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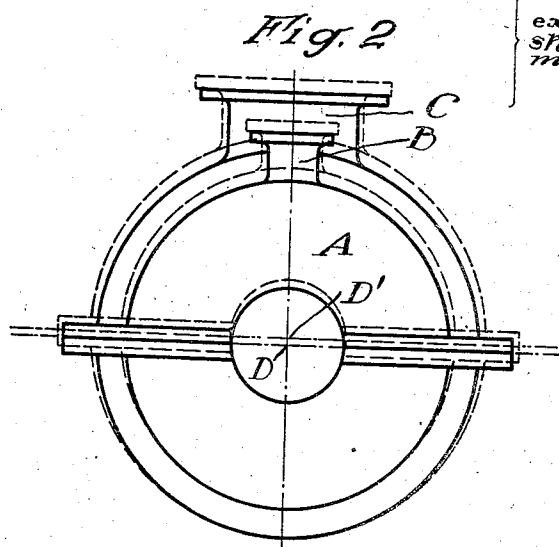
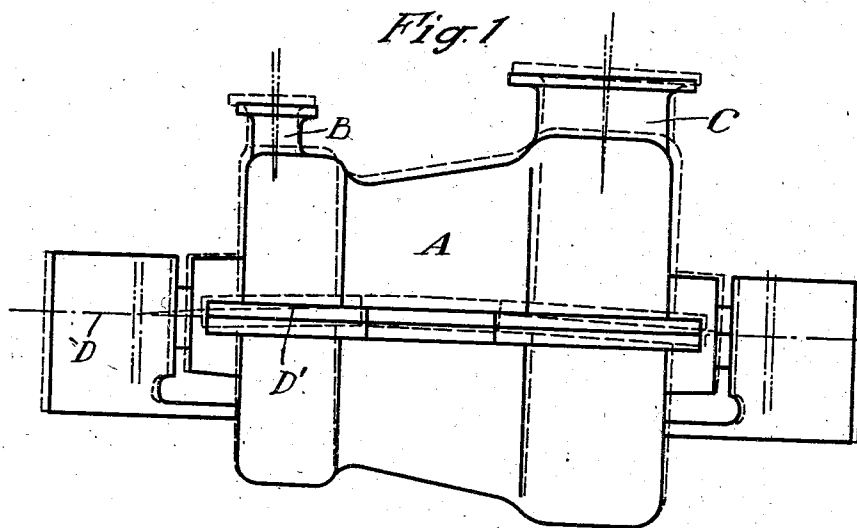
K. RÖDER

2,220,616

PACKING FOR STEAM TURBINES

Filed Feb. 27, 1937

5 Sheets-Sheet 1



*explanatory
sketches of detri-
mental distortion*

*Karl Röder
Inventor
by Knight
Attys.*

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5 Sheets-Sheet 2

Fig. 3

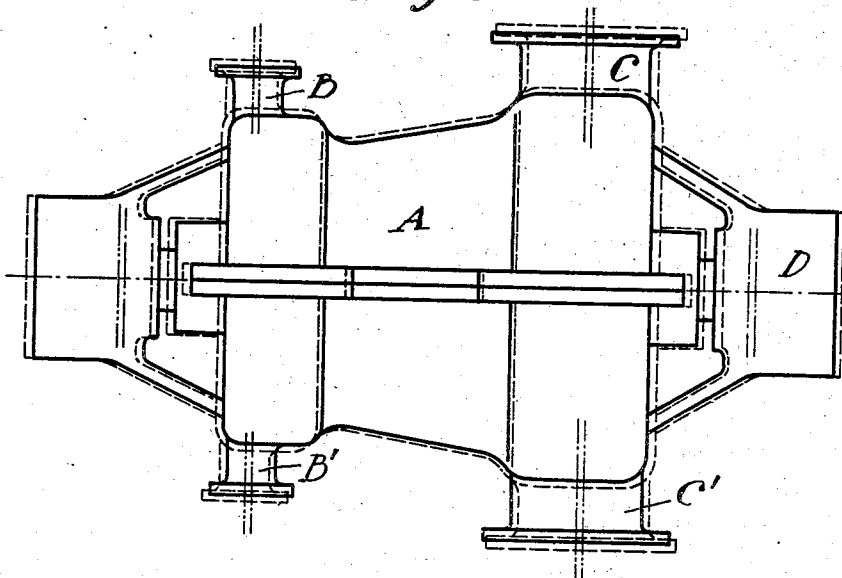
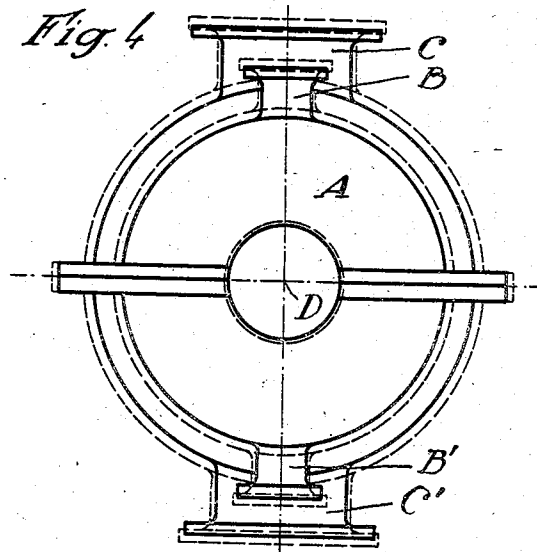


