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[33] **Germany**

[31] **P 18 12 493.1**

[56]

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[54] **MULTISHELL AXIAL TURBINE, PREFERABLY
STEAM TURBINE FOR HIGH PRESSURES AND
TEMPERATURES**
13 Claims, 7 Drawing Figs.

Primary Examiner—Henry F. Raduazo

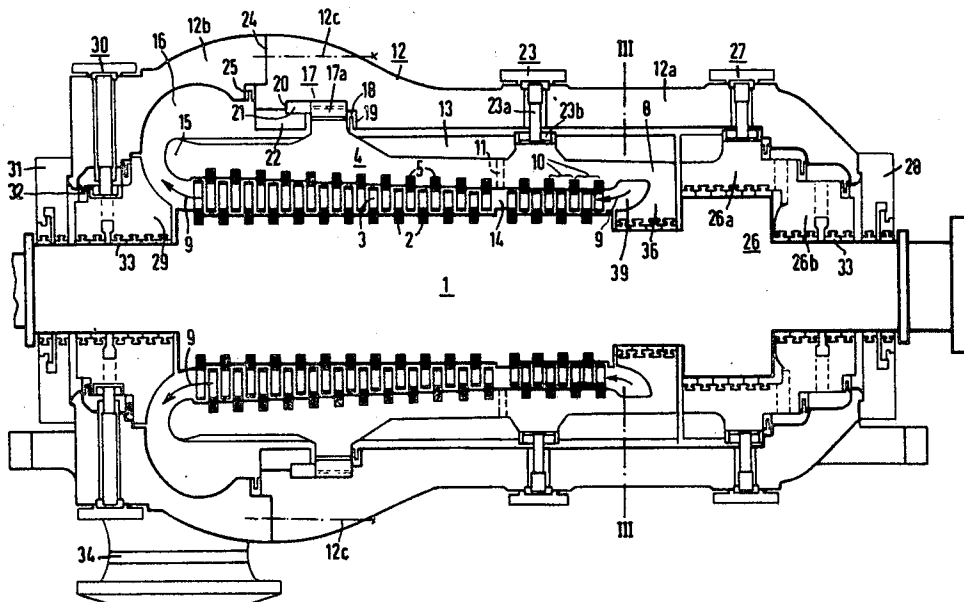
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Lerner and Daniel J. Tick

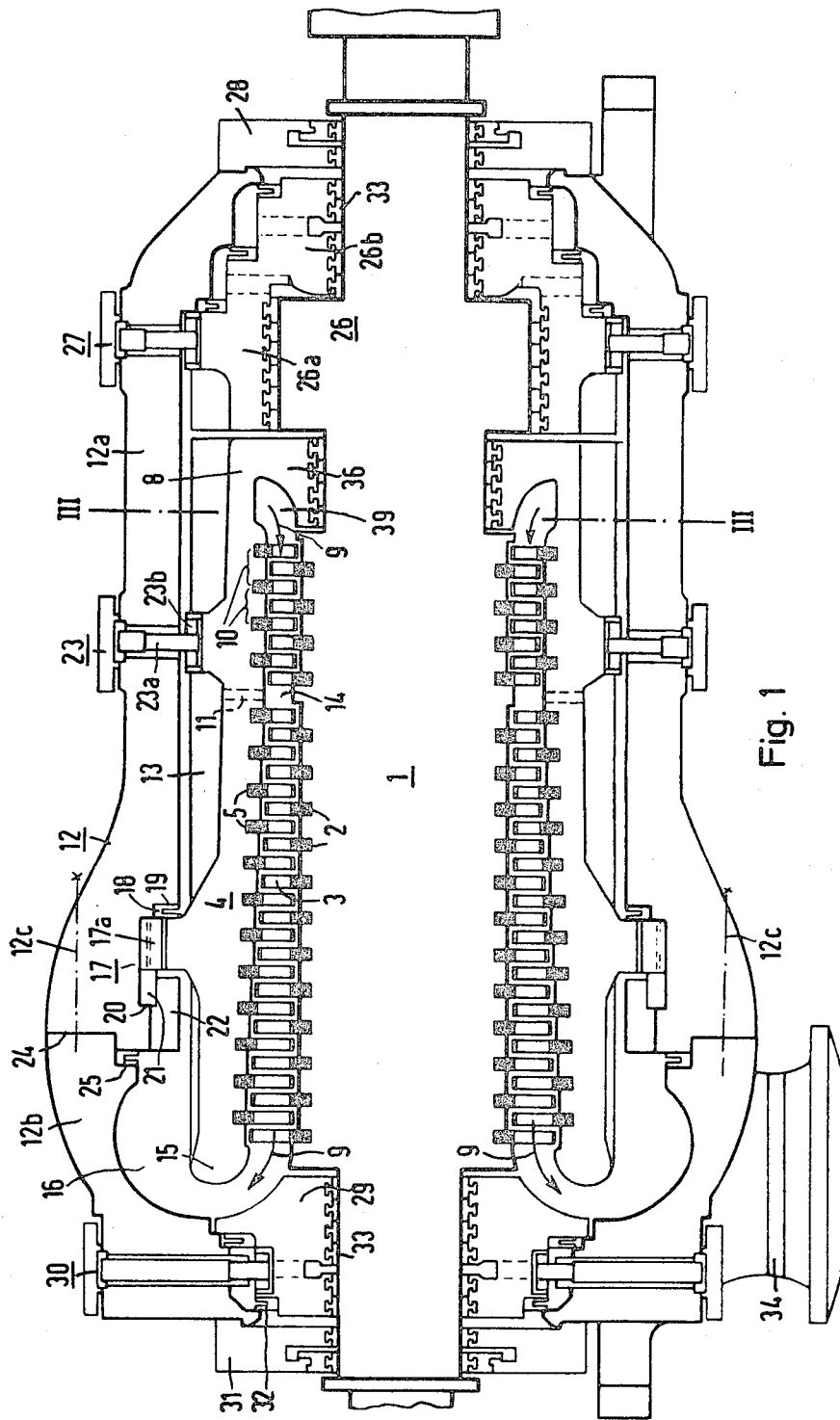
[52] U.S. Cl. **415/108,**
415/136, 415/219

