Oct. 7, 1969 C. W. EMMERSON 3,471,127

TURBOMACHINE ROTOR

Filed Dec. 8, 1966 2 Sheets-Sheet 1

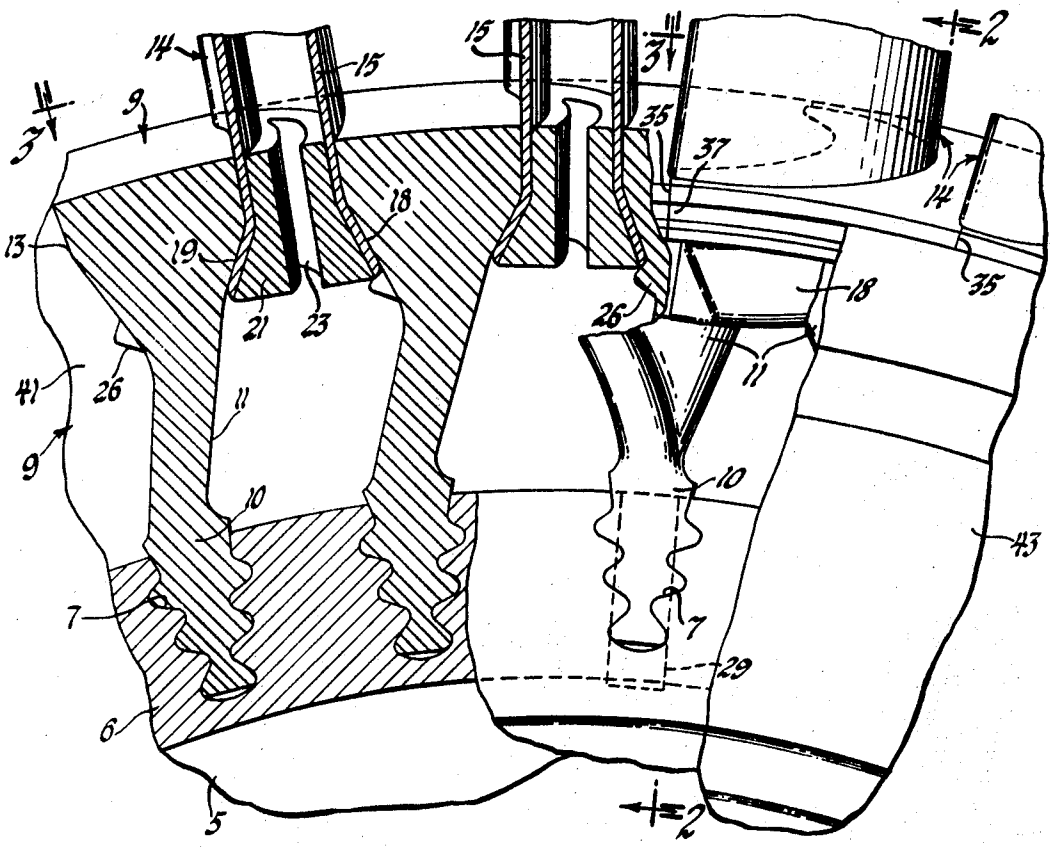


Fig. 1

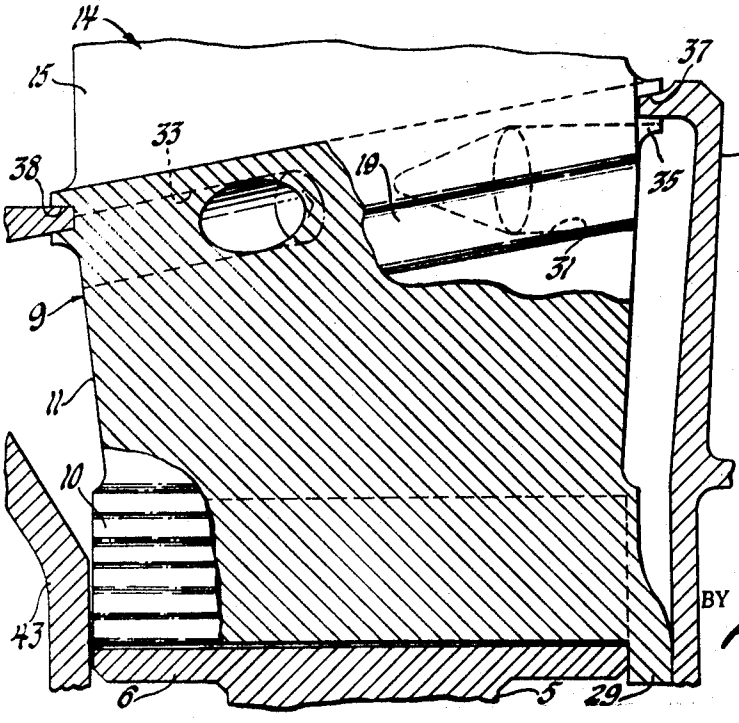


Fig. 2

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TURBOMACHINE ROTOR

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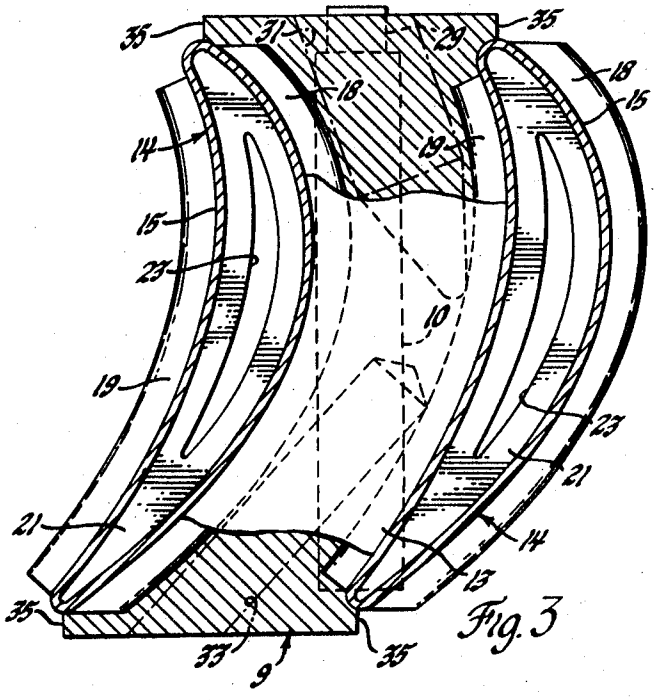


Fig. 3

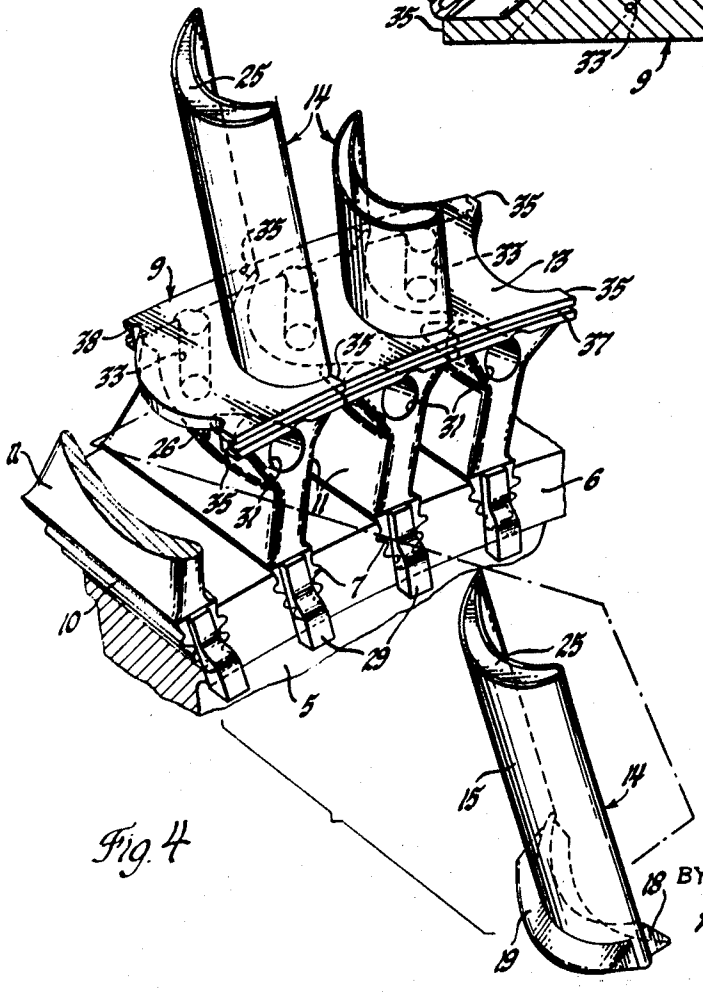


Fig. 4

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TURBOMACHINE ROTOR

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U.S. Cl. 253—39.15 2 Claims

ABSTRACT OF THE DISCLOSURE

A turbine wheel with sheet metal blades having flaring feet of similar contour to the blade airfoil, the feet being reinforced by a plug having a cooling air inlet. The feet are retained in mating recesses defined between the edges of adjacent blade platforms, which are integral with stalks and roots mounted in the wheel.

My invention relates to turbomachines, particularly to rotor structures with sheet metal blades. The use of sheet metal blades is desirable from the standpoints of ease of fabrication and economy of materials, and is particularly desirable for high temperature turbines in which the blades are to be cooled.

Because of the high centrifugal force exerted on turbine blades and the high temperatures at which they operate, the attachment of sheet metal blades to turbine rotors is difficult. Various arrangements have been proposed, including welding the blades to the rim of the wheel and welding or otherwise bonding sheet metal blades to a central stalk or the like extending through the blade and integral with the blade root. The first does not provide for removable blades, and the second creates undesirable weight.

A.S.M.E. paper 65–WA/GTP–10 entitled "Analysis and Testing of Air-Cooled Turbine Rotor and Stator Blades," by H. E. Helms and this applicant refers to a porous laminated metal particularly suited for cooled blades, including transpiration-cooled blades. It illustrates one form of turbine blade in which the sheet metal is attached to a central core extending through the blade.

It is common practice in high temperature turbines to isolate the turbine wheel rim from the hot motive fluid by providing blade platforms which extend from the sides of the blades and define a ring extending around the wheel rim and spaced from it. In such installations, the operative portion of the blade and the blade platform are connected to the root which mounts in the wheel by a stalk.

It has occurred to me that by adapting some of the principles disclosed in United States Patent No. 3,132,841 of Wilder for "Compressor Blade and Manufacture Thereof" to a turbine, the mounting of sheet metal blades can be much improved. In brief summary, my concept is that the sheet metal blades have laterally flaring feet integral with the sheet metal airfoil portion of the blade and a plug within the foot of the blade to reinforce and support the flare of the blade metal. Further, the blades thus constructed will be mounted on the wheel by being lodged in recesses in the adjoining edges of blade platforms which are separate from the blades and extend from one blade to the next. The stalks and roots will be integral parts of the blade platform. Thus, the blade root, stalk, and platform are one piece and the blade airfoil is a second piece mounted between and held by two adjacent platforms.

The nature of the invention and its advantages will be clear to those skilled in the art, particularly in view of the succeeding detailed description of the preferred embodiment of the invention and the accompanying drawings thereof.

FIGURE 1 is a view, with parts cut away and in section, of the rim portion of the rear or trailing face of a turbine wheel.

FIGURE 2 is a transverse sectional view, with parts broken away, taken on the plane indicated by the line 2—2 in FIGURE 1.

FIGURE 3 is a partial sectional view taken on the plane indicated by the line 3—3 in FIGURE 1 with parts broken away.

FIGURE 4 is a composite axonometric view further illustrating the wheel rim and blade attachment.

The turbine rotor structure illustrated comprises a wheel or disk **5** which may be considered as illustrative of my suitable rotor structure with an axially extending rim **6**. Blade slots **7** of any conventional type, such as the usual fir tree slot, extend across the rim. Intermediate members **9**, which will be called mounts for conciseness, are disposed in a ring around the turbine wheel rim. Each mount comprises a multiple dovetail root **10**, a stalk **11**, and a circumferentially extended platform **13**. As will be apparent, this arrangement of the root, stalk, and platform is similar to the mounting of conventional stalked turbine blades. A turbine blade **14** is mounted between each two adjacent platforms **13**. Each blade comprises an airfoil portion **15** of formed sheet metal and a foot **17**. The foot is defined by diverging flanges or flares **18** and **19** extending from the cambered convex and concave faces of the blade airfoil **15**. The foot also includes a plug **21**, the form of which is clearly apparent from FIGURES 1 and 3, which includes a radially outer portion fitting within the radially inner portion of the unflared portion of the blade skin and a tapering portion which fits between and supports the flanges **18** and **19**.

Thus, the plug **21** will support the flanges against forces tending to press them together and flatten the blade which result from centrifugal force tending to throw the blade from its mounting between the platforms. Since, however, the metal of the blade continues integrally into the outer portion of the foot, the tensile pull on the blade wall **15** is taken directly by flanges **18** and **19**. The plugs **21** may be welded or otherwise bonded to the blade for retention and for additional reinforcement of the blade.

The plug **21** has a radial passage **23** through it which is provided to conduct cooling air from below the platforms into the hollow blade. The upper end of the blade is closed by a sheet metal cap **25** or otherwise. Although this is not necessarily material to the mounting of the blade, in the preferred embodiment of the invention the blade is a porous metal structure adapted for cooling by diffusion of air through numerous small holes or pores distributed over the surface of the airfoil.

The blades **14** should be restrained from movement radially toward the wheel which would cause unbalance in starting up the turbine. This may be accomplished by small bosses **26** extending from the stalks **11**.

Returning now to the mounts **9**, it may be noted that each includes an integral tang **29** which is adapted to lodge against the forward face of the rim to locate the platform axially of the wheel. Also, in order to lighten the structure of the outer and thicker portions of the mounts, holes may be drilled or provided by casting; the hole **31** extending rearwardly from the leading face and the hole **33** extending forwardly from the trailing face.

It may be seen, as shown most clearly in FIGURE 3, that the side margins of the platforms conform to the blade and extend part way around the leading and trailing edges of the blades to provide portions **35** at which the adjacent platforms meet at the edges of the blade. It may be further noted that the leading and trailing edges of the platforms define circumferential grooves **37** and **38**, respectively. These grooves receive the edges of sealing shrouds fixed to the two faces of the rotor, a shroud **41**

at the leading face of the rotor bearing against the tangs **29** and a shroud **43** mounted on the trailing face of the rotor wheel which bears with slight clearance against the rear face of the rim and the rear end of roots **10**. The shrouds **41** and **43** may be fixed to the wheel by bolts (not shown) or in any other manner. Their interlocking engagement with the grooves in the platforms stiffens the assembly, and the sealing shrouds serve other functions. They include ribs which cooperate with adjacent fixed parts of the turbine to provide the usual interstage seals. Further, they define with the outer surface of the wheel rim, the blade platforms, and the inner ends of the blades a circumferential space **45** for cooling air which may flow into the blades through the passages **23**. The air may flow from a suitable source into the space between the shroud **41** and the wheel and through the spaces between tangs **29** into the space **45** from which it is exhausted into the blade.

It will be seen that the structure provides all of the structural advantages of the usual stalked blade and wheel assembly with shrouds to close off the area under the blade platforms, with the additional advantage of a strong and highly suitable structure for mounting lightweight sheet metal blades. The sheet metal blades, by use of a material such as that mentioned in the A.S.M.E. paper referred to above, can be particularly adapted for cooling and may be securely mounted, notwithstanding the more fragile character of the porous metal. Of course, the portion of the sheet metal which is impinged within the platforms and the plugs **21** will ordinarily be non-porous so as to provide maximum resistance to compression.

The assembly of the structure presents no problems; the blades may be mounted between the platforms in a suitable fixture and then the entire ring is pushed onto the wheel, or the wheel is lowered into the rim and mounts. In the event of damage, any individual wheel or mount is replaceable.

The description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

The term "wheel" is used in the appended claims for convenience and is intended to include any suitable rotatable support such as a wheel, annular disk, or drum, for example.

I claim:

1. A rotor for a turbomachine comprising, in combination, a wheel having a periphery, a circumferential row of intermediate members mounted on the periphery, each intermediate member comprising a root removably connected to the wheel, a stalk extending radially of the wheel from the root, and a platform extending circumferentially of the wheel from the end of the stalk remote from the wheel, each platform extending to the next adjacent platforms so that the platforms define a ring spaced from the wheel; and a circumferential row of blades extending from the ring, each blade including a cambered airfoil section and having an integral foot flaring circumferentially of the wheel from the cambered faces of the airfoil section and abutting two adjacent platforms, the radially outer end of the blade foot having the same cross-section as the adjacent portion of the blade airfoil and the foot having a substantially constant divergence from said outer end toward the radially inner end of the foot, the margins of the platforms being contoured to define blade-mounting recesses shaped so as to fit the feet of the blades and retain each blade between contiguous platforms, the platform defining the inner boundary of the motive fluid path through the row of blades; each blade comprising a porous sheet metal skin defining the airfoil section, the skin extending integrally to define the sides of the foot and a plug disposed within and united to the skin at the blade foot and reinforcing the flare of the foot, the plug defining an air entrance into the airfoil section.

2. A rotor for a turbomachine comprising, in combination, a wheel having a periphery, a circumferential row of intermediate members mounted on the periphery, each intermediate member comprising a root removably connected to the wheel, a stalk extending radially of the wheel from the root, and a platform extending circumferentially of the wheel from the end of the stalk remote from the wheel, each platform extending to the next adjacent platforms so that the platforms define a ring spaced from the wheel; and a circumferential row of blades extending from the ring, each blade including a cambered airfoil section and having an integral foot flaring circumferentially of the wheel from the cambered faces of the airfoil section and abutting two adjacent platforms, the radially outer end of the blade foot having the same cross-section as the adjacent portion of the blade airfoil and the foot having a substantially constant divergence from said outer end toward the radially inner end of the foot, the margins of the platforms being contoured to define blade-mounting recesses shaped so as to fit the feet of the blades and retain each blade between contiguous platforms, the platforms defining the inner boundary of the motive fluid path through the row of blades; and sealing shrouds extending from the faces of the rims to the margins of the platforms so as to define with the rim and platforms an annular cooling fluid space, each blade defining a passage from the said space into the blade, and with a circumferential dovetail connection opening axially of the wheel between each shroud and the platforms.

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U.S. Cl. X.R.

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