Fig. 4



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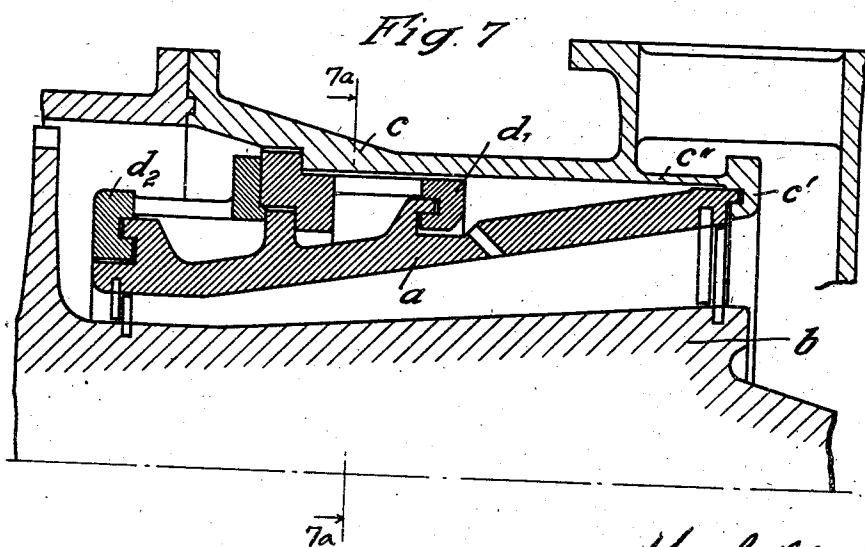
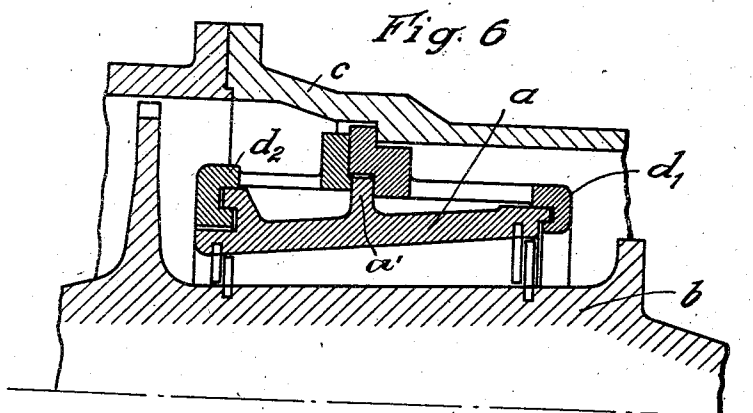
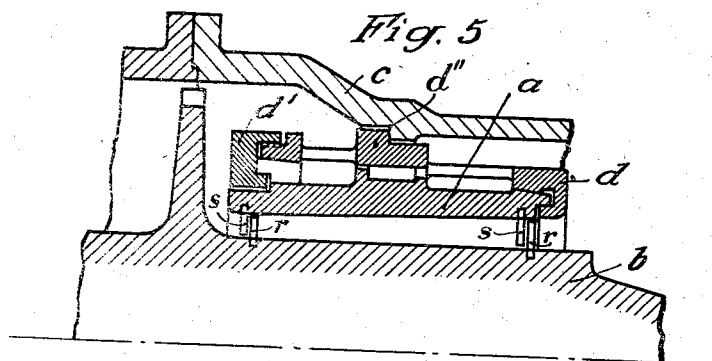
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2,220,616

PACKING FOR STEAM TURBINES

Filed Feb. 27, 1937

5 Sheets-Sheet 3



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2,220,616

PACKING FOR STEAM TURBINES

Filed Feb. 27, 1937

5 Sheets-Sheet 4

Fig. 7a.

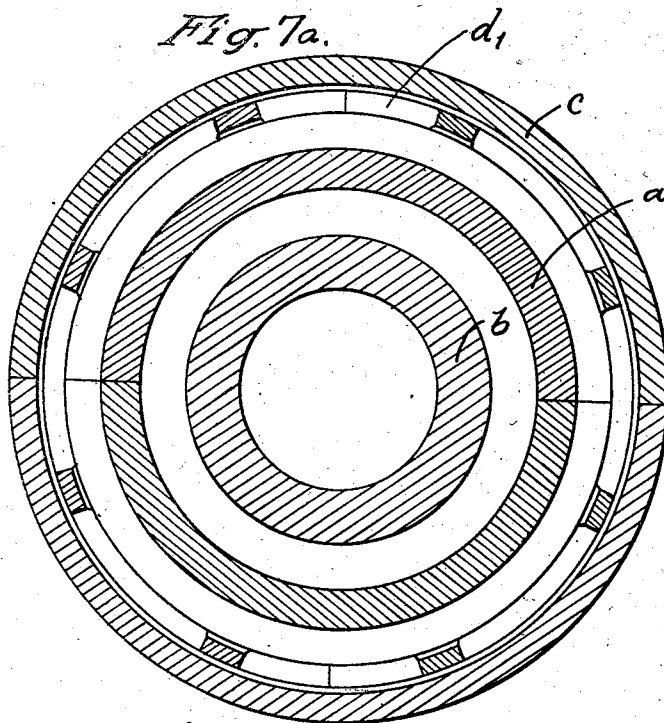
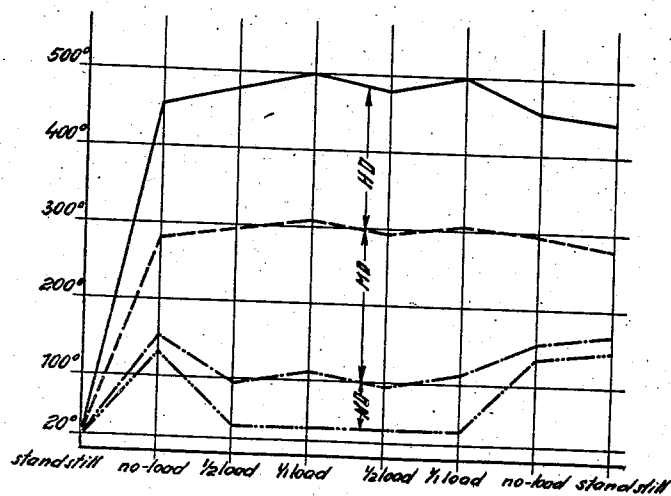


Fig. 11.



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2,220,616

PACKING FOR STEAM TURBINES

Filed Feb. 27, 1937

5 Sheets-Sheet 5

Fig. 8

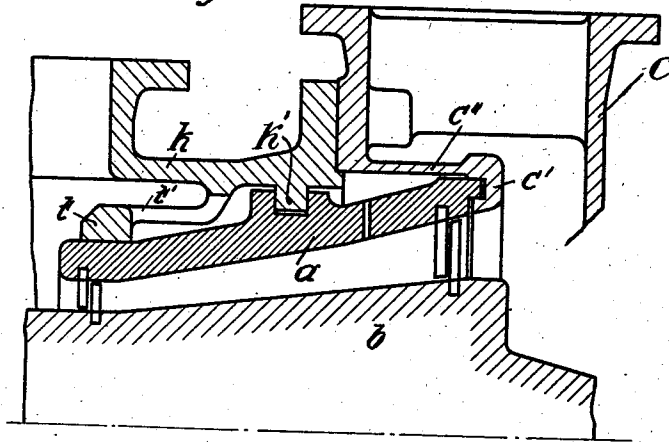


Fig. 9

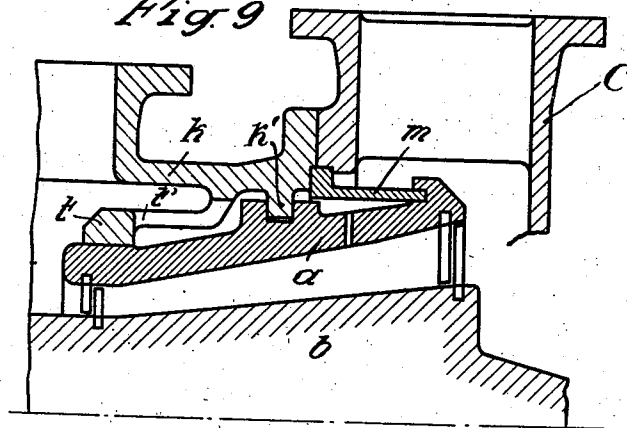
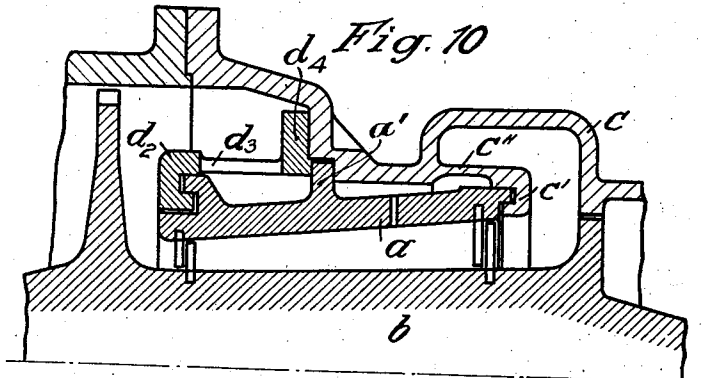


Fig. 10



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UNITED STATES PATENT OFFICE

2,220,616

PACKING FOR STEAM TURBINES

Karl Röder, Hanover, Germany

Application February 27, 1937, Serial No. 128,187
In Germany February 29, 1936

9 Claims. (Cl. 253—39)

My invention relates to improvements in packings for steam turbines.

The efficiency and reliability of a steam turbine depends to a great extent upon the packings employed therefor. This applies particularly to machines dealing with small volumes of steam, for instance, also to high-pressure parts of high-pressure turbines.

In the labyrinth packings with projecting edges which are employed in most cases, a circular sectional area of flow of small depth, namely the depth of the clearance space, is left between the revolving part and the stationary part enclosing the same, which parts should not come into contact with one another.

This depth of the clearance space should be as small as possible and should remain of the same magnitude over the entire periphery independently of the variation in pressures and temperatures of the operating fluid during the operation.

It is theoretically possible to maintain the clearance space as above mentioned strictly equal only in the case in which both elements defining the clearance space present exactly the same operating conditions, such as is the case with packings between the blade rims of turbines with nozzles and blades rotating in opposite directions.

All other packings, that is to say, the other packings employed in turbines with nozzles and blades rotating in opposite directions as well as all packings in all other radial flow turbines and axial flow turbines present clearance spaces which are limited, on the one hand, by rotating and, on the other hand, by stationary parts. Above all also the clearance spaces between the individual blade rims of reaction turbines not designed in the form of a labyrinth belong to the above-mentioned packings.

When employing packings of the usual type only the revolving part retains its circular shape under all operating conditions, whereas the stationary part loses its circular shape and cannot adapt itself, without producing mechanical stresses, to the varying temperatures, thereby causing a reduction of the clearance space which impairs the reliability of operation.

The object of my invention is: to remove the above-mentioned drawbacks, i. e., to design and to assemble the stationary parts of an expansion or compression machine (by which are denoted steady flow machines working on the expansion principle, or on the compression principle, i. e., turbines, or compressors, respectively) in such a manner

its circular shape under all operating conditions.

(2) That the expansion and contraction of the parts bounding the clearance space essentially produce enlargements of the clearance space only consequently, and

(3) That the temperature and pressure variations do not entail any appreciable decrease of the clearance space so that the danger of contact of the movable parts is eliminated.

To this end, it is above all necessary that the unavoidable departures of the machine casing from the circular form or from symmetry occur not only on one side but symmetrically on opposite sides of the central axis, and that both casing parts have the same shape and the same dimensions in planes transverse to the longitudinal axis of the casing.

The invention is illustrated in the accompanying drawings, in which—

Figs. 1 and 2 are explanatory figures, and represent respectively in side and end elevation an unsymmetrical structure, showing the distortion in dash lines, resulting from uneven expansion under the influence of heat and pressure.

Figs. 3 and 4 represent respectively in side and end elevation a symmetrical structure according to the present invention, showing in dash lines the symmetrical expansion under the influence of heat and pressure.

Figs. 5 to 10 show in sectional elevation different forms of resiliently supporting the stator ring to prevent the transmission of unavoidable casing distortions to the ring.

Fig. 7a is a transverse section through Fig. 7 on the line 7a—7a in Fig. 7, and

Fig. 11 represents a steam temperature graph at different loads of a three-stage turbine.

Referring to Figs. 1 and 2, these figures show a typical form of an unsymmetrical machine casing A, having the connecting branches B and C located all on one side of a given central axial plane. The deformations of the casing, and also of its axis when subjected to high temperatures in operation, are unsymmetrical, as indicated in dash lines.

Figs. 3 and 4 show in side and end elevation respectively the novel construction of a steam turbine casing in which correspondingly located points of the casing on diametrically opposite sides of the longitudinal central axis depart from the circular shape to the same extent (for instance, B, B'; C, C'), and in which the central axis D does not become dislocated or distorted. In other words, the unavoidable deformations of the casing are symmetrical with respect to the

(1) That the annular clearance space retains

central axis within all transverse sections of the casing.

While deformations of the casing are in this case not avoided, the axis of the casing is not deformed or shifted by these changes.

Furthermore, those parts which support the guide blades and the stationary packing elements—even if these parts are subdivided in a plane through the longitudinal axis—should be made in the form of bodies of revolution with respect to the casing axis, whatever their contour may be in the direction of the axis, and be mounted in the casing in such a manner that they may follow the changes in temperature as free bodies of revolution without losing their circular shape.

To this end, such bodies of revolution may be supported by other bodies of revolution which are concentrically mounted in the casing or assembled therewith so as to permit a symmetrical expansion or contraction thereof in response to the temperature changes.

Referring first to Fig. 5, *b* represents in cross section one-half of the revolving part or rotor of the turbine which, of course, in itself is a body of revolution. The rotor carries the rotor blades *r*. In the turbine casing *c*, which may be of the general symmetrical character as shown in and described with reference to Figs. 3 and 4, is mounted the stator support *d''* which is annular and thus also constitutes a body of revolution. Support *d''* is shaped at one end *d* into a clamping ring and carries at the other end a separate clamping ring *d'*. Between these two clamping bodies of revolution is positioned the turbine stator *a* which carries the stator blades *s* and is in itself also a body of revolution. By this arrangement complete symmetry is maintained so that no distortion, due to uneven heat expansion stresses, can occur, even though the stator carrier *d''* and its rings *d*, *d'* and the stator *a* may be divided into two halves along a plane through the rotor axis, so that one-half of these elements is located in the upper half of the casing *c* and the other half of the elements is located in the lower half of casing *c*. When these halves are assembled they act as complete bodies of revolution and expand and contract symmetrically. This symmetry is not disturbed even if the several bodies of revolution should be circumferentially divided for constructive reasons into more than two parts, for instance, four parts, provided the division lines are on planes through the longitudinal turbine axis.

The form of the different bodies of revolution of which the entire stator is composed as afore-described may, of course, vary in accordance with the design requirements. For instance, as shown in Fig. 6 at *d*₁, *d*₂, the clamping elements for the stator ring *a* may be composed of two parts, each a body of revolution, and may hold the stator ring between them at its ends and at an annular rib *a'* disposed intermediate its ends. Further, as shown in Fig. 7, the stator ring *a* may be held by clamping rings *d*₁, *d*₂, as shown in Fig. 6, between one of its ends and its middle, and its freely extending end may be held by a clamping ring *c'* provided at an annular extension *c''* of casing *c*.

As shown in Fig. 8, the intermediate clamping elements *d'*, *d''*, *d*₁, *d*₂ of Figs. 5 to 7 may be entirely omitted and the stator ring *a* may be directly held by the turbine casing. For this purpose, the outer casing may be divided transversely into several parts such as *C* and *k*. The part *C*

holds one end of the stator ring *a* by means of a ring *c'* at the end of an annular portion *c''* of casing *C* in a manner similar to that shown in Fig. 7. The other end of stator ring *a* is supported by an annular support *t* carried by the outer casing portion *k* through arms *t'*. The portion of stator ring *a* intermediate its ends is held by an annular rib *k'* on casing portions *k*, whereby it is also prevented from longitudinal shifting.

Fig. 9 shows a construction similar to Fig. 8, except that one end of the stator ring *a* is carried by a separate supporting ring *m* mounted in the casing portion *C*.

Fig. 10 shows the support of stator ring *a* at one end by means of a clamping ring *d*₂ attached by means of arms *d*₃ and a base ring *d*₁ to casing *c*. The other end of stator ring *a* is held by clamping ring *c'* supported similar to the manner shown in Fig. 7, and the stator ring *a* is supported intermediate its ends by a rib *a'* held between base ring *d*₁ and a shoulder on casing *c*.

All of the holding or clamping rings for stator ring *a*, such as *d*, *d'* in Fig. 5, *d*₁, *d*₂ in Figs. 6 and 7, *c'* in Figs. 7, 8 and 10, and *t* in Figs. 8 and 9, are supported on the outer casing *c* by means of arms extending substantially in parallel to the turbine axis so that this stator support is made sufficiently resilient in radial direction to prevent unavoidable deformations of the outer casing from being transmitted to the stator ring *a*.

The changes in temperature in the several stages of a turbine to be expected may be seen from the graph, Fig. 11. It is assumed that the turbine under consideration be a three-stage turbine having a high pressure stage HD, a medium pressure stage MD, and a low pressure stage ND. The turbine is divided into three stages.

The temperatures at the beginning and the end of these three stages are plotted in Fig. 11 against the load conditions varying within wide limits. The high-pressure HD and the medium pressure stage MD are subjected as will be seen from Fig. 11 to great changes in the temperature of the operating medium only when starting, the temperature in this case increasing to a considerable extent from standstill to no-load running.

The changes in temperature during operation between no-load to full load and back to standstill are relatively slight so that these variations in temperature during starting are only fractions of the great increase in temperature.

The temperatures of steam are not identical with the temperatures of the machine parts of the different stages; nevertheless it may be concluded with certainty from Fig. 11 that the temperatures of the individual machine parts increase considerably during and after starting and vary only to a slight extent during operation.

This fact is taken advantage of and accordingly the following fundamental principle of design may be established, which demands that the increase in temperature should result in an increase of the clearance space, while the small decreases in temperature occurring during operation should cause corresponding decrease of the clearance space, the latter being only a small percentage of the former.

These conditions are actually obtained by the arrangement of the stationary elements of the machine, such as the stator ring and its supporting elements in the manner shown in Figs. 5 to 10, in which they are exposed to the steam temperature so that they can respond more quickly to variations in temperature than the adjacent

revolving parts. As will be noted from the stator construction and its supports, these elements are much more freely exposed to the operating steam in all stages than the rotor. Consequently, an increase in the clearance space is brought about when putting the turbine into operation and when taking up a load, i. e., under operating conditions which, in the designs followed hitherto, lead rather to decreases of the clearance by which the operation of the machine is endangered. In the present designs according to the invention, on the other hand, the decreases of the clearance space below that allowed during the mounting of the machine, which occur during the operation of the machine at different loads, are so slight as to be practically negligible. Thus, in assembling the machine, the allowable clearance space between the moving elements may be made extremely small, and only the expansion of the rotor due to centrifugal forces need be taken into consideration for the amounts of these clearances.

The material for the revolving and stationary parts which limit the clearance space should have about the same coefficient of heat expansion. The dimensions, the wall thickness and the arrangement of the packing parts in the path of the flowing medium depend upon the above-mentioned method of designing steam turbines as will be seen from Figs. 5 to 10.

I claim as my invention:

1. A fluid expansion or compression machine having a casing and stator and rotor elements subject to expansion and contraction, said casing having all portions deviating from circular shape with respect to the rotor axis arranged in pairs disposed symmetrically on diametrically opposite sides of said axis, and having its stator elements mounted within said casing and formed as bodies of revolution with respect to said rotor axis, said stator elements comprising an elongated stator blade carrier and a plurality of rows of stator blades mounted directly on said carrier and being freely exposed to the varying temperatures of the operating fluid and being disposed to yield in radial and axial direction.

2. A steam turbine having a stator and a rotor and having a casing enclosing said stator and rotor and being longitudinally divided in at least one plane through the turbine rotor axis, said stator comprising a similarly divided stator blade carrier and a plurality of rows of stator blades disposed therein, said blade carrier being constructed as a body of revolution with respect to said rotor axis, and at least one body of revolution disposed to hold said divided carrier together and to support it in said casing as a single body of revolution which retains its shape at varying temperatures.

3. A steam turbine having a stator and a rotor and having a casing enclosing said stator and rotor and being longitudinally divided in at least one plane through the turbine rotor axis, said stator comprising a similarly divided stator blade carrier and a plurality of rows of stator blades disposed therein, said blade carrier being constructed as a body of revolution with respect to said rotor axis, and a plurality of rings centered in the casing with respect to the rotor axis and disposed to hold said divided carrier together and to support it in said casing as a single body of revolution which retains its shape at varying temperatures.

4. A steam turbine having a stator and a rotor and having a casing enclosing said stator and

rotor and being longitudinally divided in at least one plane through the turbine rotor axis, said stator comprising a similarly divided stator blade carrier and a plurality of rows of stator blades disposed therein, said blade carrier being constructed as a body of revolution with respect to said rotor axis, and at least one body of revolution diametrically divided in a plane through said rotor axis but at right angles to the dividing plane of said carrier and disposed to hold said divided carrier together and to support it in said casing as a single body of revolution which retains its shape at varying temperatures.

5. A steam turbine having a stator and a rotor and having a casing enclosing said stator and rotor and being longitudinally divided in at least one plane through the turbine rotor axis, said stator comprising a similarly divided stator blade carrier and a plurality of rows of stator blades disposed therein, said blade carrier being constructed as a body of revolution with respect to said rotor axis, said casing containing at least one elastically centered body of revolution disposed to hold said divided carrier together and to support it in said casing as a single body of revolution which retains its shape at varying temperatures.

6. A steam turbine having a stator and a rotor and having a casing enclosing said stator and rotor and being longitudinally divided in at least one plane through the turbine rotor axis, said stator comprising a similarly divided stator blade carrier and a plurality of rows of stator blades disposed therein, said blade carrier being constructed as a body of revolution with respect to said rotor axis, and at least one body of revolution disposed to hold said divided carrier together and to support it in said casing as a single body of revolution which retains its shape at varying temperatures, said carrier and said supporting body being arranged in the path of the entering operating medium so as to follow its temperature variations faster than the rotor elements of the turbine.

7. A steam turbine having a stator and a rotor and having a casing enclosing said stator and rotor and being longitudinally divided in at least one plane through the turbine rotor axis, said stator comprising a similarly divided stator blade carrier and a plurality of rows of stator blades disposed therein, said blade carrier being constructed as a body of revolution with respect to said rotor axis, and at least one body of revolution disposed to hold said divided carrier together and to support it in said casing as a single body of revolution which retains its shape at varying temperatures, said carrier and said supporting body being arranged in the path of the entering operating medium so as to follow its temperature variations faster than the rotor elements of the turbine, and the portions of said carrier, immediately adjacent to the rotor and by which the gap between the stator and rotor blades is determined, being made of a material of the same heat expansion coefficient as the adjacent rotor portions.

8. A steam turbine having a stator and a rotor and having a casing enclosing said stator and rotor and being longitudinally divided in at least one plane through the turbine rotor axis, said stator comprising a similarly divided stator blade carrier and a plurality of rows of stator blades disposed therein, said blade carrier being constructed as a body of revolution with respect to said rotor axis, and at least one body of revolu-

tion disposed to hold said divided carrier together and to support it in said casing as a single body of revolution which retains its shape at varying temperatures, said casing having all portions deviating from circular shape with respect to the rotor axis arranged in pairs disposed symmetrically on diametrically opposite sides of said axis.

9. A fluid expansion or compression machine having a casing and stator and rotor elements, said stator elements comprising an elongated blade carrier longitudinally divided in an axial

plane into two half shells and constructed as a body of revolution, a plurality of rows of stator blades disposed in said carrier, ring members clamping the two halves of the carrier together and maintaining the circular form of the carrier when variations of the length of the carrier occur, said ring members comprising means engaging the casing in a plane perpendicular to the rotor axis and intermediate the ends of the carrier to support the carrier in the casing.

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