[51] Int. Cl. **F04d 29/40,**
F01d 1/00

[50] Field of Search **415/108,**
109, 126, 131, 133, 134, 135, 136, 137, 138, 219

ABSTRACT: Multishell axial turbine includes a guide vane carrier divided in an axial plane, an inner casing surrounding the guide vane carrier, and an outer casing surrounding the inner casing, the inner casing being also divided in an axial plane and being structurally joined with the guide vane carrier into a single inner shell.





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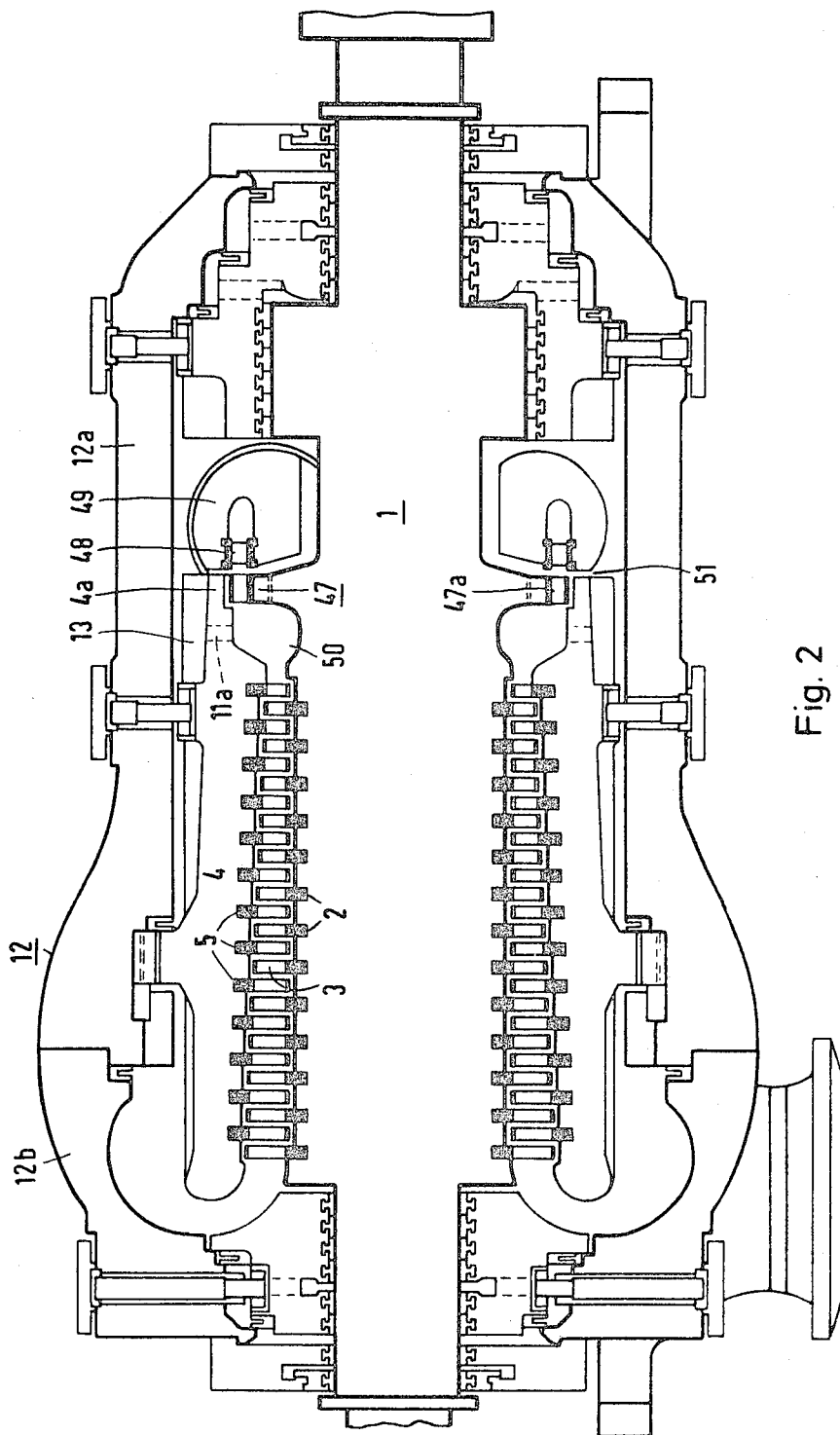
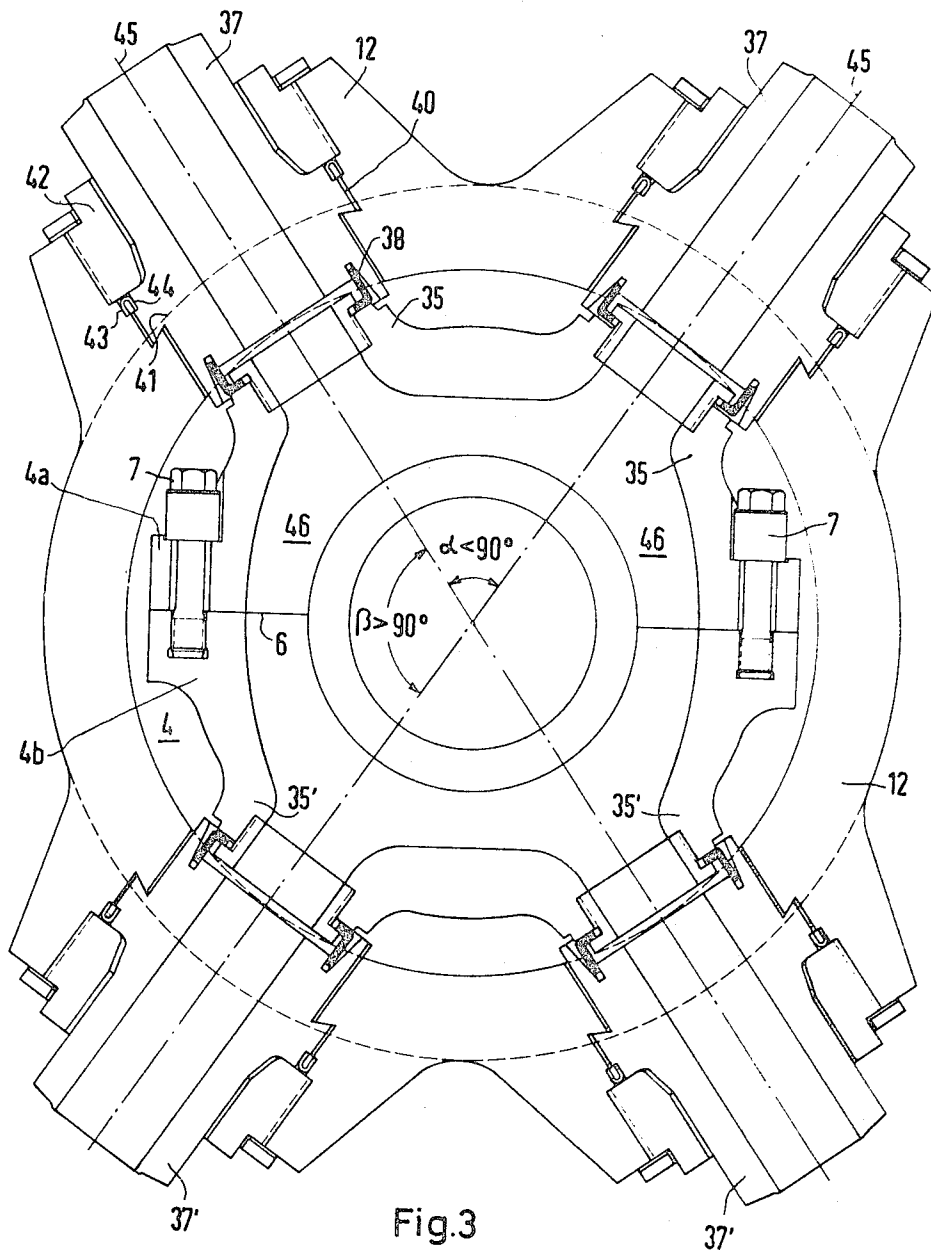


