

June 18, 1957

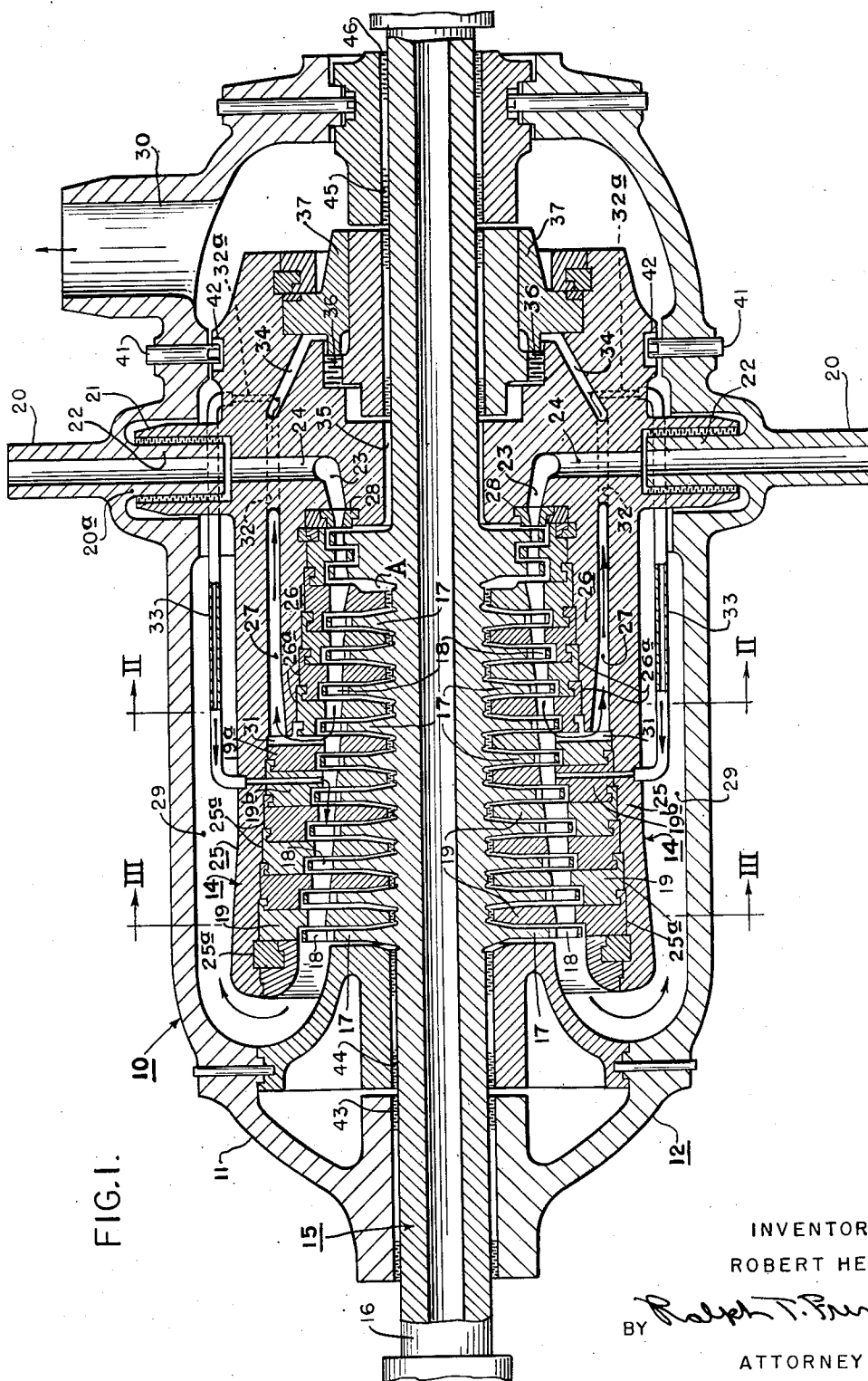
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2,796,231

HIGH PRESSURE STEAM TURBINE CASING STRUCTURE

Filed March 24, 1954

2 Sheets-Sheet 1



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FIG. 2.

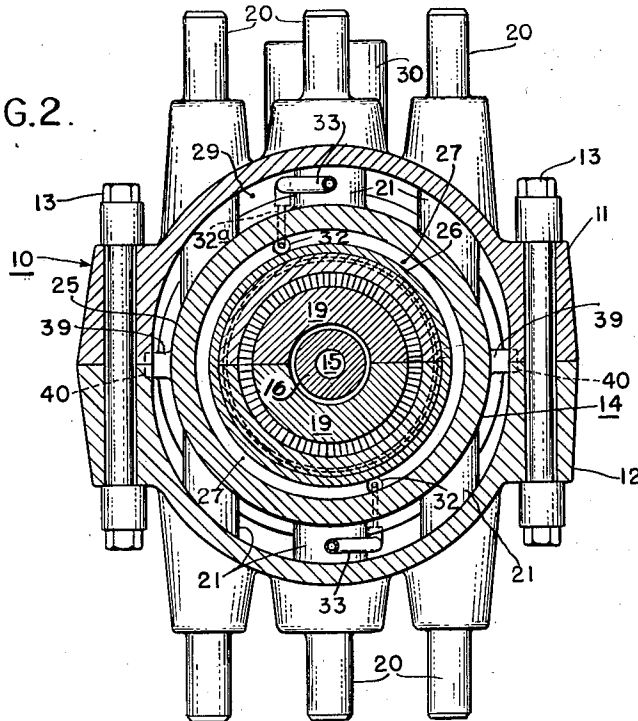
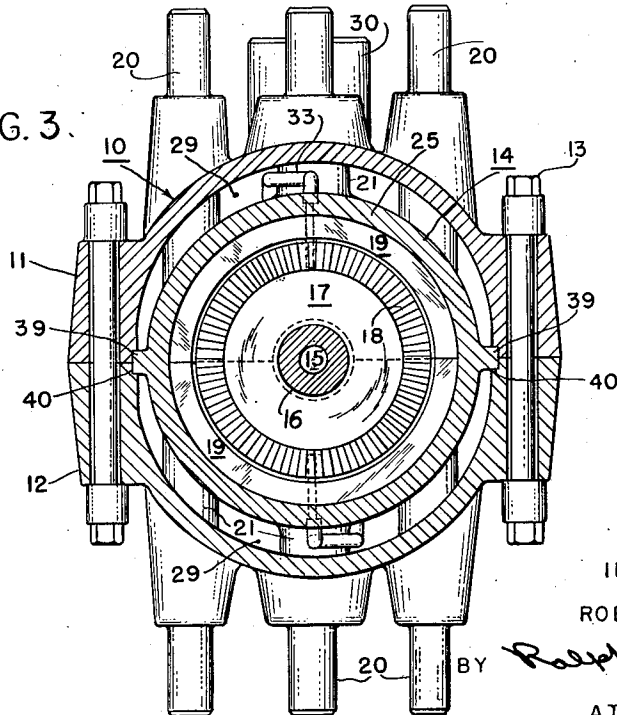


FIG. 3.



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HIGH PRESSURE STEAM TURBINE CASING STRUCTURE

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Application March 24, 1954, Serial No. 418,347

6 Claims. (Cl. 253—39)

This invention relates to a turbine utilizing high temperature motive fluid, more particularly to an axial flow steam turbine, and has for an object to provide a turbine of the above type capable of being driven by steam having very high pressure and temperature values.

For various economic reasons it is desirable to provide steam turbines capable of being driven by steam of very high pressure and temperature values. Accordingly, the trend is continuously toward utilization of steam at such high values as heretofore have presented practically insurmountable pressure differential, temperature differential and associated material stress problems. For example, as pressure values of the steam increase, turbine casing walls, particularly inner casing walls are conventionally made of thicker cross-section to withstand the increased pressure differential across the walls. However, increasing the wall thickness creates increased temperature differential between the opposite wall faces and the attendant temperature gradient induces severe thermal stresses in addition to the pressure stresses existing in the casing walls. Obviously, with such cumulative temperature and pressure stress problems, conventional solutions result in exceedingly thick casing walls, which are cumbersome, not homogeneous, difficult and expensive to manufacture and which provide a turbine which must be started and stopped with extreme care.

In view of the above, it is a further object of the invention to provide a high pressure, high temperature steam turbine having an inner casing structure arranged to provide reasonable wall thicknesses yet to permit adequate performance of the turbine.

A still further object is to provide a turbine of the above type having an inner casing structure arranged to reduce pressure and temperature differentials across the walls thereof and consequent stresses therein.

These 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 an axial sectional view of a steam turbine embodying the invention;

Fig. 2 is a sectional view taken on line II—II of Fig. 1; and

Fig. 3 is a sectional view taken on line III—III of Fig. 1.

Referring to the drawings in detail, there is shown a steam turbine having an outer casing 10 including an upper half 11 and a lower half 12 connected to each other by bolts 13, an inner casing 14 of generally tubular shape disposed within the outer casing halves 11 and 12, and in spaced relation therewith, and a bladed rotor aggregate 15 coaxially aligned with the inner casing 14 and extending through the outer casing 10.

The rotor 15 is provided with a spindle member 16 having a plurality of spaced disc portions 17 integrally formed thereon, and a plurality of annular rows of blades 18 attached to the peripheries thereof. As well understood in the art, the blades 18 may be of the side entry

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type and cooperate with a plurality of stationary diaphragm blade rows 19, as shown in Fig. 1, to provide a plurality of stages in which energy is extracted from the steam by expansion, with consequent reduction in pressure and temperature thereof. Since the specific construction of the diaphragms 19 forms no part of the invention, they will not be described in detail. However, they may be made in semi-circular halves, as shown in Fig. 3.

The outer casing 10 is provided with a plurality of steam inlet connections 20 having inward extensions 20a cooperating with a plurality of outwardly extending tubular portions 21 integrally formed with the inner casing 14 and disposed in telescopic slidable engagement with sleeve portions 22 formed integrally with the inlet connections 20. With this arrangement, as well known in the art, free thermal expansion of the associated components 20, 21 and 22 is permitted without thermal stressing of the inner and outer casings.

The inner casing 14 is further provided with an annular nozzle chamber 23 having a plurality of outwardly extending passages 24 communicating with the steam inlets 20, so that supply steam may be fed continuously to the stages heretofore described.

The inner casing 14, in accordance with the invention, comprises an outer integral tubular wall 25 and an inner integral tubular wall 26 disposed coaxially therewith but connected thereto at one end only and spaced therefrom throughout the remainder of its length to provide an annular steam chamber 27 therebetween.

The inner surfaces of the walls 25 and 26 are of stepped cylindrical shape to provide seats 25a and 26a, respectively, for the diaphragms 19. The rotor 15, with the diaphragm halves 19 in their proper positions between the disc portions 17, may be inserted in the inner casing 14 through the open end thereof (the left end as viewed in Fig. 1). In addition thereto, the inner wall 26 has inserted therein at its upstream end and adjacent the nozzle chamber 23, a nozzle block 28 through which the supply steam is fed into the stages 18, 19. The nozzle block 28 may be of boltless construction in accordance with applicant's copending application Serial No. 442,019, filed July 8, 1954, and assigned to the same assignee.

The outer wall 25 of the inner casing 14 is disposed in spaced relation with the outer casing 10 and together therewith defines an annular exhaust passage 29 communicating with the stages 18, 19 at one end and with a steam exhaust connection 30 provided in the outer casing. Thus, it will be seen that steam is supplied to the stages 18, 19 of the turbine through the steam inlet connections 20, the nozzle chamber 23 and the nozzle block 28; and after expending its energy flows through the exhaust passage 29 to the exhaust connection 30 which may be connected to another turbine either directly or through a reheater (not shown) for further heating and subsequent utilization.

As well known in the art, as the steam flows through the nozzle block 28 and courses through the various stages, the pressure thereof is reduced together with its temperature, so that the stage adjacent the nozzle block 28 is the highest pressure stage and the succeeding stages are correspondingly lower pressure stages, the lowest pressure stage being the last in the series.

The inner wall 26 of the inner casing extends axially downstream to an intermediate pressure stage 19a which stage is provided with a plurality of radial passages 31 affording communication between the diaphragm blading at that stage and the annular steam chamber 27, so that the chamber 27 is constantly flooded with steam of the same temperature and pressure values as are present at stage 19a.

Under some conditions it may be desirable to effect circulation of steam through the annular chamber 27 and

such circulation may be attained by provision of a plurality of restricted passageways 32, 32a formed in the inner casing 14 and communicating with the closed end of the chamber 27. As illustrated, the steam flowing through the restricted passageways 32, 32a is preferably fed back into the turbine at a stage 19b disposed downstream of stage 19a by a plurality of small pipes 33 extending through the exhaust passage 29. With this arrangement it is readmitted to the main steam flow through the succeeding lower pressure turbine stages to provide further energy before being exhausted into exhaust passage 29.

An annular groove 34 may also be provided in the upstream end of the inner casing 14. This groove preferably extends to the junctions of the passageways 32, 32a and is in highly restricted communication with an annular bleed-off passage 35 extending from the downstream side of the nozzle 28 and along the periphery of the spindle 16. An annular labyrinth seal 36 disposed between the inner casing 14 and a gland collar 37 provides the required restriction for the bleed-off passage 35. With this arrangement, should any high pressure steam escape beyond the labyrinth seal 36, it is directed through the annular groove 34 and thence into the passageway 32a. In addition to facilitating manufacture of the unit casing 14 by insuring communication of the passageways 32, 32a with each other, the annular groove 34 also acts to reduce the pressure and temperature differentials across the otherwise thick upstream wall portion of the inner casing 14 in a manner similar to that which will now be explained with reference to the chamber 27 and the inner casing walls 25 and 26.

With the double-walled inner casing arrangement described, the heretofore severely stressed inner casing wall portions encompassing the high pressure stages are subject to reduced temperature and pressure differentials and consequently reduced material stresses. Since the steam chamber 27 is flooded with steam at intermediate pressure and temperature values, the inner casing wall 26 is subject to maximum temperature and pressure differentials which are equal to the steam pressure and temperature values existing within the stages upstream of stage 19a minus the pressure and temperature values of the steam in chamber 27. In a similar manner, the portion of the inner casing wall 25 encompassing the wall 26 is subject to maximum pressure and temperature differentials which are equal to the steam values existing within the chamber 27 minus the corresponding steam values existing in the exhaust passage 29.

In effect, the pressure and temperature differentials, which have heretofore been imposed across a single wall, are imposed across two walls. However, since the thermal stresses are proportional to the square of the temperature differential, the combined thickness of the walls 26 and 25 may be less than the thickness of a single wall subject to the same steam values.

By way of example, in a proposed turbine incorporating the invention and utilizing a steam supply of 5000 p. s. i. a. and 1150° F., it has been calculated that the following steam values are attained in various parts of the turbine.

	°F.
Stage A, 3330 p. s. i. a.-----	1040
Chamber 27, 2470 p. s. i. a.-----	947
Exhaust passage 29, 1250 p. s. i. a.-----	758

The maximum differentials across wall 26 in the above are 860 p. s. i. a. and 93° F.

The maximum differentials across wall 25 are 1220 p. s. i. a. and 189° F.

The above differentials are reasonable for a turbine of this type and permit utilization of reasonable wall thicknesses for the inner casing walls 25 and 26. However, it is within the scope of the invention to provide an inner casing having more than two coaxial walls if desired. For example, if higher pressure and temperature

values are utilized or if it is desired to reduce the 1220 p. s. i. a. and 189° F. pressure and temperature differentials existing across the wall 25 in the example above, the wall 25 may be replaced by a double coaxial wall structure having its inner wall extending further downstream than the wall 26 and forming a steam chamber similar to chamber 27, but communicating with a stage at a lower pressure than stage 19a.

In addition, if desired, the restricted passageways 32, 32a and the pipes 33 may be omitted without serious decrease in benefit. Since the chamber 27 is in communication with stage 19a, the pressure in the chamber would be substantially of the same value as that existing in stage 19a, even though the temperature of the steam should increase because of heat transfer from the wall 26.

The inner casing 14 may be supported in the outer casing 19 in any suitable manner. As illustrated in Figs. 2 and 3, by way of example, the inner casing is supported in a horizontal plane by a plurality of pairs of diametrically opposed bosses 39 received in mating recesses 40 formed in the outer casing halves 11 and 12 adjacent the part lines thereof. In addition, as shown in Fig. 1, lateral alignment may be provided by a pair of dowel members 41 extending through the walls of the outer casing halves and engaging suitable recesses 42 in the inner casing.

To prevent excess loss of steam along the spindle 16, suitable labyrinth sealing structure 43, 44, 45 and 46 may be provided.

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. A multi-stage, axial-flow steam turbine having an outer casing, said outer casing having an exhaust outlet, an inner casing disposed within said outer casing, a rotor aggregate extending axially through said inner casing, said inner casing being integrally tubular and having an integral first wall and an integral second wall of shorter axial length than said first wall and disposed coaxially therewithin, said rotor having a plurality of annular rows of blades, said second wall supporting an annular row of stationary blades cooperating with one of said rotor blade rows to provide a high pressure stage, said first wall supporting a plurality of annular rows of stationary blades cooperating with the remaining rotor blade rows to provide a plurality of successively lower pressure stages including an intermediate pressure stage, said first wall together with said outer casing defining an annular steam flow passageway communicating with the lowest pressure stage at one end and with said exhaust outlet at its other end, said first and second walls being connected to each other adjacent the high pressure stage and defining an annular chamber communicating with said intermediate pressure stage, whereby said chamber is adapted to be flooded with steam at lower temperature and pressure values than said high pressure stage.

2. A multi-stage, axial-flow steam turbine having an outer casing, an inner casing disposed within said outer casing, a rotor aggregate extending axially through said inner casing, said rotor having a plurality of annular rows of blades, a plurality of annular rows of stationary blades supported in said inner casing, said stationary blade rows cooperating with said rotor blades to provide a plurality of stages including a high pressure stage and a plurality of successively lower pressure stages including an intermediate pressure stage, said inner casing having a first wall and a second wall disposed coaxially within said first wall, said first and second walls being connected to each other adjacent the high pressure stage and defining an annular chamber communicating with said intermediate pressure stage, whereby said chamber is adapted to be flooded with at least a portion of the steam from said intermediate pressure stage, and means providing for circulation of steam through the chamber, said means including an

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orifice provided in said inner casing and connecting said chamber with a region of lower pressure than the intermediate pressure stage.

3. A multi-stage, axial-flow steam turbine having an outer casing, an inner casing disposed within said outer casing, a rotor aggregate extending axially through said inner casing, said rotor having a plurality of annular rows of blades, a plurality of annular rows of stationary blades supported in said inner casing, said stationary blade rows cooperating with said rotor blades to provide a plurality of stages including a high pressure stage and a plurality of successively lower pressure stages including an intermediate pressure stage, said inner casing having a first wall and a second wall disposed coaxially within said first wall, said first and second walls being connected to each other adjacent the high pressure stage and defining an annular chamber communicating with said intermediate pressure stage, whereby said chamber is adapted to be flooded with at least a portion of the steam from said intermediate pressure stage, and further including means providing for circulation of steam through the chamber, said means including an orifice provided in said inner casing and a conduit in fluid flow communication with said orifice and extending into a lower pressure stage than said intermediate pressure stage, whereby the energy of said steam is further utilized for driving said rotor.

4. A multi-stage, axial flow steam turbine having an outer casing, a substantially tubular inner casing disposed within said outer casing, a rotor aggregate extending axially through said inner casing and having a plurality of annular rows of rotatable blades, a plurality of annular rows of stationary blades fixedly supported in said inner casing, said stationary blade rows cooperating with said rotatable blade rows to provide a plurality of stages ranging from a high pressure stage to successively lower pressure stages in downstream direction; said inner casing having a portion providing a steam supply passage communicating with said high pressure stage, a first tubular wall cooperating with said outer casing to provide an exhaust passage communicating with the lowest pressure stage and a second tubular wall disposed within said first wall and together therewith defining an annular chamber communicating with an intermediate pressure stage, said second tubular wall supporting at least a pair of said stationary blade rows forming the high pressure stage and an intermediate pressure stage, and said first tubular wall supporting the remainder of said stationary blade rows, whereby said chamber is adapted to be flooded with steam from said intermediate pressure stage.

5. A multi-stage, axial flow steam turbine having an outer casing, a substantially tubular inner casing disposed within said outer casing, a rotor aggregate extending axially through said inner casing and having a plurality of annular rows of rotatable blades, a plurality of annular rows of stationary blades fixedly supported in said inner casing, said stationary blade rows cooperating with said rotatable blade rows to provide a plurality of stages

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ranging from a high pressure stage to successively lower pressure stages in downstream direction; said inner casing having a portion providing a steam supply passage communicating with said high pressure stage, a first tubular wall cooperating with said outer casing to provide an exhaust passage communicating with a low pressure stage and a second tubular wall disposed within said first wall and together therewith defining an annular chamber communicating with an intermediate pressure stage, said second tubular wall supporting at least a pair of said stationary blade rows forming the high pressure and an intermediate pressure stage, and said first tubular wall supporting the remainder of said stationary blade rows, whereby said chamber is adapted to be flooded with steam from said intermediate pressure stage, and means providing circulation of said steam through said chamber in a direction counter to the direction of steam flow through said steam expansion stages, said means including an orifice and said orifice being in communication with said chamber and a region of lower pressure than said intermediate pressure stage.

6. A multi-stage, axial-flow steam turbine having an outer casing, a substantially tubular inner casing disposed within said outer casing, a rotor aggregate extending axially through said inner casing and having a plurality of annular rows of rotatable blades, a plurality of annular rows of stationary blades fixedly supported in said inner casing, said stationary blade rows cooperating with said rotatable blade rows to provide a plurality of stages ranging from a high pressure stage to successively lower pressure stages in downstream direction; said inner casing having a portion providing a steam supply passage communicating with said high pressure stage, a first tubular wall cooperating with said outer casing to provide an exhaust passage communicating with a low pressure stage and a second tubular wall disposed within said first wall and together therewith defining an annular chamber communicating with an intermediate pressure stage, whereby said chamber is adapted to be flooded with steam from said intermediate pressure stage, and means providing circulation of said steam through said chamber in a direction counter to the direction of steam flow through said steam expansion stages, said means including an orifice in communication with said chamber and a conduit extending through the exhaust passage and connecting the orifice to a lower pressure stage than the intermediate pressure stage.

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