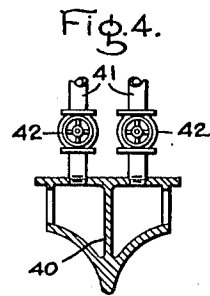
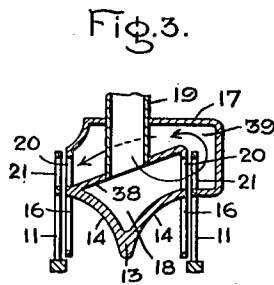
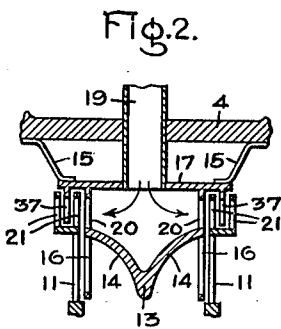
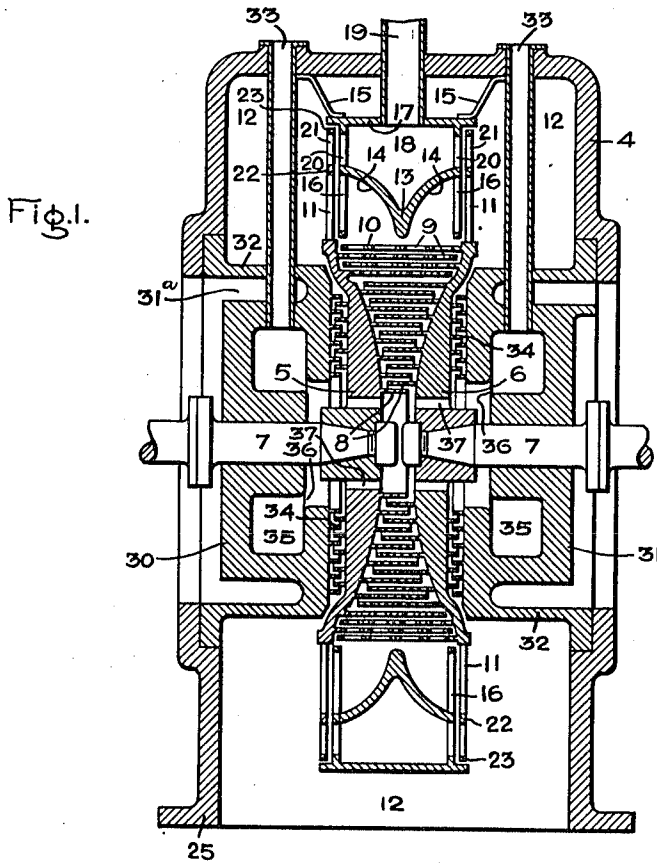


F. LJUNGSTRÖM.
 REVERSIBLE RADIAL FLOW TURBINE.
 APPLICATION FILED NOV. 14, 1917.

1,273,633.

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Inventor:
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UNITED STATES PATENT OFFICE.

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REVERSIBLE RADIAL-FLOW TURBINE.

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Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, FREDRIK LJUNGSTRÖM, a subject of the King of Sweden, residing at Stockholm, Sweden, have invented certain new and useful Improvements in Reversible Radial-Flow Turbines, of which the following is a specification.

The present invention relates to radial flow turbines having rotors that revolve in opposite directions, and has for its object to modify them in such manner as to render them reversible.

It is common practice at the present time to reverse axial flow turbines, and their construction is such that no practical difficulties are experienced. To accomplish this a separate reversing element is mounted on the same shaft as the forward driving element, and usually on the exhaust end, said elements being contained in the same casing. In such a case both elements are of the same general construction, the blades on one element, however, being reversed with respect to those on the other. Each element has, of course, suitable means for supplying motive fluid thereto. A construction of this kind obviously increases the axial length of the turbine. It has also been proposed to place reversing blades outside of the forward driving blades of such a turbine, but this has been abandoned for various reasons in favor of the one above described.

In radial flow turbines of the character referred to the use of two additional sets of reversing blade elements of the same general construction as the two forward driving elements would increase the overall length of the turbine and lead to an unsatisfactory mechanical construction, and also to a loss of economy. This is primarily due to the difficulty of supplying motive fluid to the reversing elements and transmitting the power developed thereby to the shafts. According to the present invention the difficulties are overcome by constructing the reversing elements to operate on the axial flow as distinguished from the radial flow plan and arranging them outside of the radial flow system. This permits of a good mechanical construction and one that operates with good economy at all times.

If it is made a condition that the power required for reversing shall be developed by means of a single blade ring on each of the

two rotors or elements, which is preferable from a constructional standpoint, the blades should be located at a relatively great radial distance from the axis to provide the high blade speed required. This general arrangement has the advantage that sufficient space is provided for the inner blading used for forward driving, with the result of effectively utilizing the motive fluid under such conditions. The blade elements employed for forward driving may operate wholly on the radial flow principle, or a part of the blading may operate on the radial flow principle, and the remainder on the axial flow principle. The latter arrangement is preferable because of the difficulties of constructing rings of large diameter having axially extending blades of considerable length, and also because of the possibility of mounting the reversing blades directly on and outside of the axial flow blades of the forward driving elements. In this manner the enlarged diameter desired for the reversing blades is readily obtained.

For a consideration of what I believe to be novel and my invention, attention is directed to the accompanying description and claims appended thereto.

In the drawing is illustrated a turbine of my improved construction, wherein Figure 1 is an axial section of a turbine of the combined radial and axial flow type; Fig. 2 is a modification of the reversing portion of the turbine which is velocity compounded; Fig. 3 is a further modification wherein the steam acts by pressure steps or stages on the reversing blades of the two separate rotors, said steps or stages being arranged in series, and Fig. 4 is a further modification permitting of separate control of the two rotors.

4 indicates the turbine casing which is divided in an axial plane in the usual manner. Located in the casing are two elements of rotors 5 and 6, each having a shaft 7, said elements being provided with concentric rows of axially extending high pressure blades 8 that cause the elements to rotate in opposite directions. Surrounding the high pressure blades and mounted on the rotors are rings of intermediate pressure blades 9 which are provided with reinforcing rings 10. Also mounted on the rotors are radially extending low pressure blades 11 that receive steam from the intermediate pressure

blades and through which the steam flows axially into the exhaust chamber 12. The blades 11 cooperate with the radial flow blades to produce rotation of the blade elements and their shafts in opposite directions. The steam is caused to flow right and left to these blades by the annular deflector 13 which has two curved faces 14. The deflector is supported by yielding members 15 so that it is free to expand and contract independently of the outer casing 4. On opposite sides of the curved walls of the deflector and carried by the deflector are stationary blades, nozzles or fluid directing devices 16 which direct the steam from the intermediate blades in its passage to the oppositely revolving low pressure blades 11. Since these latter rotate in opposite directions the working faces must be reversed with respect to each other, and for the same reason the fluid directing devices 16 are reversely disposed.

Surrounding the deflector is a cylindrical wall 17 which cooperates with it to form a steam chest or chamber 18 to which high pressure steam for reversing is admitted by the conduit 19. On opposite sides of the chamber are blades, nozzles or fluid directing devices 20 which are so disposed as to discharge steam in opposite directions. Situated adjacent these devices are radially disposed reversing blades 21 that are supported by the forward driving blades 11. They may be integral with said blades or attached directly thereto or to the rings 22 that surround and inclose their ends. The blades 21 have their working faces reversed with respect to the blades 11 because when active they drive the rotors in the reverse direction. The outer ends of these blades have a suitable covering; such, for example, as a ring or cover 23. By locating the reversing blades 21 in the manner shown on a part of the rotor of large diameter their speed for a given shaft speed will be high which is necessary to give good economy of operation. Furthermore, when the turbine parts are rotating in their normal manner the losses due to windage will be so small that they can be disregarded because they are rotating in an atmosphere of low pressure steam; i. e., a pressure which closely approximates that of the condenser (not shown) which is connected to the exhaust conduit 25. It will also be seen that the flow of exhaust steam from the reversing blades is direct to the condenser, there being no long or complex passages for it to flow through. This assists in improving the economy of the reversing operation. It is important to support the steam chest or chamber 18 by yielding or elastic means, such as the parts 15 for example within the turbine casing, because when the turbine parts are rotating forwardly, as is normally

the case, the walls of the chest are relatively cold; i. e., having a temperature corresponding closely to that of the exhaust steam. On the other hand for reversing the chest is filled with hot steam, usually at boiler pressure, which will cause the same to expand rapidly while the temperature of the turbine casing will not be substantially changed because it is still subjected to the temperature of exhaust steam only. I have shown one type of means for supporting the chest, but the invention is not specifically limited thereto since other means will readily suggest themselves to those skilled in the turbine art.

On opposite sides of the rotors and mounted within the casing are high pressure steam chests 30 and 31. Each of these is provided with an annular groove 31^a so as to form a relatively thin wall 32 to permit the chest to expand and contract independently of the turbine casing to the desired extent. Steam or other elastic fluid is admitted to the chests by the conduits 33. In each chest is a bearing for the rotor shaft. Between the inner faces of the chests and the rotors are labyrinth or equivalent packing devices 34 to prevent the free escape of steam from the chest to the condenser, said means also forming a balancing device to absorb thrust due to the action of the steam in flowing through the working passage formed by the rows of blades. The steam from the chambers 35 in the chests flows through the annular port 36 and thence through the passages 37, of which there are a large number, to the inner part of the blade system from which it flows radially outward to the deflector and thence axially through the radially disposed blade system to the exhaust.

For reversing the conduits 33 are shut off and conduit 19 opened to high pressure. This causes the rotors to revolve in the opposite sense from which they rotated before, due to the action of the reversing blade system.

Fig. 2 of the drawing shows a modification of the invention for use where a lower reversing speed is desired or where the pitch diameter of the reversing blades is such that the blade speed is not sufficiently high to extract the desired amount of energy from the steam in one step. The steam chest is constructed and mounted in the same manner as previously described, but in addition to the stationary fluid discharging devices 20 intermediate stationary blades 37 are provided which are located between rows of reversing blades 21 on the rotors. As shown, each rotor has two rows of blades mounted in any suitable manner, but the number can be greater if desired. If the number is increased additional rows of stationary blades must be provided. With this

arrangement the velocity of the fluid leaving the devices 20 is extracted by successive operations, commonly called velocity compounding, and hence the rotative speed of blade carrying element for a given steam velocity will be less than with the arrangement shown in Fig. 1.

In Fig. 3 is shown a further modification where each rotor has a single row of reversing blades 21, but the steam, instead of flowing in multiple paths from the source to the condenser, flows serially through said blades. In this manner the energy of the steam is extracted by pressure steps or stages, and hence the pressure drop across each device 20 is less. This requires a slight change in the construction of the steam chest. It is provided with the deflector walls 13 and 14 and annular wall 17 as before. In addition it has an annular dividing wall 38 through which the supply conduit 19 extends. This means that the chest has a high pressure chamber 18 delivering steam to the right-hand discharging devices 20 and an intermediate pressure chamber 39 delivering steam to the left-hand discharging devices 20, the path of the steam being indicated by the arrows.

In Fig. 4 is a further modification wherein the steam chest is divided into two parts by an annular perpendicular partition 40 with a supply conduit 41 leading to each of the chambers. This arrangement permits of admitting steam for reversing purposes to one or both of the rotors as desired. In each conduit is a combined throttle and shut-off valve 42.

It will be seen by mounting the reversing blades outside of all the other blades that they occupy a favorable position, both from a mechanical and from a thermo-dynamic standpoint. The structure is simple, accessible, and sufficiently strong to withstand the stresses to which it is subjected. By locating the steam chest in the manner described, one structure serves both as a steam chest and as a deflector. In this manner the total number of parts is reduced. Furthermore its location is such that it may be easily supported; the supply of steam may be readily admitted thereto, and as said structure also carries the stationary fluid directing devices for both the forward driving and reversing blades, it results in a mechanical simplification of the turbine as a whole. The most important features of the reversing arrangements reside in the fact that it does not interfere with the arrangement of the forward driving blade system and cooperating parts, it does not increase the overall length of the turbine, it adds only very slightly to the diameter, and the steam passages are short and very direct.

In accordance with the provisions of the patent statutes, I have described the princi-

ple of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In an elastic fluid turbine the combination of a rotor having an inner radial flow blade system and two outer concentric axial flow blade systems, said radial flow blade system and one of said outer axial flow blade systems being connected in parallel as regards the flow of elastic fluid for driving the rotor in a forward direction, and the other of said axial flow blade systems being for driving the rotor in a reverse direction.

2. In an elastic fluid turbine, the combination of a rotor having an inner radial flow blade system, an outer axial flow blade system, both of said systems driving the rotor in the forward direction, a second axial flow blade system surrounding the first for driving the rotor in the reverse direction, a casing means, and inlet and exhaust conduits.

3. In an elastic fluid turbine, the combination of rotors having concentric rows of axially disposed blades through which the motive fluid flows radially to drive them in opposite directions, radially disposed blades mounted on the peripheries of said rotors and through which the motive fluid flows axially to drive the rotors in the reverse direction, an inclosing casing, and inlet and exhaust conduits.

4. In an elastic fluid turbine, the combination of two rotors, a radial flow system of blading mounted on each rotor, an axial flow system of blading for each rotor arranged outside of said radial system, said systems cooperating to drive the rotors, a second axial flow blading system arranged outside the first for driving the rotors in the reverse direction, an inclosing casing, and inlet and exhaust conduits.

5. In an elastic fluid turbine, the combination of two rotors, a casing therefor, concentric rings of blades arranged to drive the rotors in opposite directions for forward running, an outer axial flow blade system associated with each rotor to assist the radial flow blades, and an axial flow blade system associated with each rotor for reversing its direction of rotation.

6. In an elastic fluid turbine, the combination of two rotors, a radial flow blade system, parts of which are carried by both rotors for forward operation, two axial flow blade systems surrounding the first system, one for each rotor, for reverse operation, a motive fluid supplying means located be-

tween the two axial flow blade systems, a casing inclosing the rotors, and inlet and exhaust conduits.

7. In an elastic fluid turbine, the combination of two rotors, a radial flow blade system, parts of which are carried by both rotors for forward operation, two axial flow blade systems surrounding the first system, one for each rotor, for reverse operation, a fluid supply chest located between the two axial flow blade systems, a casing which incloses the rotors and chest, inlet conduits communicating with the radial flow blade system and the chest, and an exhaust conduit that is common to all of the blade systems.

8. In an elastic fluid turbine, the combination of two rotors, a radial flow blade system, parts of which are carried by both rotors for forward operation, two axial flow blade systems surrounding the first system, one for each rotor, for reverse operation, a fluid supply chest located between the two axial flow blade systems, a casing which incloses the rotors and chest, yielding means for supporting the chest from the casing to reduce the effects of temperature changes, and inlet and exhaust conduits.

9. In an elastic fluid turbine, the combination of two rotors, a radial flow blade system, the parts of which are carried by both rotors, an axial flow blade system, parts of which are carried by both rotors, a second axial flow blade system for reversing, parts of which are carried by both rotors, an annular deflector which directs motive fluid from the radial to the first mentioned axial flow system, stationary blades carried by the deflector, a supply chest that is partially formed by the deflector, stationary blades carried by the chest, said deflector and chest being located between the axial flow blades in the rotors, an inclosing casing, and inlet and outlet conduits.

10. In an elastic fluid turbine, the combination of a pair of rotors bladed for radial

outflow of the fluid, axial flow blades mounted on each of the rotors for reversing, a steam chest arranged between the axial flow blades of the two rotors, and stationary directing devices carried by the chest and through which steam for all of the reversing blades passes.

11. In an elastic fluid turbine, the combination of rotor members bladed for radial flow of the fluid, two outer axial flow blade systems, one for each rotor, and a fluid distributing means arranged between the axial flow blade systems and containing two chambers which are connected through one of the axial flow blade systems.

12. In an elastic fluid turbine, the combination of a pair of rotors having cooperating concentric rows of blades through which the fluid flows radially to drive the rotors in opposite directions, two outer axial flow blade systems associated one with each rotor for reversing, an annular fluid distributor arranged between said axial flow blade system and provided with an inner and an outer fluid chamber which communicate with each other through one of the axial blade systems, a supply conduit communicating with the inner chamber, and an exhaust conduit which receives fluid from the other axial blade system.

13. In an elastic fluid turbine, the combination of two rotors arranged face to face with concentric rows of axially extending blades carried by the rotors and through which the motive fluid flows radially to drive the rotors in opposite directions, reversing blades located outside of said radial flow blades on both rotors for reversing their direction of rotation, means surrounding the radial flow blades for supplying fluid to the reversing blades, inclosing casing means for the rotors, and inlet and exhaust conduits.

In witness whereof I have set my hand this 18th day of September, 1917.

FREDRIK LJUNGSTRÖM.