Fig. 2



MULTISHELL AXIAL TURBINE, PREFERABLY STEAM TURBINE FOR HIGH PRESSURES AND TEMPERATURES

Our invention relates to multishell axial turbine, preferably steam turbine for high pressures and temperatures, and more particularly such turbine having a guide vane carrier divided in an axial plane, an inner casing thereabout, and an outer casing surrounding the inner casing.

In such turbines, it is known from German Pat. No. DBP 1,140,947 to provide inner casing and guide vane carrier parts as structural components separated from one another and axially in a row one behind the other in the steam flow direction. It is also known from German published application DAS 1,197,096 to slide a guide vane carrier, which is divided in an axial plane, into a tank- or pot-shaped inner casing, the guide vane carrier being pressure relieved by bores formed along the length thereof. In both basic known constructions it is necessary to provide a plurality of suspension and centering members for the inner casing and guide vane carrier which are constructed as separate components, and construction as well as assembly costs are relatively high.

It is an object of our invention to provide a multishell axial turbine, also and especially a steam turbine for high pressures and temperatures, wherein construction and assembly costs are reduced in many practical ways. More specifically, it is an object of our invention to reduce the number of suspension and centering locations in the turbine.

With the foregoing and other objects in view, we provide in accordance with our invention, multishell axial turbine comprising a guide vane carrier divided in an axial plane, an inner casing surrounding the guide vane carrier, and an outer casing surrounding the inner casing, the inner casing being also divided in an axial plane and being structurally joined with the guide vane carrier into a single inner shell.

The inner shell of our invention can be considered as a structural component formed of an inner casing part and a guide vane carrier part axially connected thereto, an intermediate steam pressure being removable at the points of transition between both of these casing parts which effects a desired partial stress relief of the outer casing.

In accordance with another feature of our invention, we provide pressure-relieving channels in the inner casing located downstream of at least one blading stage as viewed from the steam inlet end of the inner shell in the pressure-relieving direction of the blading channel located between the inner shell and the turbine shaft. The pressure-relieving channels connect the space between the inner shell and the surrounding outer casing with a staging chamber subjected to an intermediate pressure, this staging chamber being separated from the space located at the steam exhaust end of the inner shell by a suspension device bracing the inner shell with respect to the outer casing so that the inner shell is axially fixed and steamtight as well as radially and centrally thermally displaceable.

In accordance with a further feature of our invention, the staging chamber subjected to intermediate pressure is located within a gap formed in the blading downstream of a plurality of the blade stages disposed in the blading channel. The number of the blade stages is dependent upon the desired amount of pressure to be relieved. Such a construction is especially suitable for a turbine which is throttle regulated and wherein live steam channels pass directly into the blading channel.

In accordance with yet another feature of our invention when the turbine is nozzle regulated and has steam inflow channels passing through an equal or constant pressure regulating stage, located in the blading channel, we provide an inlet channel section as intermediate pressure chamber surrounded by the steam inlet end of the inner shell that is free of blading, and located between the regulating stage and the afterconnected blading. Thereby, a favorable partial pressure relief of the outer casing and also of the guide vane carrier part in the region thereof up to the location at which it is braced by the suspension device is afforded. In order to absorb

sure from the outer casing, in accordance with our invention, the inner shell is disposed within an outer casing of the tank- or pot-type construction having a radially extending joint at the steam discharge end thereof.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in multishell axial turbine, preferably steam turbine for high pressures and temperatures, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic longitudinal sectional view of a high-pressure steam turbine of the reaction type with throttle regulation according to the invention and omitting elements not essential to an understanding of the invention.

