This invention relates to improvements in exhaust scrolls for turbomachines. It is well known that in axial flow machines, such as turbines and compressors, it is often impractical to receive the discharged fluid in an axial direction. For this reason, exhaust scrolls are generally employed to collect the axially issuing fluid and to redirect it into one or more radial outlet passages. Such exhaust scrolls are often toroidal in shape. In other words, they generally comprise a hollow annular member with a curved wall which directs the fluid radially outward and then axially backward through an arc inscribed in a plane containing the rotor axis. The annulus may then be provided with one or more radial openings, so that the fluid will, in addition, flow tangentially toward the opening and thence radially outward. The two aspects of fluid motion produced by the curved walls of the scroll and by the pressure difference between inlet and outlet to the scroll will, therefore, combine to induce a corkscrew-like movement of the fluid toward the scroll outlet.

It is further known that forcing a fluid to flow in a curved path will cause the static pressure to increase toward the outside of the curve. Also, for the same reason, the presence of a vortex will cause a rise in average static pressure of the fluid around it. When excessive vortex action occurs in an exhaust scroll, the relatively higher static pressure in the scroll demands a higher total pressure at the entrance to the scroll for constant flow, and thereby reduces the efficiency of the turbomachine.

Accordingly, one object of the present invention is to provide an improved exhaust scroll for a turbomachine. Another object of the invention is to provide an improved exhaust scroll which has reduced energy losses therein due to vortices in the fluid within the scroll.

Another object of the invention is to provide a scroll which has a reduced pressure drop, as compared with prior art scrolls of comparable size and shape.

Briefly stated, the invention is practiced by placing inside a scroll of generally toroidal shape a baffle plate which forms a smaller toroidal chamber within the scroll. Most of the vortex action, and hence a higher average pressure, is isolated within this smaller chamber. This promotes an improved flow of the fluid moving with a substantially tangential velocity component toward the scroll outlet.

The organization and operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a schematic transverse view, in cross-section, through the turbine, scroll, and scroll outlet.

FIG. 2 is a cross-sectional view looking in an axial direction along line II—II of FIG. 1, and

FIG. 3 is an axial view, similar to FIG. 2, illustrating a modified form of the invention.

Referring now to FIG. 1 of the drawing, a turbine rotor, shown generally as 1, is disposed within a turbine casing, shown generally as 2. Rotor 1 includes at least one wheel 3 disposed thereon, to which are attached turbine blades 4. Turbine casing 2 includes an annular wall 5 terminating in a radially diverging lip 6. Extending inward from casing 5 are a plurality of radially-extending circumferentially-spaced nozzles 7, having a diaphragm 8 attached thereto which forms close clearances with the shaft of rotor 1. The blade angles of turbine blades 4 are such that, when the rotor is turning at a desired rated speed, the fluid leaves the blades in a substantially axial direction, with very little tangential velocity component.

In order to serve as a collection chamber for fluid leaving blades 4 of the rotor, an exhaust scroll shown generally as 9 comprises a hollow toroidal member enclosing the end of casing 5. Scroll 9 has one peripheral edge 10 thereof sealingly attached around the outer periphery of casing 5 by means of a suitable connection, such as the rabbot and flange fit 11 shown in the drawing.

The other edge 12 of the scroll 9 extends axially and is provided with a suitable rotating seal 13 forming close clearance with the shaft of turbine 1. The axial portion 12 connects with a radial section 14 which is adjacent turbine wheel 3 and then bends in a generally radial and axial direction to provide an annular wall portion 15 which guides fluid issuing from blades 4 in a direction indicated by arrow 16. The annular wall portion 15 thus provides a large chamber in which fluid may flow both in a radial arc as indicated by arrow 16, and also in a tangential direction toward a region of lower pressure (i.e., an outlet). In order to provide an outlet from scroll 9, an exhaust passage 18 is defined by walls 19 extending radially toward and connecting with the curved walls 15. Outlet 18 is connected with suitable piping (not shown) to a region of lower pressure.

The foregoing described construction for an exhaust scroll is more or less conventional and has been in use for many years as a means for collecting and removing fluid from an axial flow turbomachine in a minimum of space with fairly low losses.

In accordance with the invention, a radially and circumferentially extending plate 20 is attached at its inner edge to casing 5, and it extends toward the annular wall 15 of scroll 9 to define an annular opening 21 therewith. The plate divides the scroll into substantially toroidal chambers 17, 22. The proportion of the total radial distance between casing 5 and walls 15 of the scroll which is blocked off by plate 20 depends upon the proportions and size of the scroll and the pressure and velocity conditions of the fluid leaving blades 4. However, it has been found that for obtaining the benefits of the plate 26, it should extend at least half of the radial distance available.

Thus it will be seen that chamber 17, to the right of baffle 20 and communicating with the exit from blades 4, provides a toroidal chamber leading circumferentially to exhaust passage 18 and also communicating with opening 21.

Plate 20, together with a rear wall portion 15B of the scroll and the casing 5, forms a smaller substantially toroidal chamber 22 on the left which will tend to cause a toroidal whirl therein, as indicated by the smaller arrow 23. It will also be observed that the axial dimension of the chamber 23 is roughly the same as the radial dimension, so the chamber 22 can accommodate a true complete "smoke ring vortex," as represented by the arrow 23.

Referring now to FIG. 2 of the drawing, which is a cross-section looking in an axial direction, elements of the turbine and scroll are designated with the same reference numerals as in FIG. 1. Plate 20 is seen to extend the full 360° of the scroll chamber. It will be observed that the fluid in the scroll chambers assumes a tangential flow in either direction toward outlet 18. Arrows 24 represent tangential steam flow in the near end of the larger toroidal chamber 17. Behind plate 20, the steam also assumes tangential flow toward outlet 18.
as indicated by the dotted arrows 25. Although the flow both in front of and behind the plate 20 will have some whirl in radial arcs as it travels tangentially toward outlet 18, the flow behind the plate shown by arrow 25 will have a much higher whirl velocity in a radial arc. Therefore, flow behind the plate is represented by corkscrew-like movement. On the other hand, the flow in front of the plate 20 represented by arrow 24 will have a much lower whirl velocity in a radial arc and therefore is simply designated by smooth arcuate arrows 24.

A modification of the invention may be seen by reference to FIG. 3 of the drawing which, with the exception of the 360° circular plate 19 shown in FIGS. 1 and 2, is an identical scroll and turbine unit with like reference numerals. The radial plate portion of FIG. 3 is designated as 26 and it will be observed that it extends for only 180° around the turbine periphery and it is disposed on the side of the turbine toward scroll outlet 18. The modification of FIG. 3 represents a slightly less efficient (but more economical from a manufacturing standpoint) means of practicing the invention. The efficiency of the scroll with the half-plate 26 added is, however, appreciably improved over a scroll with no plate at all.

It will be observed from FIG. 3 that fluid in the upper half of the scroll chamber has velocity components both in radial and in a tangential direction as indicated by the scroll arrows 27, and that it flows in both directions toward outlet 18. In the lower half of the scroll, the dotted arrows 28 behind plate 26 have a much higher whirl velocity in a radial arc, while the full arrows 29 in front of plate 26 indicate a substantially reduced radial whirl velocity and indicate that the flow is primarily with tangential velocity components toward outlet 18. Hence, the lower half of the scroll shown in FIG. 3 operates in exactly the same manner as the complete scroll shown in FIG. 2. The plate 26 is located toward the outlet 18 since it is here that the higher pressure created in the vortices would most reduce flow from the scroll.

The operation of the invention may be described as follows, referring principally to FIG. 1 of the drawing. It is well known that curvature in a flow stream causes a pressure increase toward the outside of the bend. Although the static pressure on the inside of the bend decreases, the overall static pressure and total pressure at a point in the bend decrease due to the vortex, is increased over the pressure which would exist with no vortex at all.

Since vortices are accompanied by a static pressure increase, it is desirable that such local static pressure rises be isolated from the area adjacent the exit of the turbine blades, thus reducing the "back pressure" on the turbine rotor. While the aerodynamic mechanism by which the plate 20 produces such a substantial improvement in the exhaust scroll 9 is not entirely understood, the following explanation is suggested. The turbine exit angles are so designed with respect to the speed of rotation of the turbine wheel that fluid leaves the blades 4 with negligible tangential component. Therefore, the fluid is forced to turn substantially radially in an axial plane, as indicated by the arrow 16 (FIG. 1). The fluid nearest the arcuate scroll wall 15 enters through space 21 into the smaller toroidal chamber 22. Here it is accelerated into a fairly tight smoke-ring vortex which, due to the lower pressure at outlet 18, moves tangentially toward the scroll with a corkscrew-like motion, as indicated by arrows 25 in FIG. 2. The static pressure increase due to the vortex flow is isolated within chamber 22 and therefore it does not impede the flow of fluid from blades 4. Also, a "wall" of high pressure is formed around the opening 21 which tends to deflect fluid in the larger chamber 17 into a tangential direction. Due to the pressure difference between the turbine exhaust chamber 17 and outlet 18, the fluid to the right of plate 20 (FIG. 1) assumes a relatively large tangential velocity component, and flows toward the outlet 18 substantially unimpeded by any vortex action in chamber 17, in a manner indicated by arrows 24 in FIG. 2. Thus the strong smoke-ring vortex in chamber 22 is isolated from the radial and tangential flow in chamber 17.

The operation of the modification of FIG. 3 is as follows. Although it is desirable that local static pressure rises be kept isolated from the blade outlet around the entire periphery of the turbine casing, this is found to be most important near the exit of the scroll, i.e., in the lower half of the scroll of FIG. 3. Therefore, a substantial improvement is also derived by employing a plate 30 over only the lower half of the scroll, with resulting economies in manufacture.

Of course, it will be apparent that the outer periphery of plate 20 is not necessarily circular, but could be elliptical or have a section removed. Also the outer scroll chamber bounded by walls 15 could vary in cross-section somewhat from the shape shown in the drawings.

The foregoing arrangements have resulted in significant improvement in exhaust scrolls of the type shown without at all increasing the size or proportions of the exterior of the scroll. The primary advantage, i.e., lower pressure drop through the scroll from turbine stage outlet to the scroll outlet, appears to improve with increasing axial fluid velocity. For example, existing scrolls modified with the full 360° plate 20 of FIGS. 1 and 2 have shown a 35% decrease in pressure drop through the scroll for steam leaving the blades at an axial Mach number of .10. There is more improvement at higher Mach numbers.

For example, at Mach .17, there is a 37% decrease in scroll pressure drop. Thus, by relatively minor structural changes, exhaust scrolls of existing turbines can be modified by adding the simple plates shown in FIGS. 1 through 3.

As will be evidenced from the foregoing description, certain aspects of the invention are not limited to the particular details of the construction illustrated, and it is contemplated that modifications other than those shown and described will occur to those skilled in the art. Therefore, it is intended that the appended claims shall cover all such modifications as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An axial flow turbomachine, the combination of: a casing with a rotor therein and terminating in a lip circumscribing an annular discharge passage coaxial with said rotor, a substantially toroidal exhaust scroll disposed coaxial with said casing and surrounding the discharge end thereof and having an arcuate end wall with portions radially and axially spaced from said lip of the casing to define a first annular opening into the scroll, means providing a radial discharge opening from said scroll, and a radial circumferentially extending plate disposed within the scroll axially spaced from said lip on the outer periphery of said casing and extending radially toward said arcuate wall for at least half of the radial space between said casing and said arcuate scroll end wall to define second opening with the scroll wall, said plate dividing the scroll into a first substantially toroidal chamber fed from the first opening and a second substantially toroidal chamber supplied through said second opening from the first chamber, whereby the pressure created at the second opening due to a vortex in the second chamber is isolated from said first opening.

2. In a turbomachine, the combination of: an axial flow turbine section comprising a turbine casing and a turbine rotor disposed therein, said casing having an open end and defining a radially diverging lip, an exhaust scroll comprising a hollow toroidal member coaxial with said casing and having a first peripheral edge sealingly engaging the outside of said tur-
bine casing and spaced axially upstream from said lip, said scroll also having a second peripheral edge forming close clearances with the turbine rotor, said scroll including a continuous arcuate wall radially and axially spaced from said lip and connecting said peripheral edges, the lip and the arcuate wall defining therebetween a first annular opening into the scroll, means providing a radial exhaust passage from said scroll, and

a radial circumferentially extending plate disposed within the scroll on the outer periphery of said casing axially spaced from the terminating edge of said lip and extending radially toward said arcuate wall for at least half the radial space between said casing and said wall to define a second opening with the arcuate wall which is separated from said first opening, said plate dividing said scroll into a first toroidal flow chamber fed from the first opening and a second toroidal flow chamber fed through the second opening from the first chamber, whereby the pressure created across the second opening due to a vortex in the second chamber is isolated from the first opening.

3. The combination according to claim 2 wherein said radial plate extends circumferentially 360° around the entire turbine casing.

4. The combination according to claim 2 wherein said plate extends through an arc of the order of 180° and is disposed on the side of the turbine casing toward the exhaust passage.

5. In a turbomachine, the combination of:

an axial flow elastic fluid turbine section comprising a substantially cylindrical turbine casing terminating in an annular lip circumscribing a first annular exit opening,

a turbine rotor disposed in said casing coaxial therewith and including an axially-extending shaft portion with a plurality of turbine blades arranged to discharge fluid from the first opening,

an exhaust scroll comprising a hollow toroidal member coaxial with the casing and having a first peripheral edge engaging the turbine casing around a portion thereof axially spaced upstream from said first opening, said scroll also having a second inner peripheral edge forming close clearances with the turbine shaft, said scroll also including an arcuate wall commencing adjacent the radially innermost parts of the turbine blades, and terminating adjacent said first peripheral scroll edge, said arcuate wall being both axially and radially spaced from the turbine casing lip, means providing a radial discharge opening from said exhaust scroll, and

a radial circumferentially extending baffle disposed within the scroll on the outer periphery of said casing around a portion thereof axially spaced upstream from the turbine casing lip and extending radially toward the arcuate scroll wall for at least half the radial space between casing and scroll wall to define a second opening with the scroll wall, said arcuate scroll wall defining with the casing and baffle a first toroidal chamber fed with fluid from said first opening and directing a portion of the fluid through said second opening, the baffle, the arcuate scroll wall, and portions of the turbine casing also defining together a second smaller toroidal chamber within the scroll and arranged to conduct fluid tangentially toward the scroll exhaust passage in a smoke-ring vortex flow pattern, whereby local vortex-induced static pressure increases at the second opening are substantially isolated from the first opening.

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