hub.

10. In a turbo machine, a runner having blades movable into different angular positions, mechanism within the hub of the runner for moving said blades, a hollow runner shaft connected to the hub of the runner, an electric generator having a rotor, the hub of said rotor being formed with a bore, a one-piece cylindrical sleeve mounted within said bore, an inwardly and downwardly extending flange formed on the bottom of said sleeve, a power piston mounted in said sleeve and connected with said runner blade operating mechanism, a flange formed on said runner shaft, and means for connecting the flanged portion of said sleeve to the flanged portion of said shaft.

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