June 5, 1934. A. LYSHOLM 1,961,616

DOUBLE ROTARY TYPE STEAM TURBINE

Filed May 27, 1930 3 Sheets-Sheet 1

Fig. 1

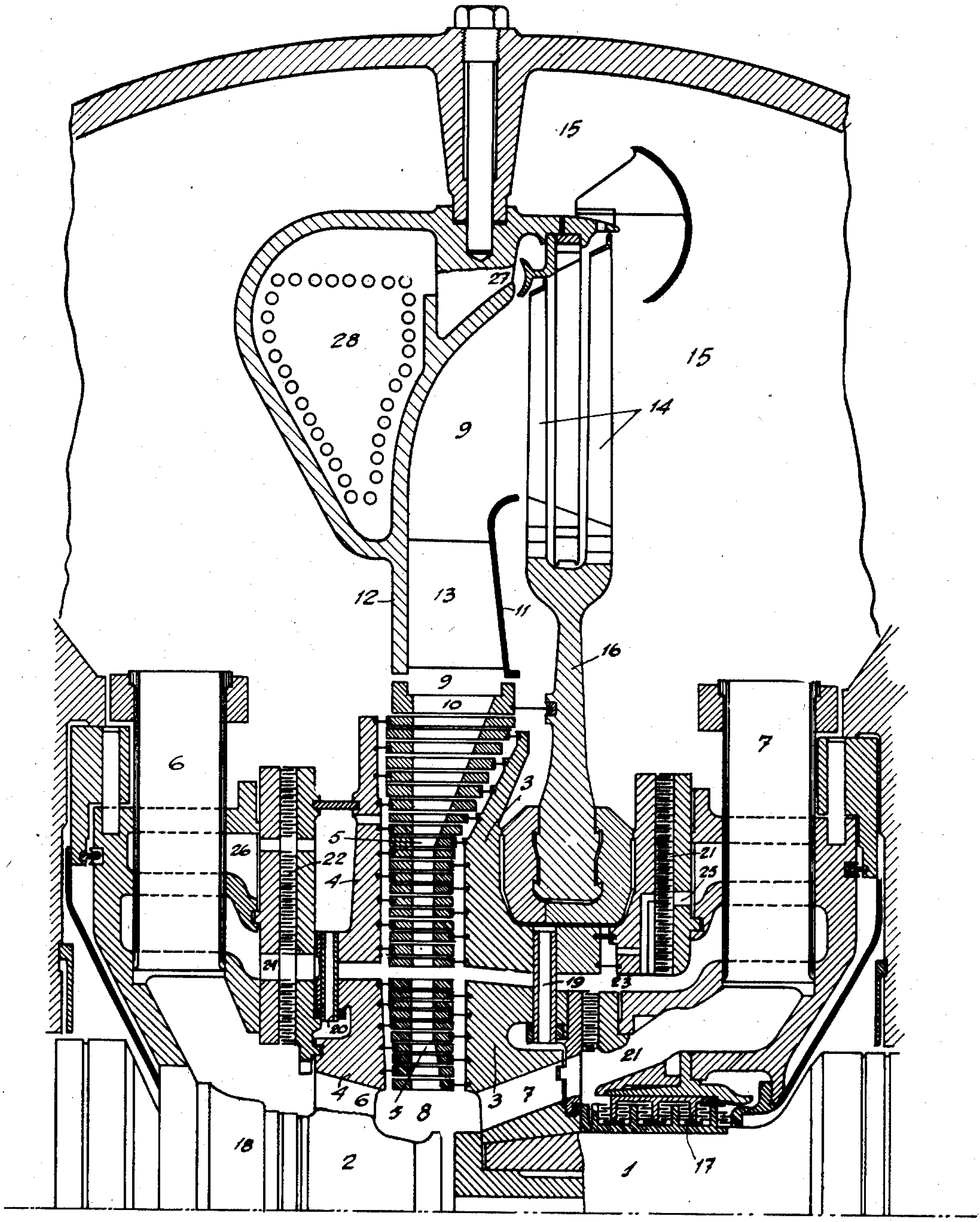

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Fig. 4

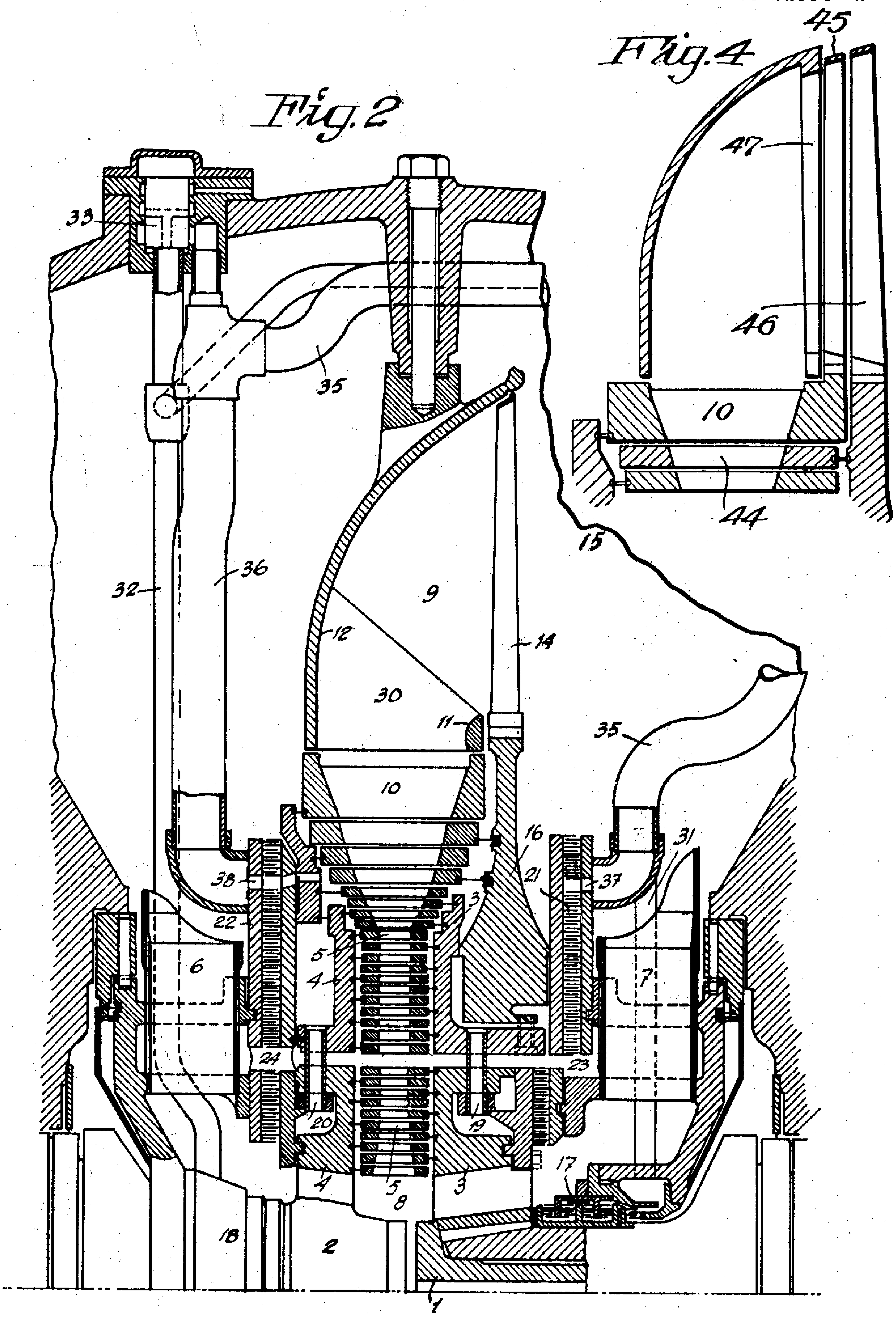

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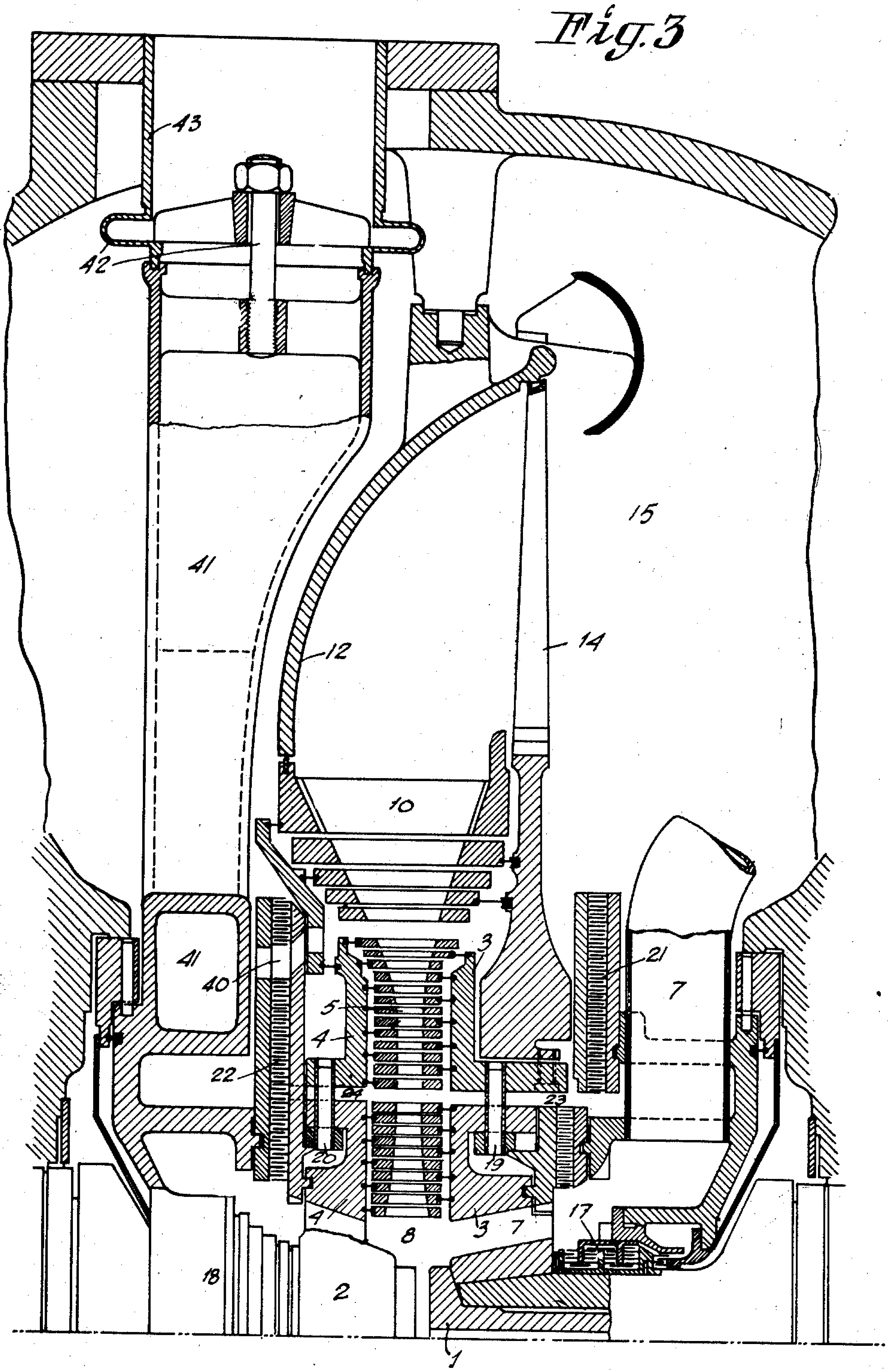
Fig. 3



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UNITED STATES PATENT OFFICE

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DOUBLE ROTARY TYPE STEAM TURBINE

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18 Claims. (Cl. 253—16.5)

The present invention relates to combined type turbines in which steam is expanded successively in a radial flow blade system and an axial flow blade system, and has particular reference to turbines of the above type in which the radial flow blade system is of the double rotation type.

Radial flow turbines, in which the entire expansion of the steam is effected in a radial flow blade system, are limited by practical considerations to relatively small sizes and for large size turbines, axial flow blade systems are usually added, these blade systems comprising two blade groups, each of said groups being associated with one part of the turbine providing the radial flow blade system.

For turbines of intermediate sizes such for example as from five thousand to fifteen thousand kilowatts capacity and operating at about three thousand revolutions per minute, the above described type of combined turbines are not suitable because of the expense incident to the manufacture of the radial flow blade system and the two groups of blades comprising the axial flow blade system. On the other hand turbines of this intermediate size cannot, because of practical considerations, be made without an axial flow blade system, largely because of the consideration of the large discharge area which must be provided for turbines of such size.

The present invention has for its general object the provision of an improved form of combined type turbine which may advantageously be made in the intermediate sizes, with respect to which neither the radial flow turbines, nor the combined type turbines as heretofore made, are well adapted. The above general object is, in accordance with the present invention, attained by the provision of a turbine comprising a radial flow blade system of the double rotation type combined with a single axial flow blade system adapted to receive and further expand all of the steam which can be suitably expanded in and exhausted from the radial flow blade system for further expansion in the turbine. Other and more detailed objects of the invention, together with its more specific nature and the advantages to be derived from its use, will become apparent as the following description of several forms of apparatus for carrying the invention into effect proceeds.

In the drawings, forming a part of this specification;—

Fig. 1 shows a section parallel with the axis of rotation through the upper part of a steam turbine embodying the invention; Fig. 2 shows a similar section through a turbine of a different type; Fig. 3 shows a similar section through a turbine which is particularly adapted for the supply of overload steam; and Fig. 4 shows diagrammatically a turbine according to the invention provided on one side with an axial flow blade system of the double rotation type.

Referring to Fig. 1, 1 and 2 designate shafts rotating in opposite direction, of which shaft 1 supports the turbine disk 3 and shaft 2 supports the turbine disk 4. These turbine disks support in known manner, by means of articulated or resilient connections, a number of blade rings, which are inserted in between each other and in this manner constitute the radial flow blade system 5 of the turbine. The steam is introduced through the supply conduits 6 and 7 to the inlet chamber 8 of the turbine, from which it flows in radial direction through the blade system 5 to the space 9 radially outside the last blade ring 10 of the radial flow blade system 5.

Annular stationary members 11 and 12 support the guide blades 13 and provide between these members a space 9 for flow of steam to the single axial flow blade system. It will be observed that member 12 provides a curved wall extending from adjacent the end of the outermost radial flow blade ring remote from the axial flow blade system to adjacent the outer periphery of the first blade ring of the axial flow blade system. This wall acts as a deflecting guide for smoothly turning the steam into the inlet of the axial flow blade system. Steam discharged from the axial flow blade system flows to the main exhaust chamber of the turbine. The moving blade rings 14 of the axial flow blade system are attached to a turbine disk 16 and may be connected to directly or by articulated members the turbine disk 3 supporting the blades of the radial flow blade system. In order to prevent leakage of steam from the turbine, labyrinth packings 21 and 22 are provided for the turbine disks and stuffing boxes 17 and 18 of the labyrinth type are provided for the turbine shafts. In Fig. 1 the stuffing box 17 is shown in section and the stuffing box 18 is shown in elevation. The turbine disk 3 which in the same manner as the turbine disk 4 may be divided into two or several parts interconnected by hollow bolts 19 and 20, supports in the present case a labyrinth packing 21 divided into two parts, the parts of the packing rotating together with the turbine disk 3 being inserted between packing parts which are fixed to the non-rotating parts of the turbine. While, as will be evident from Fig. 1, the turbine disks are built up of a number of separate parts, the specific construction of the disks is not material to the present invention and the term disks will hereinafter be employed to include the members forming the complete disk assemblies. In the same manner the turbine disk 4 carries a labyrinth packing 22. The labyrinth packings provide in the usual known manner an axial balancing system for the turbine and through these packings the steam supply conduits 23, 24, 25, and 26 pass, these conduits providing for the admission of additional or overload steam for increasing the power of the turbine. Because of the manner in which the axial flow blade system is situated in accordance with the present invention, the conducting of overload steam to the radial flow blade system through the supply conduit 26 is facilitated.

A channel 27 is provided for withdrawing or bleeding steam from the space 9 between the axial and radial flow blade systems. This steam is led to a heat exchanger which may advantageously be in the form of a preheater 28 built into the turbine. Because of the fact that in accordance with the present invention the axial flow blade system is entirely to one side of a transverse plane passing through the radial flow blade system, and only because of this fact, the necessary space for such a heat exchanger is available within the turbine. As will be apparent from the figure, the steam conducted to the heat exchanger through channel 27 may be used in the most efficient manner, without the heat loss which would be incurred if the heat exchanger were outside the turbine casing, because of the fact that the heat exchanger is situated adjacent to the point where the steam is bled from the turbine and also because of the fact that the heat exchanger is within the exhaust steam space in the turbine casing.

In the turbine shown in Fig. 2 the last moving blade ring 10 of the radial flow blade system rotates in opposite direction with respect to the moving blades of the axial flow blade system 14. The axial flow blade system is not provided with any special system of guide blades through which the steam expands, but in place of such system there is provided a plurality of bent plates 30 or the like which prevent the formation of eddies in the steam in the space 9 or make such formation difficult and between which the steam flows without appreciable expansion and deviation.

In this embodiment the steam leaking out through the axial labyrinth packings 17 and 18 is partly or wholly utilized by guiding the same back to the turbine. A space surrounded internally and externally by tightening edges is connected by conduits 31 and 32 respectively with a control valve 33 which, when the pressure surpasses the atmospheric pressure surrounding the turbine, feeds steam in to the conduits 35 and 36 respectively. By this means the pressure is increased on the balancing disks of the labyrinth packing, whereby a better compensation of the axial thrust on the turbine disks is effected and at the same time the corresponding steam quantities may be introduced to the turbine.

In the turbine shown in Fig. 3 the last moving blade ring 10 of the radial flow blade system 5 also rotates in opposite direction to the direction in which the moving blades of the axial flow blade system 14 rotate. A special guide ring for the steam, either in the form of blades adapted for expansion or exclusively for guiding the steam, has not been provided, but the steam coming from the last blade ring 10 reaches immediately after its deviation the axial flow blade system 14 consisting of one single moving blade ring. The blade ring 10, therefore, serves to a certain degree as a guide blade ring for the axial flow blade system, and as it rotates in opposite direction to the axial flow blade ring, there is obtained a double rotation effect between the radial flow blade system and the axial flow blade system. In other words, the steam enters the blade ring 14 without having the direction of its rotational component of flow reversed after leaving the blade ring 10. In this respect the construction in Fig. 2 is similar to that in Fig. 3, since in each of these arrangments the last row of radial flow blades and the row of axial flow blades rotate in opposite directions and as has been previously pointed out the stationary guides 30 of Fig. 2 do not function to turn the steam rotationally as do the blades 13 of Fig. 1 where the last row of radial flow blades and the first row of axial flow blades rotate in the same direction.

By the arrangement shown in Figs. 2 and 3, the sum of the squares of the blade speeds for a given turbine may be increased, and as is well known this contributes to an increase in efficiency in the turbine for a given heat drop. The turbine efficiency is also enhanced by the elimination of guide blade friction losses between the radial flow and axial flow blade systems.

In addition to the above described arrangements for the supply of additional steam, a channel 41 is provided in this turbine for the supply of the additional steam, and for this channel sufficient space is available, for the reason that the axial flow blade system is arranged on one side only of the central plane passing at right angles through the axis of the turbine. The channel 41 may be in communication with a steam accumulator in order to be able to utilize the steam accumulated therein. The channels or conduits 41 which are situated adjacent to the space 15 and are surrounded by the discharge steam, are connected with the external conduit 43 by a resilient connection in order to prevent undesirable expansion stresses due to heat.

Fig. 4 shows diagrammatically still another embodiment of the invention, in which the two last blade rings 10 and 44 of the radial flow blade system are connected respectively to the moving blade rings 45 and 46 of the axial flow blade system. The axial flow blade rings are arranged closely adjacent to each other in the manner disclosed in the figure and, therefore, are adapted for rotation in opposite directions. As the blade rings 10 and 45 rotate in the same direction, a guide blade system 47 fixed to the turbine housing is preferably arranged in front of the blade ring 45. It will be observed that in this embodiment the characteristic of double rotation between the oppositely rotating blades 45 and 46 of the axial flow blade system is obtained, and this construction, like the constructions in the embodiments in Figs. 2 and 3, results in important advantages because of the possibility of increasing the sum of the squares of the blade speeds in this portion of the turbine.

The turbine according to the invention involves for certain sizes a cheaper manufacture, because the number of the required blades becomes smaller. The construction is more compact, for the axial flow blade system is arranged only on one of the turbine disks or on parts built together with the latter. The possibilities for supplying and drawing off steam are greater, because space for these purposes is available at such places, where in turbines having symmetrically arranged axial flow blade systems, the second part of the latter would be situated. The above described places for the supply of additional steam may of course also be utilized for drawing off steam for different purposes.

What I claim is:—

1. An elastic fluid turbine comprising two turbine disks adapted to rotate in opposite direc-

tions, a radial flow blade system comprising a plurality of blade rings carried by said disks, an axial flow blade system comprising movable blades adapted to further expand all of the motive fluid which can be suitably expanded in and exhausted from said radial flow blade system, all of said moving blades being situated axially to one side of the center of the radial flow blade system and radially a greater distance from the axis of rotation of the turbine than the outermost blades of the radial flow blade system and being carried by one of said disks, the radially outermost blade ring of the radial flow blade system being carried by the other of said disks.

2. An elastic fluid turbine comprising two turbine disks adapted to rotate in opposite directions, a radial flow blade system comprising a plurality of blade rings carried by said disks, an axial flow blade system adapted to further expand all of the motive fluid which can be suitably expanded and exhausted from said radial flow blade system, said axial flow blade system comprising moving blades all of which are carried by one of said disks, the radially outermost blade ring of the radial flow blade system being carried by the other of said disks, and means for conducting motive fluid directly from said outermost blade ring to moving blades of said axial flow blade system without reversal in direction of its rotational component of flow.

3. An elastic fluid turbine comprising two turbine disks adapted to rotate in opposite directions, a radial flow blade system comprising a plurality of blade rings carried by said disks, an axial flow blade system adapted to further expand all of the motive fluid which can be suitably expanded and exhausted from said radial flow blade system, said axial flow blade system being formed entirely by moving blades carried by one of said disks, the radially outermost blade ring of the radial flow blade system being carried by the other of said disks, and means for conducting motive fluid directly from said outermost blade ring to moving blades of the axial flow blade system without reversal in direction of its rotational component of flow.

4. An elastic fluid turbine comprising a radial flow blade system and an axial flow blade system for receiving motive fluid exhausted from the radial flow blade system, each of said blade systems comprising adjacent rows of moving blades adapted to rotate in opposite directions with respect to each other.

5. An elastic fluid turbine comprising two turbine disks adapted to rotate in opposite directions, a plurality of blade rings carried by said disks and providing a radial flow blade system having an outermost blade ring carried by one of said disks, a single axial flow blade system comprising a row of moving blades carried by the other of said disks and a row of moving blades carried by said outermost ring of the radial flow blade system, and means for conducting motive fluid from the radial flow blade system to the axial flow blade system.

6. An elastic fluid turbine comprising two turbine disks adapted to rotate in opposite directions, a plurality of blade rings carried by said disks and providing a radial flow blade system having an outermost blade ring carried by one of said disks, a single axial flow blade system comprising a row of moving blades carried by the other of said disks and a row of moving blades carried by said radially outermost ring of the radial flow blade system, and means for conducting motive fluid from the radial flow blade system to the axial flow blade system, said means comprising a stationary member carrying a plurality of stationary guide vanes situated between the radial flow blades and the axial flow blades carried by said outermost blade ring.

7. An elastic fluid turbine comprising a radial flow blade system having central admission for initial expansion of motive fluid within the turbine, an axial flow blade system for final expansion in the turbine of all of the motive fluid to be expanded therein after discharge from said radial flow blade system, said axial flow blade system comprising moving blades all of which extend radially a greater distance from the axis of rotation of the turbine than do the radially outermost blades of the radial flow blade system and all of which are located axially to one side of the radial flow blade system, and a stationary annular member for guiding motive fluid from the radial flow blade system to the axial flow blade system, said member comprising a curved wall extending from adjacent the end of the outermost radial flow blade ring axially opposite the axial flow blade system to adjacent the outer periphery of the first blade ring of the axial flow blade system.

8. An elastic fluid turbine of the double rotation radial-axial flow type comprising a casing, two turbine disks adapted to rotate in opposite directions and carrying a plurality of blade rings forming a radial flow blade system having central admission for initial expansion of motive fluid within the turbine, an axial flow blade system comprising moving blades all of which are carried by one of said disks axially to one side of said radial flow blade system and radially a greater distance from the axis of rotation of the turbine than the radially outermost blade ring of the radial flow blade system, said casing providing a chamber for the reception of motive fluid exhausted from said axial flow blade system and means for causing all of the motive fluid discharged from the radial flow blade system for further expansion within the turbine to flow through said axial flow blade system, said means comprising an annular stationary member within said casing providing a curved wall extending from adjacent the end of the outermost radial flow blade ring axially opposite the axial flow blade system to adjacent the outer periphery of the first blade ring of the axial flow blade system.

9. An elastic fluid turbine of the double rotation radial-axial flow type comprising a casing, two turbine disks adapted to rotate in opposite directions and carrying a plurality of blade rings forming a radial flow blade system having central admission for initial expansion of motive fluid within the turbine, an axial flow blade system comprising moving blades all of which are carried by one of said disks axially to one side of said radial flow blade system and radially a greater distance from the axis of rotation of the turbine than the radially outermost blade ring of the radial flow blade system, said casing providing a chamber for the reception of motive fluid exhausted from said axial flow blade system and an annular stationary member within said casing, said member providing an annular heating chamber within said first mentioned chamber and a curved wall for guiding all of the motive fluid discharged from the radial flow blade system for further expansion within the turbine to said axial flow blade system, said wall extending from adjacent the end of the outermost radial

flow blade ring axially opposite the axial flow blade system to adjacent the outer periphery of the first blade ring of the axial flow blade system, there being passages through said wall for conducting motive fluid and condensate to said heating chamber from the space between the radial flow and axial flow blade systems.

10. An elastic fluid turbine of the double rotation radial-axial flow type comprising a casing, two turbine disks adapted to rotate in opposite directions and carrying a plurality of blade rings forming a radial flow blade system having central admission for initial expansion of motive fluid within the turbine, an axial flow blade system comprising moving blades all of which are carried by one of said disks axially to one side of said radial flow blade system and radially a greater distance from the axis of rotation of the turbine than the radially outermost blade ring of the radial flow blade system, said casing providing a chamber for the reception of motive fluid exhausted from said axial flow blade system, and an annular stationary member within said casing, said member providing an annular heating chamber within said first mentioned chamber and spaced radially inwardly of said casing whereby to permit said chamber to be surrounded by motive fluid at at least exhaust temperature and a curved wall for guiding all of the motive fluid discharged from the radial flow blade system for further expansion within the turbine to said axial flow blade system, said wall extending from adjacent the end of the outermost radial flow blade ring axially opposite the axial flow blade system to adjacent the outer periphery of the first blade ring of the axial flow blade system, there being passages through said wall for conducting motive fluid and condensate to said heating chamber from the space between the radial flow and axial flow blade systems.

11. An elastic fluid turbine of the double rotation radial-axial flow type comprising a casing, two turbine disks adapted to rotate in opposite directions and carrying a plurality of blade rings forming a radial flow blade system having central admission for initial expansion of motive fluid within the turbine, an axial flow blade system comprising moving blades all of which are carried by one of said disks axially to one side of said radial flow blade system and radially a greater distance from the axis of rotation of the turbine than the radially outermost blade ring of the radial flow blade system, said casing providing a chamber for the reception of motive fluid exhausted from said axial flow blade system, means for causing all of the motive fluid discharged from the radial flow blade system for further expansion within the turbine to flow through said axial flow blade system, said means comprising an annular stationary member within said casing providing a curved wall extending from adjacent the end of the outermost radial flow blade ring axially opposite the axial flow blade system to adjacent the outer periphery of the first blade ring of the axial flow blade system, and a plurality of circumferentially spaced guide blades carried by said member and extending axially of the turbine in the space between the radial flow and the axial flow blade systems.

12. In an elastic fluid turbine, a radial flow blade system and a single axial flow blade system adapted to receive all of the motive fluid discharged from the radial flow blade system for further expansion in the turbine, said axial flow blade system comprising a row of moving blades arranged to receive motive fluid directly and without reversal in direction of its rotational component of flow from the next preceding row of moving blades in the turbine and said rows of blades rotating in opposite directions during normal operation of the turbine.

13. In an elastic fluid turbine, a radial flow blade system having an outermost blade ring discharging motive fluid for further expansion in the turbine, and axial flow blading for effecting further expansion of the motive fluid discharged from said outermost ring comprising a row of moving blades arranged to receive motive fluid directly without reversal in direction of its rotational component of flow from a preceding row of blades moving in the opposite direction.

14. In an elastic fluid turbine of the double rotation type, a radial flow blade system having an outermost blade ring, a single axial flow blade system for expanding motive fluid discharged from said radial flow blade system, said outermost blade ring and the first row of moving blades of the axial flow blade system being mounted to rotate in opposite directions and means providing an open unobstructed channel for direct flow of motive fluid without reversal in direction of its rotational component of flow from the outermost blade ring of the radial flow blade system to the first row of moving blades of the axial flow blade system.

15. In an elastic fluid turbine, two turbine disks adapted to rotate in opposite directions and carrying a plurality of blade rings forming a radial flow blade system, a single axial flow blade system comprising a row of moving blades carried by one of said disks, the outermost blade ring of the radial flow system being carried by the other of said disks, and means providing a channel for conducting motive fluid discharged from the outermost blade ring of the radial flow blade system directly and without reversal in direction of its rotational component of flow to said row of moving blades of the axial flow blade system.

16. In an elastic fluid turbine of the double rotation type, a row of moving axial flow blades and a row of moving radial flow blades discharging motive fluid directly and without reversal in direction of its rotational component of flow to said first mentioned row of blades, said rows of blades rotating in opposite directions during normal operation of the turbine.

17. In an elastic fluid turbine of the double rotation type, two oppositely rotating rows of blades, the first of said rows constituting the last row of blades in a radial flow blade system and the second of said rows constituting the first row of blades in an axial flow blade system, the first of said rows discharging motive fluid directly and without reversal in direction of its rotational component of flow to the second of said rows.

18. In an elastic fluid turbine of the double rotation type, a radial flow blade system, an axial flow blade system receiving all of the motive fluid discharged from the radial flow blade system for further expansion in the turbine, said axial flow blade system comprising a row of moving blades constituting the last expansion stage of the turbine and said row of moving blades receiving motive fluid directly from a preceding row of moving blades rotating in opposite direction without reversal of its rotational component of flow between the first-mentioned row of moving blades and said preceding row of moving blades.

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