

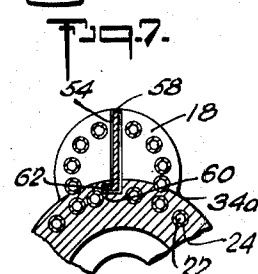
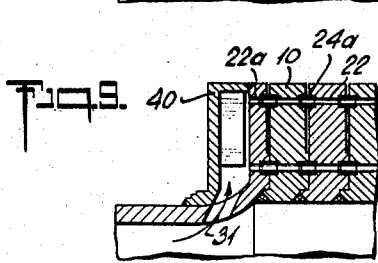
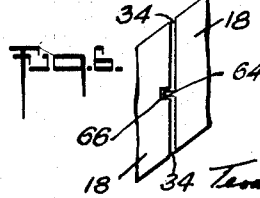
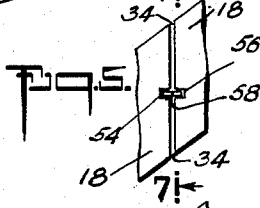
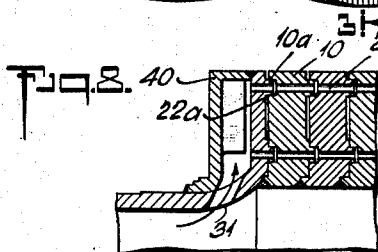
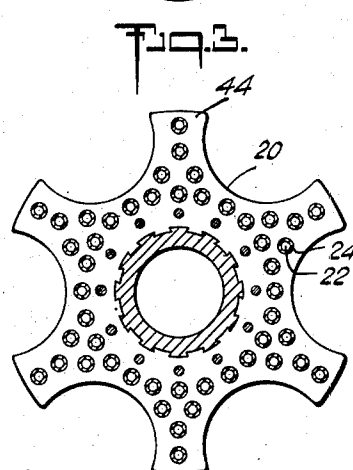
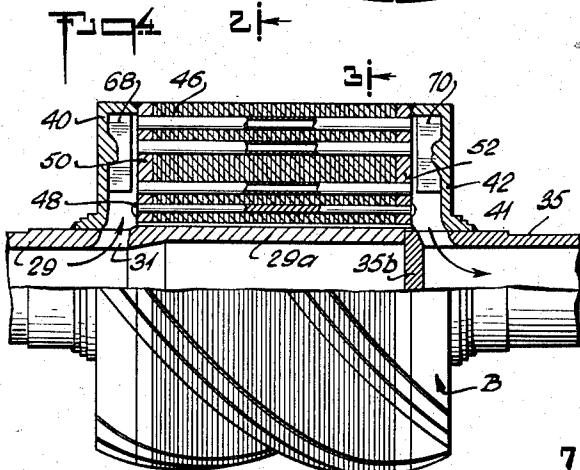
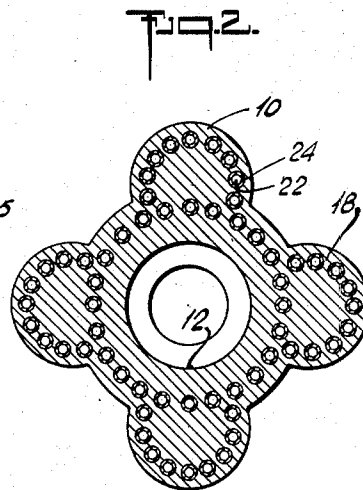
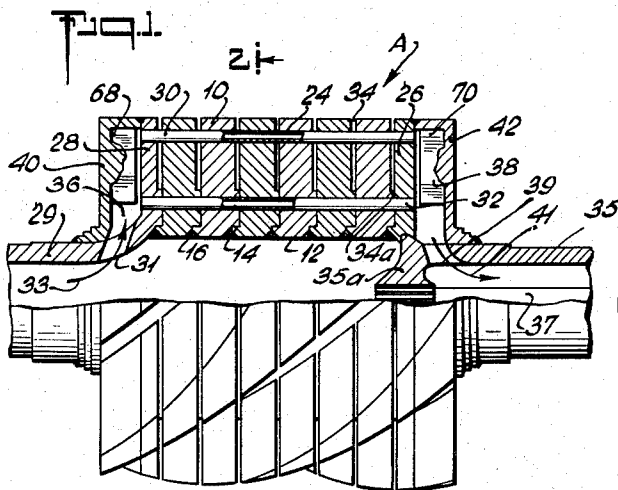
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COOLING OF MACHINE STRUCTURES

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2,801,792

COOLING OF MACHINE STRUCTURES

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22 Claims. (Cl. 230—210)

The present invention relates to the cooling of machine structures and has particular reference to the cooling of machine structures which in their normal operation are subjected to high temperatures of the order utilized in gaseous motive fluids employed for operating power generating prime movers. Still more particularly the invention relates to the cooling of rotary displacement machines of the kind in which rotors having intermeshing lands and grooves cooperate with a casing structure to form working spaces or chambers for fluid, and more specifically to that type of such machines in which the lands and grooves of the rotors are helical and form, with the casing, expansible working chambers varying in volume as the rotors revolve to provide for the expansion of gaseous motive fluid to produce power or to compress a gaseous fluid when the machine is utilized as a compressor.

Machines of the kind under consideration have successfully been employed as prime movers operated by gaseous fluid comprising products of combustion at very high temperatures, in excess of 2000° F. In the operation of such machines the cooling of the structure, particularly that of the rotors, in order to prevent heat distortion, constitutes a major problem, especially in the types of machine wherein as is often the case the intermeshing rotors have different profiles and the helical lands of different rotors have different angles of lead or wrap. Such heat distortion must be controlled within very close limits and if possible entirely eliminated if successful operation is to be achieved, since such machines ordinarily depend upon close clearances between the intermeshing parts to provide for so-called "space packing" for the working chambers, and any appreciable distortion will result either in loss of efficiency due to leakage resulting from the opening up of the clearance spaces, or damage to the machine due to closing of the clearance spaces and consequent rubbing of the parts, or both.

Since the invention has particularly advantageous utility in the construction of rotors in the components of power plants of the kind in which air is compressed in a compressor component, heated by combustion with fuel to provide hot motive fluid, expanded in a power component to produce the power required for compression and the net useful power, and is further employed, after compression but before heating, as a cooling fluid for cooling the power component, it will hereinafter be discussed and described in its application to such construction, it being understood however that the invention is not limited to the structure herein disclosed by way of example but is to be considered as embracing all structures coming within the scope of the appended claims.

For manufacturing and other reasons, experience has demonstrated that rotors of the kind under discussion may advantageously be built up of a number of axially contiguous sections of plate or disc like form, the thickness of which may vary considerably, that is, from very thin laminations to plates of substantial thickness as compared with their diameter, and as hereinafter employed the term

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"section," and derivatives thereof, except as they may be modified by the context, are to be understood as including parts of different thickness inclusive of very thin laminations. As heretofore constructed, the sections have usually been provided with central bores and also with a plurality of relatively smaller apertures adjacent to the perimetral surfaces, the latter being aligned when the sections are assembled to provide a plurality of channels for cooling fluid extending through the rotor adjacent to the working surfaces thereof. Such sections have been assembled by securing them together at or adjacent to the central bore, in some instances by welding, in others by screw threaded connection and in still others by mounting on a central sleeve engaging the bores.

With such construction, however, in which the sections are connected to each other only at or near the central or hub region, experience has shown that when the rotors are operated in contact with high temperature fluid, heat distortion occurs which tends to warp the sections sufficiently to open up small clearances between the faces of adjacent sections at the outer portions thereof. Such clearances are productive of several operating deficiencies the effect of which is disproportionate to the extent to which such clearances, which may be very small, are opened up. In most instances the fluids in the working chambers and in the cooling channels are at different pressures, this being necessarily the case when the fluid in the working chambers is expanded or compressed through a substantial pressure ratio, since the pressure of the cooling fluid is substantially constant along the length of the rotor while that of the working fluid may vary greatly from end to end of the rotor. Thus, the pressure of the cooling fluid may be less than that of the working fluid throughout the length of the rotor, the reverse may be the case, or one condition may be found along one part of the rotor while the other exists at another part. At those places where the pressure of the cooling fluid exceeds that of the working fluid, clearance between sections permits leakage of cooling fluid into the working chambers, and when the cooling fluid is a compressed component of the motive fluid of the system, even a relatively very small amount of such leakage materially affects the efficiency of plant, since the work of compression expended on the leaking fluid is largely lost. If on the other hand, the motive fluid is at higher pressure than the cooling fluid, hot motive fluid will leak into the cooling channels and such leakage not only represents power loss but also adversely affects the cooling effect by raising the temperature of the fluid in the cooling channels.

Additionally, clearance between the faces of adjacent sections permits flow of working fluid from one working chamber to an adjacent chamber at lower pressure which also adversely affects the efficiency of the machine.

To remedy these deficiencies, attempts have been made to hermetically seal the sections together at their peripheries, as by welding or the like, but such expedients have proved to be impractical for the reason that when subjected to very high temperature conditions, the internal heat stresses developed have been sufficient to break such welds or other sealing means.

It is therefore the general object of the present invention to improve upon prior constructions of the nature above discussed and to provide an improved construction of simple and practical nature in which a structure built up from a plurality of parts may be effectively cooled by a closed cooling system sealed against leakage. A further object is to provide an effectively cooled and sealed construction which at the same time permits the limited relative movement between adjacent parts necessary to relieve excessive heat stresses and to avoid cumulative distortion of the structure as a whole due to such stresses.

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For a better understanding of the manner in which the above and other objects of the invention may be attained and the advantages thereof secured, reference may best be had to the ensuing portion of this specification taken in conjunction with the accompanying drawings forming a part hereof, which, as previously noted, constitute a disclosure by way of example but without limitation of the invention.

In the drawings:

Fig. 1 is a longitudinal view, partly in elevation and partly in section of a rotor embodying the invention and of kind having helical lands and grooves, the sectional portion being warped into the plane of the paper for clarity of illustration;

Fig. 2 is a section taken on line 2—2 of Fig. 1;

Fig. 3 is a section, taken on line 3—3 of Fig. 4, of a rotor adapted to mesh with the rotor of Fig. 1 and of a different specific construction embodying the invention;

Fig. 4 is a view similar to that of Fig. 1 of the rotor of Fig. 3;

Figs. 5 and 6 are fragmentary plan views of land portions of rotors illustrating sealing means employed between adjacent sections in accordance with one aspect of the invention;

Fig. 7 is a fragmentary view taken on lines 7—7 of Fig. 5, and

Figs. 8 and 9 are fragmentary views of rotors similar to that shown in Fig. 1 and illustrating different specific forms of construction.

Referring now more particularly to Figs. 1 and 2 the rotor designated generally at A comprises a plurality of relatively thick metal plate sections 10 having central openings providing a bore 12, the sections being provided with centering flanges 14 and being welded together at 16. The outer peripheries of the sections are shaped to provide a plurality of generally convex lands 18 the sides of which are angularly related to the axis of the bore so that when the sections are assembled they provide a rotor body having helical lands and intervening grooves as indicated in the lower part of Fig. 1. The sections are further provided with a multiplicity of relatively small diameter apertures 22, the majority of which are, as shown, preferably located adjacent to the perimetral surfaces of the sections. These apertures are axially parallel with the adjacent surfaces, and when the sections are assembled are aligned to provide continuous channels paralleling and adjacent to the surfaces of the lands and grooves. As the plates are assembled, tubes 24 are inserted through the apertures 22 to provide continuous cooling conduits extending through the assembly. Since these tubes are directly cooled they need not be of high temperature resistant material and may be of relatively ductile metal readily accommodating itself to the shape of the helical channels. The tubes should be of such external diameter as to provide good heat transmitting contact with the walls of the apertures and preferably are fixed and sealed in the assembly by being expanded and/or rolled at their ends into the end sections 26 and 28 of the assembly, in the same manner as boiler tubes and the like are fixed to tube sheets. By this construction, any leakage to or from the cooling channels is prevented from their inlets 30 to their outlets 32, regardless of the presence or absence of clearance spaces 34 between the outer portions of the sections, which in the present embodiment are free to expand and contract independently of each other, the nature of the material and the manner of assembly of the tubes 24 permitting the very small amounts of differential expansion and contraction between adjacent sections that is all that is required in practice to avoid extreme internal stresses and cumulative distortion resulting therefrom.

In some instances, other means may be employed to provide for substantially fluidtight cooling channels, as for example by forming hollow projections 10a extending from one face of each section coaxially of the apertures 22 to be received in and tightly fit counterbores 22a

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in the confronting ends of the apertures in the adjacent section, as shown in Fig. 8. Fig. 9 illustrates still other means for securing substantially fluidtight cooling channels. In this embodiment counterbores 22a are provided in all of the confronting ends of the bores 22 and the clearance spaces between confronting faces of adjacent sections 10 are bridged by means of nipples 24a seated in the counterbores.

In the embodiment illustrated, the end section 28 is formed integrally with a hollow shaft part 29 and an annular end closure member 40 is welded to the end section to provide a distributing chamber 36 communicating with the inlets 30 of tubes 24 and to which cooling fluid is admitted through the hollow shaft part 29 and one or more ports 31 as indicated by the arrow 33. The section 26 at the opposite end of the assembly is welded to a hollow shaft member 35 having a hub part 35a at its inner end in which is secured a shaft for transmitting power from or to the rotor, as the case may be. A second end closure member 42 is welded to the structure to provide a chamber 38 communicating with the ends 32 of tubes 24 and providing for flow of cooling fluid from the rotor through ports 39 in shaft 35 and the annular space between the latter and shaft 37, as indicated by arrow 41, the hub portion 35a and shaft 37 forming a closure at one end of bore 12 to prevent flow of cooling fluid directly through the core of the rotor. Obviously the direction of flow of the cooling fluid may be the reverse of that shown.

It will be understood of course that the peripheral walls of the end closures 40 and 42 are shaped like those of the sections 10, so that the helical lands and grooves extend from end to end of the body portion of the rotor, as seen in the lower part of Fig. 1.

Referring now to Figs. 3 and 4, there is illustrated a rotor B adapted to mesh with the rotor of Fig. 1 and in which the peripheries of the rotor sections are shaped to provide lands 18 of generally concave profile with intervening grooves 20. The rotors shown are of known configuration and of the so-called male and female type in which the pitch circle coincides or approximately coincides with the envelope of the female rotor. Also, in the example shown the female rotor has six lands whereas the male rotor has only four, consequently the helix and angles of the lands of the two rotors are different. While such construction is well known and forms no part of this invention, it is illustrative of a desirable form of apparatus which because of the dissimilar form of the meshing rotors, presents difficulties of the kind which it is an object of this invention to overcome.

While the rotor B may be of the same construction as rotor A, it is employed herein to illustrate another form of construction embodying the principles of the invention.

In the present instance the rotor sections comprise a multiplicity of thin plates or laminations 46 clamped together between end plates 50 and 52 by means of through bolts or rivets 48 extending through holes in the inner or hub portions of the laminations. In the present construction the hollow shaft part 29 is provided with a hollow extension or sleeve portion 29a engaging the central openings in the laminations to center them and advantageously being splined as shown to properly locate the laminations peripherally and provide a force transmitting connection between the shaft and the laminations.

As in the previously described embodiment the laminations are perforated to provide cooling channels in which are located the cooling tubes 24 which are expanded into the end plates 50 and 52, and end closure members 40 and 42 providing end chambers 36 and 38 are welded to the structure as previously described. In order to aid in adequately cooling the end closure members 40 and 42, they may advantageously be provided with radially extending laterally ribs or fins 68 and 70, presenting extended heat dissipating surface to the cooling fluid.

Since the female rotor may act merely as a gate member for defining in part the working chambers, without transmitting power, the shaft 37 is omitted and the inner end of the hollow shaft 35 closed at 35b to prevent direct flow through the rotor core of the cooling fluid. The construction just described may of course be used equally well for rotors of the kind of rotor A shown in Fig. 1. Obviously many changes may be made in the constructional and assembly details of the component parts so far as the present invention is concerned, which for example does not preclude some central cooling if desired, by making the parts 35a and 35b perforate to some extent to allow flow through the central bore while at the same time providing the required obstruction to flow necessary to force the desired quantity of cooling fluid through the tubes 24.

As previously mentioned clearance between the faces of adjacent sections may result in leakage across the lands from one chamber to another at lower pressure and in accordance with another aspect of the invention this is avoided in a sectional construction where relative movement between adjacent sections is possible, by the provision of sealing means extending generally radially of the lands and between adjacent confronting faces.

As will be apparent from a consideration of Figs. 2 and 3 the severest heat stresses and the major portion of relieving movement required is in the outer or land portions of the sections and where sealing means as herein contemplated are to be employed the land portions of the sections may have a predetermined initial clearance provided between them by slightly relieving one or both faces of the sections over the area outside of the radius defining the perimeter of the peripherally continuous hub portions of the sections, that is, outside the circle 34a indicated in Figs. 1 and 7.

Leakage will occur across the lands, whether clearance is deliberately provided or results from heat distortion and to prevent such leakage adjacent faces may be radially slotted to provide confronting slots 54 and 56, as shown in Fig. 5, extending to the crests of the lands. These slots may advantageously be of rectangular cross section, as shown, and a sealing member 58 inserted therein of similar cross section and substantially filling the slots, sufficient axial clearance being left, however, between the sealing member and the bottoms of the slot to permit slight axial movement of the sealing member relative to the sections engaged by it and to keep the sealing member from acting as a wedge preventing relative movement of the confronting faces toward each other under the influence of heat and other stresses. Obviously the sealing member can extend radially inwardly as far as desired and may be anchored against radially outward displacement in any suitable fashion, as by providing a lateral projection 62 at its inner end to be received in a recess or groove 60 in either or both of the sections engaged by the member, as shown in Fig. 7.

Alternatively, the seal may be provided by making the sealing member integral with and in the form of a radial projection extending axially from one face of a section into a corresponding radial groove in the confronting face of the adjacent section, as shown at 64 and 66 in Fig. 6. In such case the depth of the groove should be at least as great and preferably slightly greater than the height of the projection to avoid any possibility of the projection acting as a wedging member for holding the confronting faces of the sections apart. While for clarity of illustration the sealing means of Figs. 5 and 6 has been omitted from the showing of Fig. 1, the invention contemplates the inclusion of such structure in the embodiment of Fig. 1.

Where very thin laminations constitute the sections, the arrangement of Fig. 5 becomes impractical; but since such laminations may be and usually are metal stampings, the arrangement of Fig. 6 may be utilized by stamping

radial ridges in the plates when they are formed, to provide the desired projections and grooves.

Obviously, the features of design herein disclosed may be combined in different ways, they may be incorporated in different structures, and certain features may be employed to the exclusion of others, without departing from the spirit or scope of the invention as defined by the appended claims.

What is claimed is:

1. In a machine of the character described, a component comprising an assembly of adjacent sections exposed to high temperature fluid during normal operation of the machine, there being joints between adjacent sections to permit relative movement between the sections due to expansion and contraction thereof and said sections each having a plurality of apertures extending therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid through the assembly and sealing means at said joints for preventing leakage of fluid to or from said channels at the joints between adjacent sections, said sealing means comprising a plurality of hollow projections on each of said sections extending into aligned counterbores in confronting apertures of adjacent sections.

2. In a machine of the character described, a component comprising an assembly of adjacent sections exposed to high temperature fluid during normal operation of the machine, there being joints between adjacent sections to permit relative movement between the sections due to expansion and contraction thereof and said sections each having a plurality of apertures extending therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid through the assembly and sealing means at said joints for preventing leakage of fluid to or from said channels at the joints between adjacent sections, said sealing means comprising a plurality of nipples seating in aligned counterbores in confronting apertures in said sections.

3. In a machine of the character described, a component comprising an assembly of adjacent sections exposed to high temperature fluid during normal operation of the machine, said sections each having a plurality of apertures extending therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid through the assembly and tubular elements extending through said channels in contact with the walls thereof and bridging the joints between adjacent sections to provide fluidtight linings for said channels.

4. In a machine of the character described, a component comprising an assembly of adjacent sections exposed to high temperature fluid during normal operation of the machine, said sections each having a plurality of apertures extending therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid through the assembly and tubular elements extending through said channels in contact with the walls thereof and bridging the joints between adjacent sections to provide fluidtight linings for said channels, said tubular elements being expanded in the end ones of said sections to provide fluidtight seals at the ends of the elements.

5. In a machine of the character described, a component comprising an assembly of adjacent plate-like sections exposed to high temperature fluid during normal operation of the machine, said sections each having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid through the assembly and tubular elements extending through said channels from end to end of said component and in contact with the walls thereof, said elements being sealed to the end ones of said sections.

6. In a machine of the character described, an assembly of adjacent relatively thin laminate sections and end sections of heavier material than said laminate sections, said sections being exposed to high temperature fluid during normal operation of the machine, each of said sections

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having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, and tubular elements extending through said channels in contact with the walls thereof and being sealed to said end sections.

7. In a machine of the character described, a component comprising an assembly of adjacent sections having surfaces exposed to high temperature fluid, confronting faces of adjacent sections in the region adjacent to said exposed surfaces having clearance therebetween and said confronting faces in the region more remote from said exposed surfaces being without clearance therebetween, said sections having a plurality of apertures therethrough in the first named region, said apertures being aligned to provide channels for cooling fluid extending through said assembly and means for bridging said clearance spaces to render said channels fluidtight from end to end.

8. In a machine of the character described, a component comprising an assembly of adjacent sections having surfaces exposed to high temperature fluid, confronting faces of adjacent sections in the region adjacent to said exposed surfaces having clearance therebetween and said confronting faces in the region more remote from said exposed surfaces being without clearance therebetween, said sections having a plurality of apertures therethrough in the first named region, said apertures being aligned to provide channels for cooling fluid extending through said assembly and continuous tubular elements extending through said channels in contact with the walls thereof and bridging the clearance spaces between adjacent sections to provide fluidtight liners for said channels from end to end thereof.

9. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having a plurality of apertures extending therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, and sealing means bridging the joints between adjacent sections for rendering said channels fluidtight at the joints between adjacent sections.

10. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having a plurality of apertures extending therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, and continuous tubular elements extending through said channels in contact with the walls thereof to provide fluidtight passages from end to end of the assembly.

11. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having confronting faces spaced apart to provide clearances between adjacent land portions and having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, and sealing means associated with each of said channels for bridging the clearance spaces between the sections to provide continuous fluidtight passages for the cooling fluid from end to end of the assembly.

12. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having confronting faces spaced apart to provide clear-

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ances between adjacent land portions and having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, and tubular elements extending through said channels in contact with the walls thereof and bridging said clearance spaces to provide continuous fluidtight passages for the cooling fluid from end to end of the assembly.

13. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having confronting faces spaced apart to provide clearances between adjacent land portions and having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, and tubular elements extending through said channels and sealed to the end ones of said sections to provide continuous fluidtight passages from end to end of the assembly for said cooling fluid.

14. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having confronting faces spaced apart to provide clearances between adjacent land portions and having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, sealing means engaging the walls of each of said channels for bridging the clearance spaces between the sections to provide continuous fluidtight passages for the cooling fluid from end to end of the assembly, and sealing means extending generally radially of said land portions and bridging the clearance spaces therebetween to prevent flow of fluid peripherally between adjacent land portions.

15. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having confronting faces spaced apart to provide clearances between adjacent land portions and having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, sealing means engaging the walls of each of said channels for bridging the clearance spaces between the sections to provide continuous fluidtight passages for the cooling fluid from end to end of the assembly and sealing means extending generally radially of said land portions and bridging the clearance spaces therebetween to prevent flow of fluid peripherally between adjacent land portions.

16. A rotor for a machine of the character described comprising a body portion including an assembly of adjacent sections each having a peripherally continuous hub portion and a plurality of peripherally spaced land portions extending from the hub portion, said land portions having confronting faces spaced apart to provide clearances between adjacent land portions and having a plurality of apertures therethrough, said apertures being aligned to provide a plurality of channels for cooling fluid extending through the assembly, sealing means engaging the walls of each of said channels for bridging the clearance spaces between the sections to provide continuous fluid tight passages for the cooling fluid from end to end of the assembly, and sealing means extending generally radially of said land portions and bridging the clearance spaces therebetween to prevent flow of fluid peripherally between adjacent land portions, the last mentioned sealing means comprising a projection extending from a face of one land portion and a confronting groove in the face of the adjacent land portion receiving said projection.

17. In a rotor of the character described, a body portion comprising an assembly of adjacent sections each having a hub portion and a plurality of peripherally spaced land portions, the confronting faces of adjacent land portions being spaced apart to provide clearance therebetween, and sealing means extending generally radially of said land portions for bridging the clearance spaces therebetween to prevent flow of fluid peripherally between adjacent land portions.

18. In a rotor of the character described, a body portion comprising an assembly of adjacent sections each having a hub portion and a plurality of peripherally spaced land portions, the confronting faces of adjacent land portions being spaced apart to provide clearance therebetween, and sealing means extending generally radially of said land portions for bridging the clearance spaces therebetween to prevent flow of fluid peripherally between adjacent land portions, said sealing means comprising confronting grooves in adjacent land portions and sealing members extending into each of the confronting grooves.

19. A rotor as defined in claim 18, in which said sealing members are movable in at least one of cooperating grooves to permit adjacent land portions to move toward and away from each other.

20. A rotor of the character described comprising a hollow shaft structure and a body portion carried by said shaft structure, said body portion comprising an assembly of adjacent sections and end members at the ends of said assembly, said end members and said sections being rigidly fixed relative to said shaft structure, said sections each comprising a hub portion and a plurality of peripherally spaced land portions extending from the hub portion and said land portions having a plurality of sets of aligned apertures therethrough providing channels for flow of

cooling fluid through the land portions of the assembly, tubular elements extending through said channels in contact with the walls thereof and sealed to the end sections of the assembly, said end members providing chambers at the ends of the rotor body communicating respectively with the opposite ends of said channels, and means providing communication between said hollow shaft structure and the respective chambers, to provide a path of flow for cooling fluid to and from the rotor and through said chambers and cooling channels.

21. A rotor as defined in claim 20, in which confronting faces of the land portions of adjacent sections are separated to provide clearance spaces permitting relative movement between the land portions to relieve internal stresses developed by high temperature operation, said tubular elements bridging said clearance spaces.

22. A rotor as defined in claim 21 including sealing means extending generally radially of said land portions and bridging said clearance spaces to prevent flow of fluid peripherally across the lands through the clearance spaces.

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