FIG. 2 is a view similar to FIG. 1 of a corresponding high-pressure turbine having, however, nozzle regulation;

FIG. 3 is a radial cross section of FIG. 1 taken along the line III—III and showing more clearly the relation of the live steam supply means to the inner shell.

FIG. 4a is a fragmentary, much enlarged view of FIG. 1, showing one of the centering pin devices;

FIG. 4b is a sectional view of FIG. 4a taken along the line IVb—IVb in the direction of the arrows;

FIG. 4c is a cross-sectional view of FIG. 4b taken along the line IVc—IVc in the direction of the arrows; and

FIG. 4d is a schematic view illustrating the principle of the centering pin device in a radial centering plane.

Referring now to the drawings, and first particularly to FIGS. 1 and 3 thereof, there is shown a multishell steam turbine of the axial type of construction and moreover a high-pressure stage turbine with a reaction blading which is suitable for high pressures and temperatures. A turbine shaft 1, which is to be coupled with other turbine parts not shown in the Figure, is provided with axially disposed successive runner blading rings 2 which, within the blading channel 3, together with the guide vane rings 5 located at the inner periphery of the inner shell 4 and similarly disposed axially one behind the other, form the reaction blading. The inner shell 4 is divided in an axial plane (FIG. 3) and is formed of two inner shell halves 4a and 4b which are flanged together by flange screws 7 within the axial joints 6. As shown, the inner shell 4 forms a unitary structure made up of a guide vane carrier and an inner casing. For this purpose, the turbine is constructed so that, as seen from the steam inlet end 8 of the inner shell in the pressure-relieving direction (the arrow 9) of the blading channel 3, pressure-relieving channels 11 are provided in the inner shell 4 behind at least one blading stage 10. These pressure-relieving channels 11 connect the space 13, which is located between the inner shell 4 and the outer casing 12, with a staging chamber 14 subjected to a pressure intermediate the steam inlet and exhaust pressures of the turbine. This intermediate pressure chamber 14 and correspondingly the casing chamber 13 are separated from the space 16 located at the steam exhaust end 15 of the inner shell 4 by a bracing suspension member 17 at the outer casing 12 and which is axially fixed and steamtight as well as radially centrally heat displaceable. The suspension member 17 is formed by a fastening device which tightens an annular collar 17a of the inner shell 4 in axial direction against a shoulder 19 formed in the inner periphery of the outer casing 12, with an elastic sealing ring 18 interposed between the collar 17a and the shoulder 19. The elastic sealing ring 18 is preferably, as illustrated, constructed in the form of a U-ring which is mounted in a corresponding annular groove and which is disposed with both legs thereof elastically against the side surfaces of the annular groove. The

annular collar 17a of the inner shell 4 is centered, as shown, at the outer periphery by adapters or fittings and grooves with axially parallel fitting surfaces and a capability of radial expansion, and held against axial displacement by ring parts 21 that are form lockingly assemblable and insertable in the groove 20, the ring parts 21 being in turn held by a support ring 22 against displacement in radial direction. In the increasing direction of the pressure drop of the steam along the path represented by the arrow 9 and toward the suspension member 17, the inner shell is centered in another radial plane by a suspension member 23 which is axially and radially centrally heat displaceable. The suspension member 23 is made up of conventional radial pins 23a mounted in the outer casing 12 received in eccentric bushings and having at the free end thereof slide blocks or rings 23b. On the latter, the inner shell 4 is axially displaceably mounted and can be centered most accurately radially and in the peripheral direction by adjusting the radial pins, as discussed hereinafter more fully with regard to FIGS. 4a and 4d.

The outer casing 12 is formed as a tank, or pot-shaped casing, with a steam inlet and casing part 12a and a steam exhaust and casing part 12b, both parts being steamtightly flanged together at radial joints 24 with the interposition of an elastic sealing ring 25, preferably also a U-ring, the location of the flange screws or bolts being indicated by the dot-dash lines 12c. A shaft seal 26 is provided on the steam inlet end 8 of the inner shell 4 and is formed of a sealing shell with an axial joint. A mounting and centering device 27 corresponding to the members 23 is further provided adjacent the steam inlet end 8 of the turbine as well as an equalizing piston device 26a and a labyrinth seal 26b located within a shaft seal 26. A sealing cover 28 is steamtightly secured to the steam inlet end of the outer casing 12. An additional shaft seal 29 is provided at the steam exhaust end 15 of the inner shell 4 and is furnished with additional mounting and centering devices 30 corresponding to the mounting and centering devices 23 and 27 except for the fact that the pins of the devices 30 are radially increased in length. A sealing cover 31 is fastened at the steam exhaust end of the turbine stage in a manner similar to the sealing cover 28. Respective elastic sealing rings 32 preferably having a U-shape, are disposed between the shaft seals 26 and 29 on the one hand and corresponding abutment shoulders in the outer casing 12 on the other hand. Axial labyrinths 33 are provided for the shaft seals 26 and 29. A steam exhaust pipe 34 communicates with the steam exhaust chamber 16 and can be connected to a nonillustrated superheater or a succeeding turbine stage. As is shown in FIGS. 1 and 3, the inner shell 4 is provided at the steam inlet end 8 with steam inlet pipes 35 and a sealing shell 36 surrounding the shaft 1. The illustrated turbomachine is a throttle-regulated machine wherein the live steam is supplied through suitable live steam inlets 37, which are connected through a radially and axially displaceable and steamtight angle ring connection 38 at the inlet pipe 35, passing to the inflow chamber 39 and from the latter to the blading channel 9. The steam inlets 37 are insertable from the outside in corresponding receiving openings 40 of the outer casing 12 and are held at annular collars 41 against the inner steam pressure by clamping nuts 42 which are threadable in the pipe bores 40, an elastic U-shaped sealing ring 44 being inserted in an annular groove 43 between the clamping nut 42 and the annular collar 41 for sealing purposes, and the annular spacing 43 being connected to a nonillustrated leak exhaust. As shown in FIG. 3, both steam inlet pipes 35 and 35' are coordinately coordinated with an inner shell half 4a, and 4b and, correspondingly, the live steam inlets 37 and 37' connected thereto form with their axes 45, as shown, an angle α smaller than 90° , whereby in the joint sector region 46 of the inner shell 4 extending over an angle β greater than 90° , the space afforded for the joint flange 6 and the flange screws or bolts 7 is increased.

In FIG. 1, the intermediate pressure chamber 14 is located behind several stages 10 disposed in the blading channel 9 (behind four such stages in the specific embodiment of FIG.

1) within a suitable blading gap. This number of stages can be varied upwardly and downwardly depending upon the particular intermediate pressure that is to prevail in the space 13. In the case at hand for a throttle-regulated turbine consideration is given to the fact that the live steam should not yet be relieved in the inlet channel 39. It is recommended that the pressure-relieving channels 11 be connected to the blading channel 9 only after a plurality of stages 10. The outer casing 12 is thereby subjected to this intermediate pressure reduced in comparison to the inlet pressure, and the inner casing part of the inner shell 4, which can be considered as being located from the inlet end 8 to the channels 11, is subjected to a relatively slight pressure difference; the guide vane carrier part of the inner shell 4, beginning with the channels 11, is subjected to a reduced effective pressure difference, measured from the outside to the inside, and from the suspension point 17 down to the steam exhaust end 15 to the remainder of the effective pressure difference from the inside to the outside between the channel 9 and the space 16. Seen all together, an advantageous construction of the inner shell 4 subjected to a favorably distributed loading is attained. Assembly is also relatively simply carried out: the shaft 1, provided with the inner shell 4 and the shaft seals 26 and 29, is insertable in axial direction in the casing part 12a and, after mounting and centering, the steam exhaust end part 12b of the casing is placed thereon.

FIG. 2 shows a turbine which is substantially the same as that of FIG. 1 except that nozzle regulation through an equal pressure regulating stage 47 is provided. Like parts in FIGS. 1 and 2 are identified by the same reference numerals. Live steam inlet 49 carrying the nozzle inlets or segments 48 are steamtightly and heat transferably mounted so as to pass through the outer casing 12. The essential feature is that an inlet channel section 50, which is surrounded by the inlet end 4a of the inner shell 4 which is free of any blading, is located between the regulating stage 47 and the afterconnected blading 2, 5 and the blading channel 9. The inlet channel section 50 serves as an intermediate pressure chamber and accordingly communicates through pressure-relieving channels 11a with the space 13. The live steam travels thus from the steam inlets 49 through the nozzles 48 first through the runner blade ring 47a of the regulating stage 47 and, after it has been partially pressure relieved in the regulating stage 47, into the chamber 50. This chamber 50, which already has a reduced pressure and a reduced temperature, is connected to the chamber 14. It is also possible to connect the pressure-relieving channels 11a in a blading gap or the like when a regulating stage 47 is located at a further staging chamber located in the decreasing direction of the pressure drop, if an even greater pressure relief of the outer casing is desired. The annular gap 51 is sealed in the embodiment of FIG. 2 by suitable nonillustrated sealing elements so that the steam cannot flow directly from the nozzle segments 48 into the space 13.

In FIG. 4d there is illustrated the principle of radial pin centering in a schematic and perspective view between a generally identified inner shell 4 and a generally identified outer casing 12. The rotary axis of the turbine is identified by the reference character 1'. As indicated, four suspension or centering points Z1, Z2, Z3 and Z4 are provided per centering plane, each of the centering points being afforded a relative displacement of both casing parts 4 and 12 with respect to one another in the peripheral direction as indicated by the double-headed arrows t , in the radial direction as indicated by the double-headed arrows r and in the axial direction as indicated by the double-headed arrows a . Of the just-mentioned arrows, the arrows t are shown respectively extended to imply that they relate to an adjustment in the peripheral direction at assembly, which is a fixed adjustment, while the broken arrows a and r are meant to imply that a radially central heat-movable relative displacement, due to dissimilar thermal expansions between the inner casing 4 on the one hand and the outer casing 12 on the other hand is possible in axial and radial direction during the operation of the turbine. The use of the

reference characters 23, 27, 30 is meant to bring out that the aforescribed centering principle is applicable for the centering pin devices 23, 27, 30 of FIG. 1 as well as for the nonidentified but diagrammatically indicated centering pin devices of FIG. 2. Accordingly, the hereinafter following description of FIGS. 4a to 4c is applicable to all of the aforementioned centering pin devices.

As is shown in FIGS. 4a to 4c in detail, the outer casing 12 is formed with a radial bore 23c wherein a cylindrical bushing 23d formed with a flange 23e is inserted. The bushing 23d is provided with an eccentric bore 23f whose eccentricity e is clearly shown in FIG. 4c. The hollow cylindrical centering pin or bolt 23a is inserted in this eccentric bore 23f, and the lower end of the eccentric pin 23a is fitted in a sliding block or ring or an adjusting spring 23b. The sliding ring 23b is slidably guided in the axial direction with sliding surfaces 23g thereof extending in the axial direction of the turbine against corresponding opposing surfaces 23h of longitudinal grooves 23i formed in the inner shell 4. In order that the slide blocks or rings 23b be prevented from slipping within the slide surfaces 23h of the inner shell 4 when the respective centering pin device is installed, they are secured with a setscrew 230 (FIG. 4a) within a recess 231 formed in the inner shell 4 so that, as shown, adequate clearance for movement of the respective slide blocks or rings 23b in the axial direction is provided. The radial pins or bolts 23a are provided at their outer periphery with grooves 232 through which a possible wear or binding between the parts 23a and 23d which are radially displaceable relative to one another can be suppressed. A cover 23k is tightly fastened by bolts 233 from the outside on the outer casing 12 to seal the casing bore 23c and is pressed by an annular bead 234 formed thereon against corresponding opposing surfaces formed on the outer casing 12. As shown in FIGS. 4a and 4b, relative motion in the radial direction between the radial pins 23a and bushings 23d as well as between the pins 23a and the sliding blocks or rings 23b in radial direction is afforded as represented by the arrows r of FIG. 4d. Furthermore, relative motion in axial direction between the sliding blocks or rings 23b and the respective opposing surfaces 23h at the inner housing 4 is afforded in direction of the arrow a , as shown in FIG. 4d. The adjustment, i.e. the centering, of the inner shell 4 with respect to the outer casing 12 is effected, with the covers 23k removed, by turning the respective bushings 23d in their bore 23c. When the foregoing measures are carried out in all four centering points Z1 to Z4 of a centering plane (FIG. 4d), all desired relative positions of the inner shell 4 with respect to the outer casing 12 can then be attained within the desired adjustment limits, i.e. a raising or lowering or a lateral displacement or a rotation in the peripheral direction of the inner shell 4 relative to the outer casing 12.

We claim:

1. Multishell axial turbine comprising a turbine shaft, a guide vane carrier divided in axial plane and an inner casing part, both surrounding said turbine shaft, an outer casing surrounding said guide vane carrier and said inner casing part, said inner casing part being also divided in axial plane and being structurally joined with said guide vane carrier into a single inner shell, a blading channel located between said turbine shaft and said inner shell, guide vanes extending from said inner shell into said channel and runner blades extending from said turbine shaft into said channel and forming respective blading stages with said guide vanes, pressure-relieving channels in said inner shell connecting a staging chamber located downstream of at least one blading stage in the flow direction of steam through said blading channel, with a space located between said inner shell and said outer casing, said staging chamber being subjected to a pressure intermediate the steam pressure at the inlet and exhaust ends of said blading channel, and suspension means bracing said inner shell relative to said outer casing so that said inner shell is fixed against axial displacement and steamtight as well as radially centrally heat displaceable, said suspension means separating said staging chamber from a space located at the exhaust end of said inner shell.

2. Multishell axial turbine according to claim 1, wherein said staging chamber is located within a gap in the blading of said blading channel and downstream of a plurality of blading stages in direction of steam flow through said blading channel.

3. Multishell axial turbine according to claim 2, including means for throttle regulating the turbine, and live steam inlet channels leading directly to said blading channel.

4. Multishell axial turbine according to claim 1, including means for nozzle regulating the turbine comprising a constant-pressure regulating stage connected to said blading channel, live steam inlet channels connected through said regulating stage with said blading channel, an inlet channel section forming a staging chamber subjected to an intermediate pressure and located between said regulating stage and afterconnected blading in said blading channel, said inlet channel section being surrounded by a space free of blading and defined by said inner shell at the steam inlet end of the turbine.

5. Multishell axial turbine according to claim 1, wherein said axially fixed and radially centrally heat-displaceable suspension means is disposed in a radial plane, and in another radial plane located in increasing direction of steam pressure drop, there is disposed an axially displaceable and radially centrally heat-displaceable suspension means for centering said inner shell.

6. Multishell axial turbine according to claim 5, wherein said axially fixed suspension means is located in the vicinity of the steam exhaust end of the turbine, and said axially displaceable suspension means is located in the vicinity of the steam inlet end of the turbine.

7. Multishell axial turbine according to claim 6, wherein said axially displaceable and radially centrally heat-displaceable suspension means comprises a radial pin receivable in an eccentric bushing and having a slide block at an end thereof.

8. Multishell axial turbine according to claim 1, wherein said axially fixed and radially centrally heat-displaceable suspension means is formed by an Uhde-Brettschneider lock, comprising an annular collar surrounding said inner shell and tightened in axial direction against a shoulder formed at the inner periphery of said outer casing, an elastic sealing ring being interposed between said annular collar and said shoulder.

9. Multishell axial turbine according to claim 8, wherein said sealing ring has a U-shaped cross section.

10. Multishell axial turbine according to claim 1, wherein said guide vane carrier part of said inner shell is formed with reaction blading.

11. Multishell axial turbine according to claim 1, wherein said inner shell is disposed within an outer casing of the pot structural type.

12. Multishell axial turbine according to claim 1, wherein said inner shell is provided with steam inlet ducts at the steam inlet end of the turbine and with means forming a sealing shell surrounding the turbine shaft.

13. Multishell axial turbine comprising a turbine shaft, a guide vane carrier divided in axial plane and an inner casing part, both surrounding said turbine shaft, an outer casing surrounding said guide vane carrier and said inner casing part, said inner casing part being also divided in axial plane and being structurally joined with said guide vane carrier into a single inner shell, a blading channel located between said turbine shaft and said inner shell, guide vanes extending from said inner shell into said channel and runner blades extending from said turbine shaft into said channel and forming respective blading stages with said guide vanes, pressure-relieving channels in said inner shell connecting a staging chamber located downstream of at least one blading stage in the flow direction of steam through said blading channel, with a space located between said inner shell and said outer casing, said staging chamber being subjected to a pressure intermediate the steam pressure at the inlet and exhaust ends of said blading channel, and suspension means bracing said inner shell relative to said outer casing so that said inner shell is fixed against axial displacement and steamtight as well as radially centrally heat displaceable, said suspension means separating said stag-

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ing chamber from a space located at the exhaust end of said inner shell, said inner shell being provided with steam inlet ducts at the steam inlet end of the turbine and with means forming a sealing shell surrounding said turbine shaft, two of said steam inlet ducts being coordinated respectively with an inner shell half, said two steam inlet ducts being connected

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with live steam inlets so as to define an angle smaller than 90° with the intersection axes thereof, so that in a joint sector of said inner shell extending over an angle greater than 90°, increased space is provided for a joint flange and screws.

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PO-1050
(5/69)UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTIONPatent No. 3,628,878 Dated December 21, 1971Inventor(s) Werner Trassl, Wilhelm Engelke and Axel Remberg

It is certified that error appears in the above-identified patent
and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification,
the name of the first inventor should read
--Werner Trassl--

Signed and sealed this 25th day of July 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents