Oct. 29, 1968 J. J. HART 3,408,045

TURBINE NOZZLE SEAL STRUCTURE

Filed June 28, 1966 3 Sheets-Sheet 1

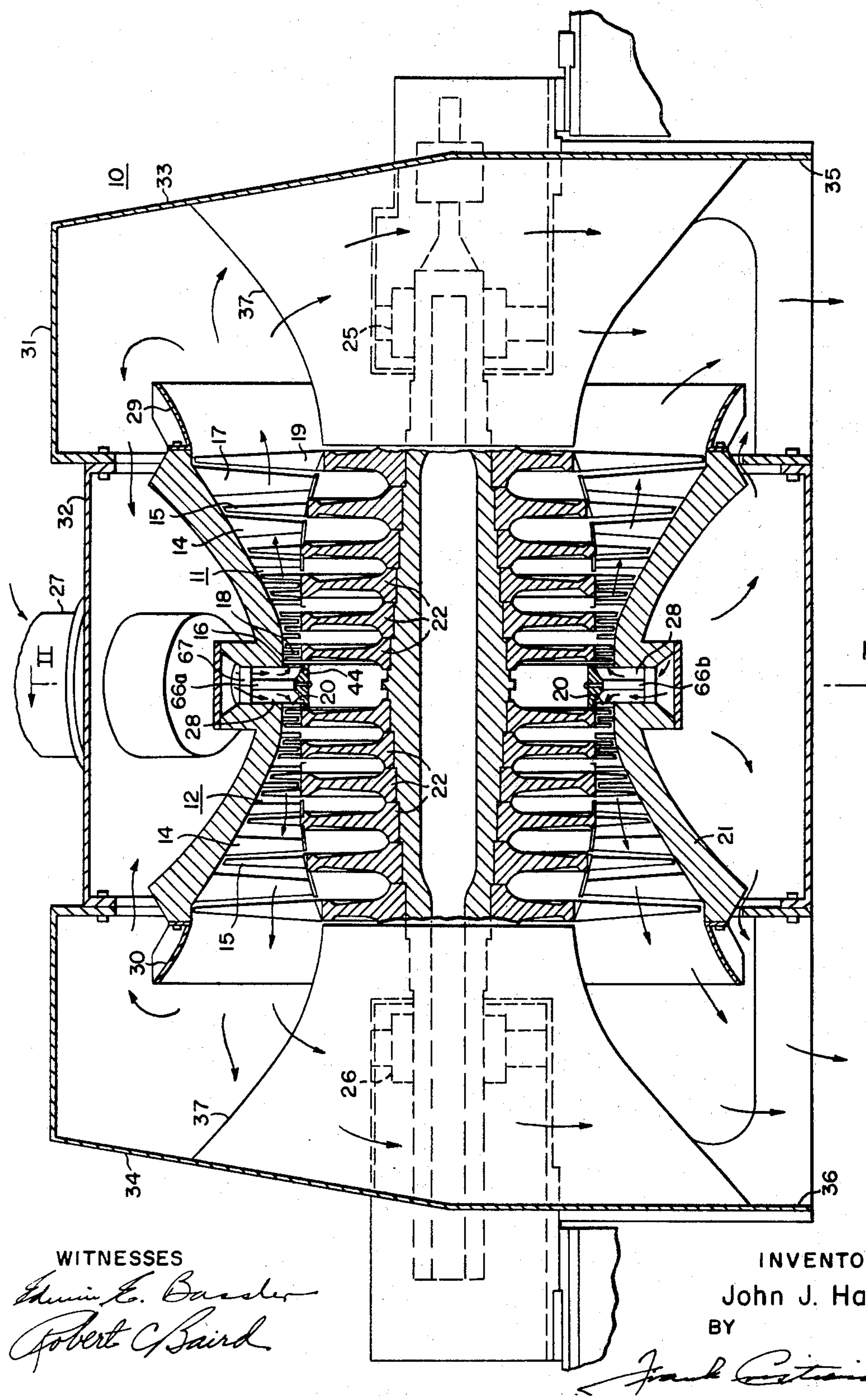

FIG. I.

WITNESSES

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TURBINE NOZZLE SEAL STRUCTURE

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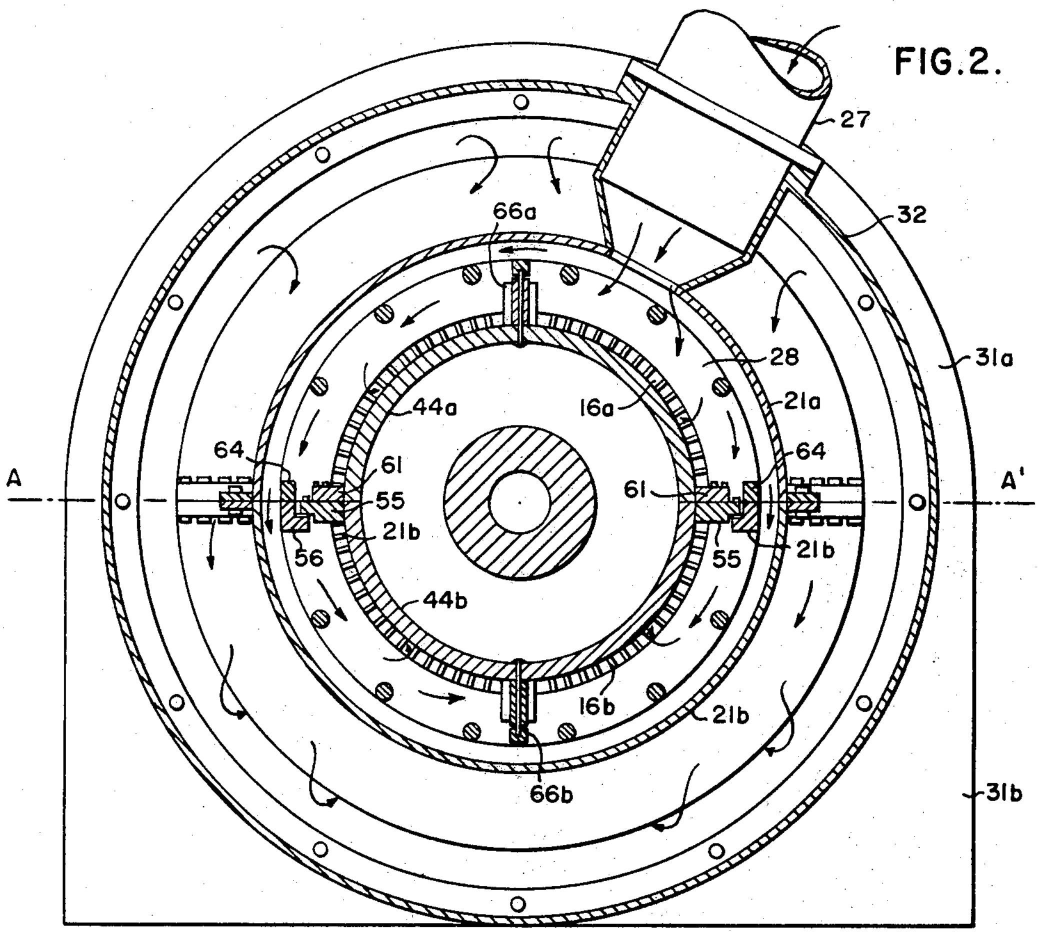
FIG. 2.



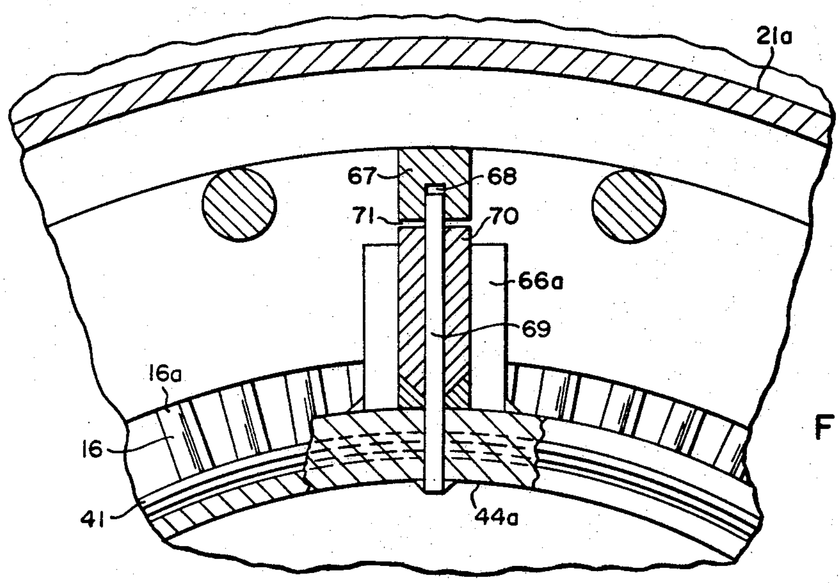


FIG. 3.

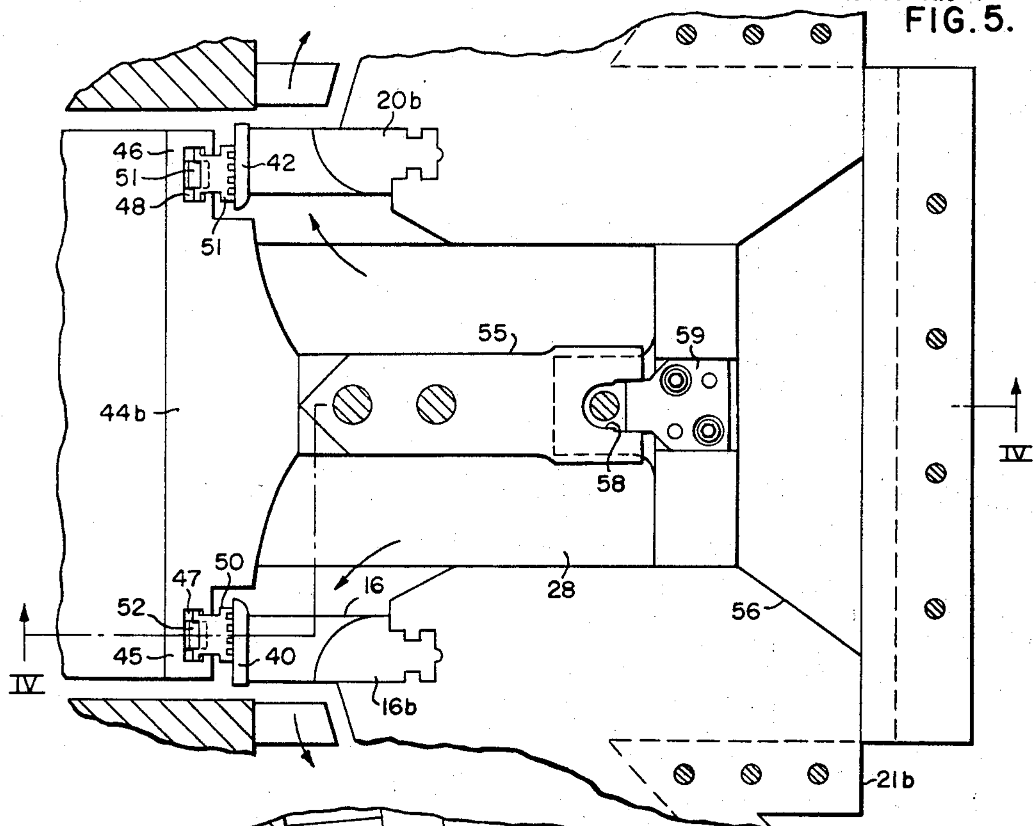


FIG. 5.

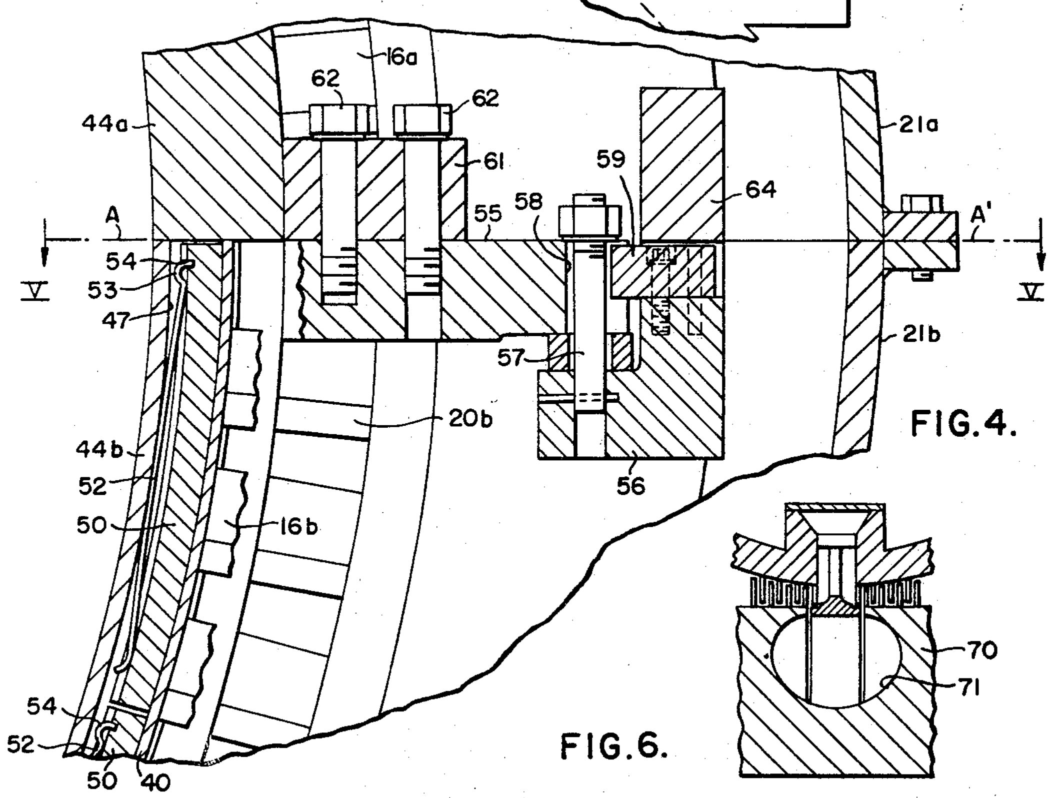


FIG. 4.

FIG. 6.

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TURBINE NOZZLE SEAL STRUCTURE

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ABSTRACT OF THE DISCLOSURE

This invention provides an improved sealing arrangement for the rows of nozzle vanes of the two opposed first expansion stages of a double opposed axial flow turbine. The above nozzle vanes are mounted in the turbine casing structure and are provided with annual shroud members at their radially inner ends. The two nozzle vane rows are axially spaced and jointly with the casing structure partially define an annular motive fluid inlet space. An annular wall member spans the inlet space and is provided with peripheral marginal portions disposed in lapping relation with the associated shroud members, but spaced radially inwardly therefrom. The two annular spaces thus formed are individually sealed by an annular array of preferably arcuately segmented seal members interposed therein and disposed in slidable sealing relation with the shroud and marginal wall portion.

This arrangement permits relative thermal expansion of the components to occur in both axial and radial directions with minimal stressing of the components.

This invention relates to elastic fluid turbines, more particularly to double opposed axial flow turbines, and has for an object to provide improved apparatus of this type.

Turbines of the above type have expansion stages arranged to extract motive power to rotate the rotor from motive fluid admitted to a central portion of the turbine and thence directed in opposed axial directions through the stages to the exhaust outlets. One of the principal advantages of the above described turbine arrangement is that the axial thrust on the rotor due to the fluid expansion in one axial direction is substantially opposed and balanced by the axial thrust due to the fluid expansion in the opposite direction.

However, the first stage nozzle vanes are disposed in axially spaced relation with each other and jointly form (in part) an annular space for the entering fluid that is directed thereto through the casing structure by a suitable inlet conduit structure. To form the inner circular periphery of the inlet fluid space, an annular inner wall member or band has heretofore been provided of sufficient axial extent to span the space, and the band has been rigidly fastened to the annular shrouds carried by the first stage nozzle vanes by bolting, welding or equivalent means to provide a leakproof joint.

The above arrangement has been generally satisfactory although difficult to manufacture and assemble. Further, due to the rigid connection of the inner wall member to the nozzle vane shrouds, when the turbine is motivated by hot elastic fluid such as gas or steam, for example, thermal expansion of the components is transmitted through the rigid connections, giving rise to undesirable thermal stresses.

It is a primary object of this invention to provide an arrangement, in a double opposed axial flow hot elastic fluid turbine, in which the annular inner wall member that partly defines the annular inlet motive fluid space is cooperatively associated with the nozzle vanes of the two opposed first expansion stages in a manner to provide a substantially leakproof seal while permitting thermal expansion of the associated components to occur without the imposition of undue thermal stresses.

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Another object is to provide an arrangement of the above type in which the inner wall member is free to expand and contract but is maintained in a centered position.

A further object is to provide an arrangement in accordance with the above objects that is relatively simple in structure, easy to manufacture and readily assembled and/or serviced.

Briefly, in accordance with the invention, the opposed first rows of expansion nozzle vanes in a double opposed axial flow turbine are mounted in the inner casing structure of the turbine and provided with annular shroud members at their radially inner ends. The two axially spaced rows of nozzle vanes, together with the inner casing structure partially form an annular motive fluid space. The hot motive fluid is admitted to the space by conduit structure extending radially through the casing structure.

An annular inner wall member is provided of sufficient axial width to span the inlet fluid space and having peripheral marginal portions disposed in lapping relation with the associated shroud members but spaced radially inwardly therefrom to a small degree. The two annular spaces thus formed are individually sealed by an annular array of preferably arcuately segmental seal members interposed therein and disposed in sealing realtion with the inner surface of the associated shroud structure and the outer surface of the marginal wall portions. The seal members are preferably metallic, and each array is seated in an annular recess provided in one of the surfaces and biased by spring members into engagement with the other of the surfaces.

In operation, as hot motive fluid is admitted into the inlet space, the annular wall member and sealing structure is effective to substantially prevent leakage of fluid around the first rows of nozzle vanes, and as the shrouds, nozzle vanes, inner casing and inner wall members are heated by the fluid, thermal expansion in both axial and radial directions is free to occur with minimal stressing of the components, since the shrouds are not connected to each other and the inner wall member is not connected to the shrouds.

To prevent any tendency of the annular wall member to rotate and to maintain the annular wall member in centered relation with the associated shroud structure, the annular wall member is connected to the inner casing structure by a plurality of radially extending strut members.

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

FIGURE 1 is an axial sectional view, taken in a vertical plane, of a central admission, double opposed flow turbine incorporating the invention;

FIG. 2 is a transverse sectional view taken on line II—II of FIG. 1;

FIGS. 3 and 4 are enlarged fragmentary views showing portions of the structure illustrated in FIG. 2;

FIG. 5 is a view taken on line V—V of FIG. 4; and

FIG. 6 is a fragmentary view, on a scale similar to FIG. 1, illustrating a modification of the invention.

Referring to the drawings in detail, in FIG. 1 there is illustrated a central admission double opposed axial flow turbine **10** having a first set or plurality of stages **11** for expanding fluid in one axial direction and a second set or plurality of stages **12** for expanding fluid in an opposite axial direction. As well known in the art, each expansion stage comprises an annular row of stationary nozzles or vanes, such as vanes **14**, cooperating with and immediately preceding an annular row of rotatable blades, such as the blades **15**. The stationary nozzles in the first set of stages **11** increase in radial length progressively from the first row of expansion stage nozzles **16** to the last row of expansion stage nozzles **17**, and, similarly, the rotatable blades in the first set of stages **11** increase in radial length progressively from the first row of expansion stage blades **18** to the last row of expansion stage blades **19**. The second set of stages **12** are similar to the first set of stages **11** described above, and includes a first row of expansion nozzles **20** of the same radial length as the first row of nozzles **16**.

The stationary nozzles are retained in an inner tubular casing structure **21**, while the rotatable blades are carried by rotor discs **22** attached to a rotor shaft **23** disposed concentrically within the inner casing **21** and rotatably supported at its end portions by suitable bearings **25** and **26**.

A suitable inlet conduit structure **27** is provided for directing hot motive fluid to an annular chamber or space **28** in the inner casing **21** and thence in opposite axial directions through the axially spaced first rows of nozzles **18** and **20** for expansion in the first and second sets of stages **11** and **12**, respectively.

After expansion, the motive fluid is exhausted through opposite annular outlet members **29** and **30** attached to the inner casing structure **21** in any suitable manner.

The entire structure described thus far is enclosed in an outer casing structure **31** comprising a central tubular outer casing portion **32** disposed in spaced encompassing relation with the inner casing **21** and a pair of oppositely disposed end portions or hoods **33** and **34** disposed in spaced encompassing and enclosing relation with the exhaust outlet members **29** and **31**, respectively, and having openings **35** and **36** for further directing the expanded motive fluid in a downward direction to a region of lower pressure, such as a lower pressure turbine or a fluid condenser (not shown).

The exhaust hoods **33** and **34** may be provided with centrally disposed annular fairing members **37** and **38** to enhance the flow characteristics of the hoods and permit the exhausting fluid to flow smoothly and with a minimum of turbulence therethrough to the outlets **35** and **36**.

As thus far described the structure is substantially conventional, and further, as well known in the art the stationary components may be divided along a horizontal axial plane A–A', as indicated in FIGS. 2 and 4, to facilitate assembly and servicing. As shown in FIG. 2, the outer casing **31** is divided into upper and lower casing portions **31***a* and **31***b*, the inner casing **21** is divided into upper and lower casing portions **21***a* and **21***b*, and the stationary nozzle rows including the first rows of nozzles **16** and **20** are divided into upper and lower semi-circular half portions **16***a*, **16***b* and **20***a*, **20***b*, respectively.

In accordance with the invention, to permit expansion without imposing thermal stresses on the first row of nozzles **16** and **20** to prevent leakage of the hot motive fluid therepast during operation, the upper and lower first nozzle halves **16***a* and **16***b* are formed as integral and substantially identical halves, and FIG. 5 is a plan of one end portion of the lower nozzle halves **16***b* and **20***b* at the horizontal part line. The lower nozzle half **16***b*, as best seen in FIGS. 4 and 5 includes a semi-circular shroud member **40** attached to the radially innermost ends of the nozzles **16**, and similarly the corresponding upper nozzle half **16***a* as seen in FIG. 3 includes a semi-circular shroud member **41** attached to the radially innermost ends of the nozzles **16**. The lower nozzle half **20***b* and the corresponding upper nozzle half **20***a* are also provided with semi-circular shroud members, only the lower shroud member **42** being shown.

An annular inner wall member **44**, divided into upper and lower halves **44***a* and **44***b* is disposed in encompassed concentric relation with the inner shrouds of the first row nozzles and defines the inner periphery of the chamber

28, that is, the lower wall member half **44***b* (as best viewed in FIG. 5) has one lateral peripheral portion **45** disposed in juxtaposed radially inward relation with the lower shroud half **40** and an opposite lateral peripheral portion **46** in juxtaposed relation with the lower shroud half **42**.

The lateral portions **45** and **46** are provided with peripheral grooves **47** and **48**, respectively, and a semi-circular array of arcuately segmented seal members **50** and **51** are respectively retained in the grooves. The seal members **50** and **51** are biased in radially outwardly directions into abutment with the associated shroud members **40** and **42**, respectively, by suitable springs **52** disposed in the grooves. As best seen, in FIG. 4, each spring **52** is of the leaf type with a bent end portion **53** received in a suitable recess **54** in its associated seal member to prevent relative displacement in operation.

As illustrated in FIG. 2, the lower wall member half **44***b* is attached adjacent the horizontal plane A–A' to the lower half **21***b* of the inner casing by a pair of diametrically opposed radially extending strut portions **55** in a substantially identical manner, hence only one will be described.

As best seen in FIGS. 4 and 5, the strut **55** has its upper surface flush with the plane A–A' and is attached to a downwardly depressed flange **56** provided in the internal portion of the lower casing half **21***b*, by a threaded stud **57** extending through an open-ended notch **58** formed in the outer end portion of the strut. The stud **57** is of smaller cross-sectional area than the notch **58** so that the strut is free to move in any direction in the horizontal plane. However, the flange **56** is provided with a keying member **59** extending into the notch and in slidable relation therewith to restrict movement of the strut in all horizontal directions except radial.

As illustrated in FIG. 2, the upper wall half **44***a* is attached adjacent the horizontal parting plane A–A' to the lower wall half **44***b* by a pair of diametrically opposed radially extending struts **61** in a substantially similar manner, hence only one will be described.

As best shown in FIG. 4, the strut **61** has its lower surface flush with the plane A–A' and is attached to the strut **55** by suitable bolts **62**. For further support, the upper casing half **21***a* may be provided with a pair of diametrically opposed internal braces **64** (FIG. 2) arranged to abut the flanges **56** of the lower casing half **21***b* along the horizontal parting plane A–A'.

Accordingly, the upper and lower casing halves **21***a* and **21***b* are integrated into a unitary structure and effective to properly position the upper and lower nozzle halves **16***a* and **16***b*, while permitting expansion and contraction thereof with minimum internal stresses by sliding of the seal members **50** and **51** on their associated shrouds **40** and **42**, respectively.

The inner wall structure comprising the upper and lower wall members **44***a* and **44***b* are thus retained in properly assembled relation by the integrated nozzle structure **16***a*, **16***b* as best shown in FIG. 2. However to prevent rotation of the inner wall members **44***a*, **44***b*, there is provided similar upper and lower guiding and retaining structure **66***a*, **66***b* (see FIGS. 1 and 2), disposed in the vertical central plane for permitting radial expansion and contraction but preventing transverse or rotational movement thereof, in operation.

Referring to FIG. 3, the upper guiding structure **66***a* comprises an internal transverse brace **67** provided in the upper inner casing half structure **21***a* having a radial bore **68** and a dowel member **69** attached to the upper wall member half **44***a* and extending radially outwardly therefrom into mating registry with the bore **68**. The dowel member **69**, extends through a sleeve member **70** of shorter length, welded at its inner end to the inner wall member **44***a* and forming a clearance space **71** with the brace **67** to accommodate the above described expansion.

In FIG. 6 there is shown a modification of the structure described above wherein the rotor **70** is of integral form (thereby not requiring the discs **22** shown in FIG. 1) and having an annular cavity **71** disposed in the central portion. The remaining structure may be substantially identical to the structure already described.

It will now be seen that the invention provides a highly improved double opposed axial flow turbine in which leakage of hot motive fluid around the first stage nozzle rows **16** and **20** is substantially minimized, while permitting the associated inner wall structure **44** to expand and contact with minimal thermal stress on the nozzle structure and other associated structure in the central portion of the turbine.

Further the invention provides an arrangement having the above advantages wherein the entire turbine structure may be readily assembled at the factory and readily opened for repair in the field when required.

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

I claim as my invention:

1. A central admission double opposed-flow elastic fluid turbine comprising

a casing structure having a motive elastic fluid inlet and a pair of exhaust outlets for the expanded motive fluid,

a rotor having at least two annular rows of blades and a rotational axis,

a pair of annular rows of stationary nozzle vanes cooperating with said blades to provide a pair of first axial flow motive fluid expansion stages,

each of said rows of vanes having an annular shroud structure connected to said vanes and axially spaced from each other, thereby jointly defining in part, an annular space,

means associated with said inlet for directing motive fluid to said annular space,

a stationary wall member spanning the axial space between said rows of vanes and having axially opposed peripheral marginal portions disposed in lapping relation with said shroud portions, and

sealing means interposed between the shrouds and said marginal portions, said sealing means being carried by one of said shrouds and marginal portions and being in slidable abutment with the other of said shrouds and marginal portions.

2. The structure recited in claim **1**, wherein the

sealing means comprises an annular array of arcuate segments, and

said segments are maintained in said slidable abutment by spring members.

3. The structure recited in claim **2**, and further including

means cooperating with the casing structure and the annular wall member permitting radial expansion of the member.

4. The structure recited in claim **1**, wherein

the marginal portions of the annular wall member are encompassed by the shroud structure,

the sealing means comprises an annular array of arcuate segments,

said segments are maintained in said slidable abutment by spring members, and

the annular wall member is retained by the casing structure in a manner permitting radial expansion but restraining rotative movement of the annular wall member.

5. A central admission double opposed flow elastic fluid turbine comprising

inner and outer casing structure,

means defining a motive fluid inlet extending from said outer casing into said inner casing,

at least a pair of annular rows of stationary nozzle vanes carried by said inner casing structure,

a rotor rotatable about its horizontal central axis and having at least two annular rows of blades extending radially outwardly,

said stationary vanes being spaced axially from each other and at least partially defining an annular motive fluid space communicating with said inlet,

said stationary vanes extending radially inwardly and cooperating with said rotor blades to provide a pair of first axial flow expansion stages for the motive fluid, wherein the motive fluid through one of the stages flows in one axial direction and the motive fluid through the other of said stages flows in the opposite direction; and

means for preventing diversion of elastic motive fluid about said rows of nozzle vanes including an annular shroud structure disposed at the radially innermost portions of the vanes in each row,

a stationary annular wall member spanning the axial spacing between said rows of nozzle vanes and having axially opposed peripheral marginal portions disposed in lapping relation with said shroud structures and encompassed thereby,

an annular array of arcuately segmented sealing members interposed between each of said shroud structures and said marginal wall portions; and

means for biasing said segmented sealing members in radial directions.

6. The structure recited in claim **5**, wherein

the inner casing structure, the nozzle vane rows and the annular wall member are divided into upper and lower semi-circular portions at a horizontal central plane and

said upper and lower wall member portions are connected to the upper and lower inner casing portions respectively, for slidable radial movement in said horizontal plane.

7. The structure recited in claim **6**, wherein

the upper and lower wall portions are connected to the upper and lower inner casing portions, respectively, for radial movement in a substantially vertical central plane.

References Cited

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EVERETTE A. POWELL, Jr., *Primary Examiner.*