Sept. 22, 1959 W. H. NICHOLSON 2,904,962

CASINGS FOR ELASTIC FLUID UTILIZING APPARATUS

Filed Nov. 8, 1956 3 Sheets-Sheet 1

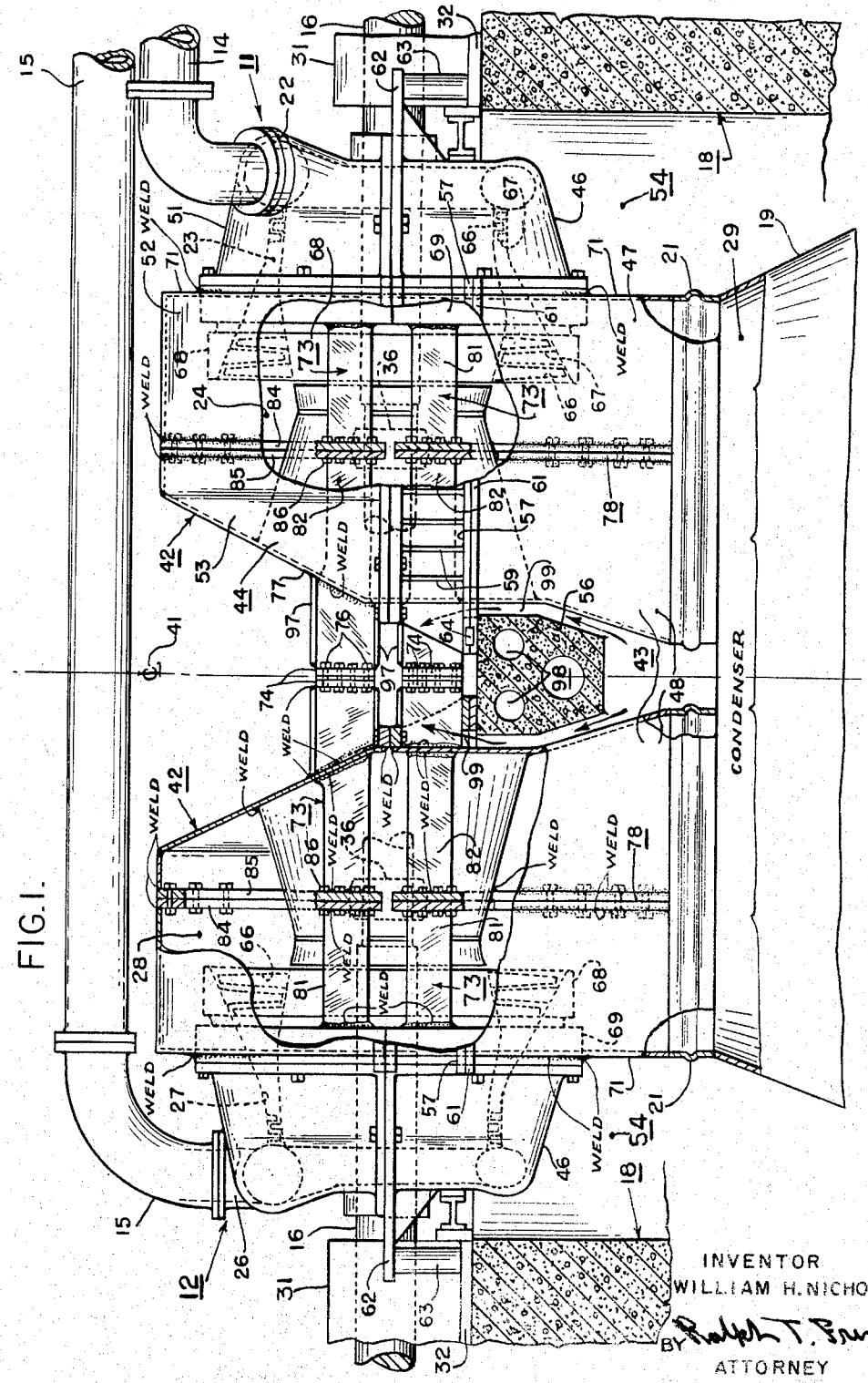


FIG. 1.

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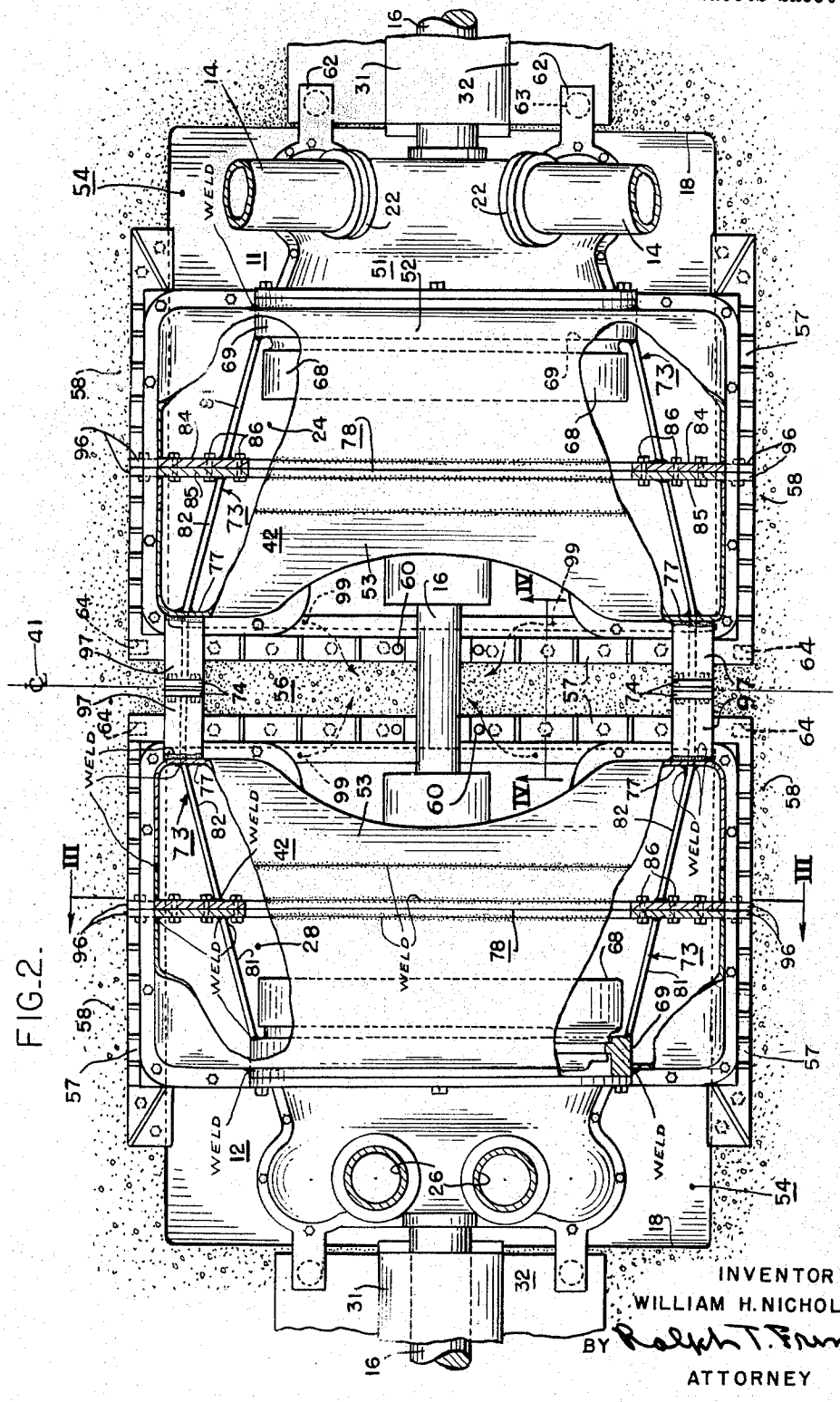


FIG. 2.

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FIG. 4.

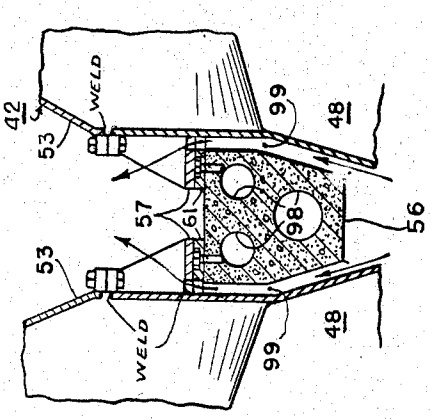
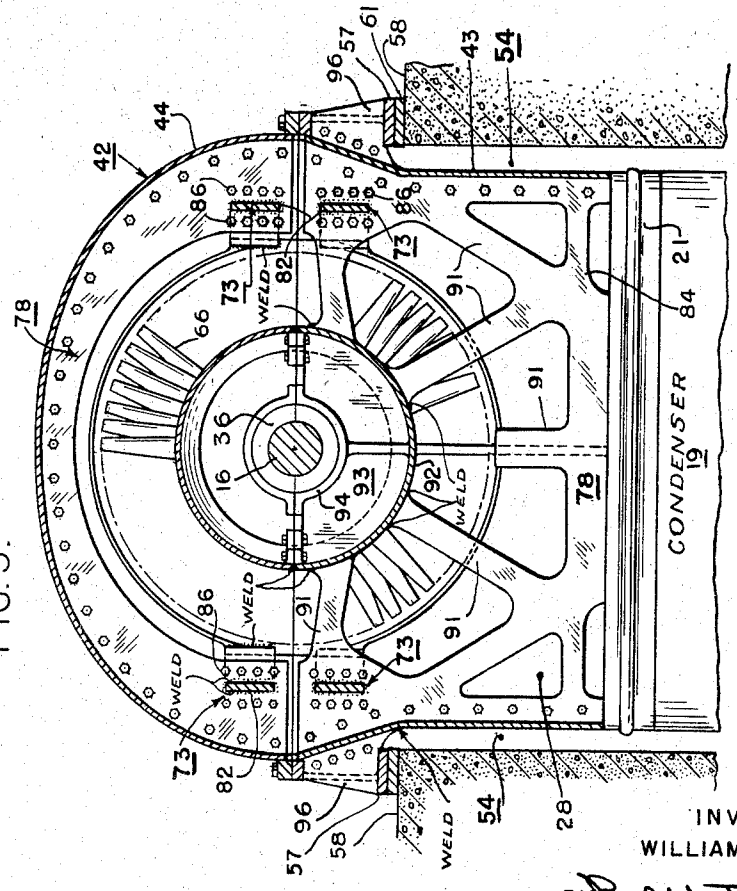


FIG. 3.



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2,904,962

CASINGS FOR ELASTIC FLUID UTILIZING APPARATUS

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Application November 8, 1956, Serial No. 621,090

6 Claims. (Cl. 60—102)

This invention relates to casings for elastic fluid utilizing devices and in particular to an arrangement of casings for a plurality of steam turbines.

Steam turbine power plants, especially those constructed for central stations have, in the interest of economy, been constructed to operate so that the last turbine in the cycle exhausts at the lowest pressure practicable. This has been achieved by condensing the steam in a condenser after it leaves the last row of turbine blades so that the reduction in volume from steam to water creates a vacuum. In such a power plant one of the limiting features upon the maximum power output of the turbine unit, for a given vacuum, is the cross-sectional area of the annulus defined by the last blade row in the blade path because of the large volume of steam for a given vacuum pressure. In view of the foregoing, it has been the tendency to design turbines which operate at a vacuum with last blade rows of larger and larger diameter, resulting in larger and larger casings.

It has been a common practice heretofore to utilize as the turbine which exhausts to the condenser, one constructed with a divided flow path. The divided flow path is constructed so that, with respect to the longitudinal axis of the turbine, the steam enters in the center, divides, and flows towards both ends of the turbine. At both ends of the turbine suitable exhaust annuli have been provided in communication with the condenser.

In the foregoing arrangement, as the diameter of the last turbine blade row is increased, the weight of the turbine components becomes greater than a crane of practical size can handle. In addition, the length of the turbine becomes such that serious shipping problems may arise.

In view of the foregoing, it has been proposed to divide the turbine exhausing to the condenser into two separate elements. But in such a construction additional bearings and associated elements would be required. Consequently, the distance between exhaust annuli would become such that the condenser would require two separate chambers, one in communication with each exhaust annulus. When such plural chambers are used, complicated expansion joints are usually required to allow for relative movement between the turbine and the condenser.

In view of the foregoing, it is an object of the present invention to provide an arrangement of turbines exhausting to a common condenser, resulting in turbines which can be easily handled by cranes of practical size and shipped without difficulty.

It is a further object to provide suitable supporting structure for a plurality of turbines of the foregoing type.

Another object of the present invention is to control the reaction forces imposed on the turbine casings.

It is another object to provide an arrangement of turbine casings such that the movement of one casing relative to the other is controlled.

One embodiment of the present invention is adapted to be utilized with a pair of turbine casings disposed in tandem. Each casing encloses a plurality of low pressure blades so arranged with respect to those in the other casing that in normal operation one casing tends to separate from the other casing. Each casing is provided with a plurality of tie bars which connect the casings to each other so that their relative movements may be controlled in a predetermined manner.

The foregoing and other objects are effected by the invention as will be apparent from the following description taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a side elevational view illustrating the present invention as applied to a pair of low pressure turbine casings, with a portion of each of the casings cut away to show details of interior construction;

Fig. 2 is a plan view of the apparatus illustrated in Fig. 1 wherein portions of the casings are cut away;

Fig. 3 is a sectional view, taken along the line III—III of Fig. 2, looking in the direction indicated by the arrows; and,

Fig. 4 is a fragmentary sectional view of a portion of the structure shown in Fig. 1.

Referring to the drawings and in particular to Figs. 1 and 2, there is illustrated a steam turbine **11**, disposed on the right-hand side in each figure, and a similar turbine **12**, disposed on the left-hand side. The turbines **11** and **12** are of the type commonly referred to as low pressure turbines for use in central station power plants. The steam supplied to such turbines is usually at a moderate pressure of about 50 pounds per square inch absolute and is exhausted from the turbines at a vacuum of about one inch of mercury absolute.

The turbines **11** and **12** are disposed in tandem, that is, they are disposed along a common longitudinal axis. Steam is supplied to turbines from a source (not shown) located to the right of the turbine **11**. The source may be a turbine designed for operation at intermediate pressures; in other words, a turbine which exhausts steam at a pressure of about 50 pounds per square inch absolute. The steam is supplied to the turbines **11** and **12** by means of conduits **14** and **15**. Disposed to the left of the turbine **12** may be a generator, (not illustrated), adapted to be driven by a rotor aggregate **16** including interconnected individual rotors associated with the turbines **11** and **12**. The rotor aggregate **16** extends along the common longitudinal axis of the turbines **11** and **12** and may be connected to additional turbines, not illustrated, which may be disposed to the right of the turbine **11**, such as the intermediate pressure turbine hereinbefore mentioned. For the sake of clarity, however, in Fig. 1, the portion of the rotor between turbine **11** and turbine **12** has been omitted.

The turbines are supported by a foundation **18** hereinafter referred to in greater detail and are connected to a common condenser **19** by means of expansion joints **21**.

The turbine **11** is provided with inlets **22** at the right-hand end leading to flow path **23**, the latter being in communication with an exhaust annulus **24** located at the left-hand end of the turbine **11**. The turbine **12** is similarly provided with inlets **26** but in this instance, the inlets **26** are located at the left-hand end and lead to a flow path **27**, the latter being in communication with an exhaust annulus **28** at the right-hand end of the turbine **12**. The lower portions of the exhaust annuli **24** and **28** are in communication with a common chamber **29** located in the top portion of the condenser **19**.

The rotor aggregate **16** is supported by a plurality of pairs of bearings. The first pair comprises one bearing placed within a housing **31**, supported on a pedestal **32**, at the right-hand end of the turbine **11** and another bearing placed within a similar housing **31** supported on a similar pedestal **32**, at the left-hand end of turbine **12**. The second pair comprises bearings **36**, one encompassed by the annular exhaust space **24** and the other encom-

passed by the annular exhaust space 28 (Figs. 1 and 3).

The turbines 11 and 12 are constructed essentially symmetrically about a transverse centerline 41. In other words, the turbines 11 and 12 are of similar construction except for elements not material to this invention and with the further exception that the flow path in one turbine is in a direction opposite to that of the flow path in the other turbine. In view of the foregoing, the subsequent description will, in the interests of clarity and brevity, be restricted to a detail description of turbine 11, but it will be understood that corresponding members are to be found in turbine 12.

The turbine 11 is provided with a casing 42 which is divided along an axial horizontal plane into a base 43 and a cover 44. The base 43 is divided along vertical planes into an inlet portion 46, an intermediate portion 47, and an exhaust portion 48. The cover is similarly divided along the same vertical planes into an inlet portion 51, an intermediate portion 52, and an exhaust portion 53.

The base of the turbine 11 is disposed within an opening 54 defined by the foundation 18 and a transverse beam 56 and is provided with a soleplate 57 of approximately U-shape in a horizontal plane, as viewed in Fig. 2. A liner 61 of the same shape as the soleplate may be interposed between the soleplate and the foundation. The base of the U of the soleplate is positioned by dowels 60 and keys 64. The dowels 60 are placed on both sides of the rotor 16, as viewed in Fig. 2, and the keys 64 are placed at both ends of the transverse beam. In this manner the legs of the U are free to expand and contract transversely and axially. The soleplate is secured to the casing base by vertical webs or struts 59.

At the inlet end the base is provided with feet 62 resting upon columns 63 supported by the pedestal 32. The pedestal 32 is provided with keys (well known in the art and not illustrated) allowing the turbine casing to expand and contract along the longitudinal axis of the turbine.

The rotor is provided with a plurality of rotating blades 66, only a portion of the latter being shown, in dotted lines, in Fig. 1. The inlet portions 46 and 51 of the base and cover, respectively, support a plurality of stationary blades 57 cooperating with the rotating blades. Additional stationary blades 67 are supported by a blade ring 68. The blade ring 68 is secured to a support ring 69 by means well known in the art. The support ring 69 is welded to a transversely-extending plate 71 which defines end walls of the intermediate casing portions 47 and 52.

With the turbines 11 and 12 arranged in the foregoing manner, the flow of steam through the stationary blades and the pressure forces on the casing will result in forces being applied to the two turbine casings which are approximately equal in magnitude, but opposite in direction, thus tending to separate the casings.

In order to control the tendency of the turbine casings to separate one from the other, a plurality of tie bars or tension plates 73 are provided. The tie bars or tension plates connect one casing to the other casing in such a manner that the forces which are imposed upon one casing will tend to balance those upon the other casing. In this instance, each casing is provided with four tie bars 73. Two of the tie bars are disposed on one side of the longitudinal axis of the casing and two on the other side. One of the two tie bars on each side is disposed above the horizontal joint and one below. Each tie bar is disposed with a major portion of its longitudinal axis at an oblique angle to the longitudinal axis of the turbine casing and rotor (Fig. 2). Each tie bar is secured to the support ring 69 at one end. At the other end, each tie bar is secured by a flange 74 and suitable bolts and nuts 76 to the corresponding tie bar of the other casing.

The tie bars are partly disposed within the exhaust

annulus 24 or 28 and partly in the space between the two casings. Each tie bar passes through an end wall 77 of the exhaust end of the turbine casing. Suitable welding secures the tie bar to the end wall 77 and also prevents leakage of air into the exhaust annulus. Between the end wall 77 and the support ring 69 the tie bars are secured to an internal frame member or flange 78. At the frame member 78 the tie bar is divided into two portions 81 and 82. The frame member 78 comprises two portions 84 and 85, frame portion 84 being welded to the casing intermediate portions 47 or 52 and frame portion 85 to the casing exhaust portions 48 or 53. Referring to turbine 11, the right hand part of the tie bar 81 is welded to the right hand portion of the frame member 84. Similarly, the left hand portion 82 of the tie bar is welded to the left hand portion 85 of the frame member. In order that the forces may be transmitted from one portion of the tie bar to the other, the right and left hand portions of the frame member are joined, in the vicinity of the tie bars, by bolts and nuts 86.

Referring to Fig. 3, the frame member is divided in the plane of the horizontal centerline. The portion above the horizontal centerline is formed as an arc, and adds strength to the outer wall of the turbine casing. The lower portion of the frame is formed as a truss, in that it is provided with approximately radially extending fingers or struts 91 which are welded to a semi-circular member 92 encompassing the bearing 36. The semi-circular member 92 is welded to a similarly shaped plate 93, the latter being connected to a housing 94 enclosing the bearing 36. The truss portion of the frame is provided with feet portions 96 sliding onto the soleplate. Thus the truss provides a support for that portion of the rotor load taken by the bearing 36.

As illustrated by Fig. 2, the major portion of each tie bar has a longitudinal axis which is at an oblique angle to the longitudinal axis of the turbine. This oblique angle is provided so that one end of the tie bar may be connected to the support ring and yet be as far removed as practical from the main portion of the fluid stream within the exhaust annulus. It is advisable to secure the support ring to the tie bar as the majority of the forces tending to separate the turbines originate as a result of the reaction forces of the stationary blades. If the tie bars extended from the support ring 69 in parallel relation to the longitudinal axis in the casings they would constitute obstructions in the flow path in close proximity to the last blade row which might excite undesirable vibrations in the blades of the last row. In addition, undesirable flow disturbances might be set up in the exhaust annulus which might impair the efficiency of the turbine. For this reason, the angle is made as oblique as possible to place the tie bars out of the flow path as much as practical. Thus, referring to turbine 11, the left hand portion of the tie bar 82 extends through the end wall of the casing at a location which is as far removed from the rotor as feasible. Those portions of the tie bars which are outside of the casings are parallel to the axis of the turbines, and are reinforced by top and bottom flanges 97 (Fig. 1).

The transverse beam 56 on which a portion of the soleplate 57 and liner 61 rests is so constructed that its temperature may be controlled and maintained within a safe operating range. The beam is constructed with a plurality of passages 98 extending longitudinally thereof and transversely of the turbine axes. A cooling fluid, such air or other medium, may be circulated through the passages 98 by suitable means not herein illustrated. Additional cooling of the transverse beam may be effected by the provision of spaces 99 between the beam and the adjacent turbine casings for passage of cooling medium in a generally vertical direction, as illustrated by the arrows in the drawings.

The foregoing construction provides an arrangement

of turbines wherein the equal and opposite forces upon the casings are effectively balanced by means of the tie bars. In addition, by being able to separate each turbine into three parts, longitudinally, the size of each component is such that shipment is facilitated and handling by conventional power house cranes is feasible.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. In elastic fluid turbine apparatus, the combination of first and second turbine casings disposed in tandem, each of said casings enclosing a fluid flow path in which the direction of flow is towards the other casing and reaction forces induced by the flow urge the casings away from each other, a support ring secured to each of said casings, a first group of longitudinally-extending tie bars secured at one end to one of said support rings and extending towards the other casing, a second group of longitudinally-extending tie bars secured at one end to the other of said support rings and extending towards the first casing, and means securing the extended ends of the tie bars of the first group to the corresponding extended ends of the tie bars of the second group.

2. In elastic fluid utilizing apparatus, the combination of a first casing and a second casing arranged in tandem, each of said casings enclosing a fluid flow path in which the direction of fluid flow is towards the other casing whereby a reaction force is produced tending to move each casing away from the other casing, a first support member secured to said first casing, a second support member secured to said second casing, a first tension plate secured to said first support member and extending towards said second casing, a second tension plate secured to said second support member and extending towards said first casing, and means securing said first tension member to said second tension member.

3. In elastic fluid turbine apparatus, a first turbine casing and a second turbine casing arranged in tandem, each casing being subjected to an equal and opposite force, a first annular element attached to said first casing, a second annular element attached to said second casing, a first tie plate secured to said first annular element and extending towards said second casing, a second tie plate secured to said second annular element and extending towards said first casing, a connection between said first tie plate and said second tie plate, a first frame secured to said first casing and to said first tie plate intermediate said first annular element and said connection, and a second frame secured to said second casing and to said second tie plate intermediate said second annular element and said connection.

4. In elastic fluid turbine apparatus, the combination of first and second turbine casings arranged in tandem, each of said casings enclosing a fluid flow path in which the direction of fluid flow is towards the other casing, whereby each casing is subjected to a force tending to move it away from the other casing, a first support ring attached to said first casing, a second support ring attached to said second casing, a first tension plate having a first end portion secured to said first support ring and having a second end portion extending towards said second casing, a second tension plate having a first end portion secured to said second support ring and having a second end portion extending towards said first casing, means connecting said second portions of said tension plates, and said tension plates being disposed at oblique angles to the longitudinal axis of said turbine casings.

5. In elastic fluid turbine apparatus, first and second turbine casings arranged in tandem, each of said casings enclosing a fluid flow path in which the direction of fluid flow is towards the other casing, whereby each casing is subjected to a force tending to move it away from the other casing, each casing comprising a base and a cover, a first support ring attached to said first casing, a second supporting ring attached to said second casing, first and second pairs of tension plates, each plate of said pairs having one end portion secured to said first support ring and having a second end portion extending towards said second casing, third and fourth pairs of tension plates, each plate of said third and fourth pairs having one end portion secured to said second support ring and having a second end portion extending towards said first casing, said first and third pairs of tension plates being disposed in the covers of said first and second turbine casings, respectively, said second and fourth pairs of tension plates being disposed in the bases of said first and second turbine casings, respectively, connections between said second portions of said first and third pairs of tension plates and between said second and fourth pairs of tension plates, and said tension plates being disposed at oblique angles to the longitudinal axis of said turbine casings.

6. A turbine including a casing divided intermediate its ends in a transverse plane into an upstream portion and a downstream portion considered in the direction of flow of motive fluid therethrough, said casing portions having mating internal flanges defining a transverse joint, a supporting ring secured to the upstream end of the casing upstream portion, a first tie bar portion secured at opposite ends to the supporting ring and to the internal flange of said casing upstream portion and bridging the space therebetween, a second tie bar portion secured at opposite ends to the internal flange of the casing downstream portion and to the downstream end of said casing downstream portion and bridging the space therebetween, said tie bar portions being substantially aligned longitudinally, means joining said internal flanges adjacent their connections with said tie bar portions whereby said tie bar portions function as a single continuous tie bar, and anchoring means secured to the downstream end of said second tie bar portion, whereby forces imposed on the supporting ring may be transmitted through the tie bar to an external anchor.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,904,962 September 22, 1959

William H. Nicholson

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 44, for "blades 57" read -- blades 67 --; column 4, line 68, after "such" insert -- as --; column 6, line 51, after "portion" insert -- externally of said casing downstream portion --.

Signed and sealed this 8th day of March 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents