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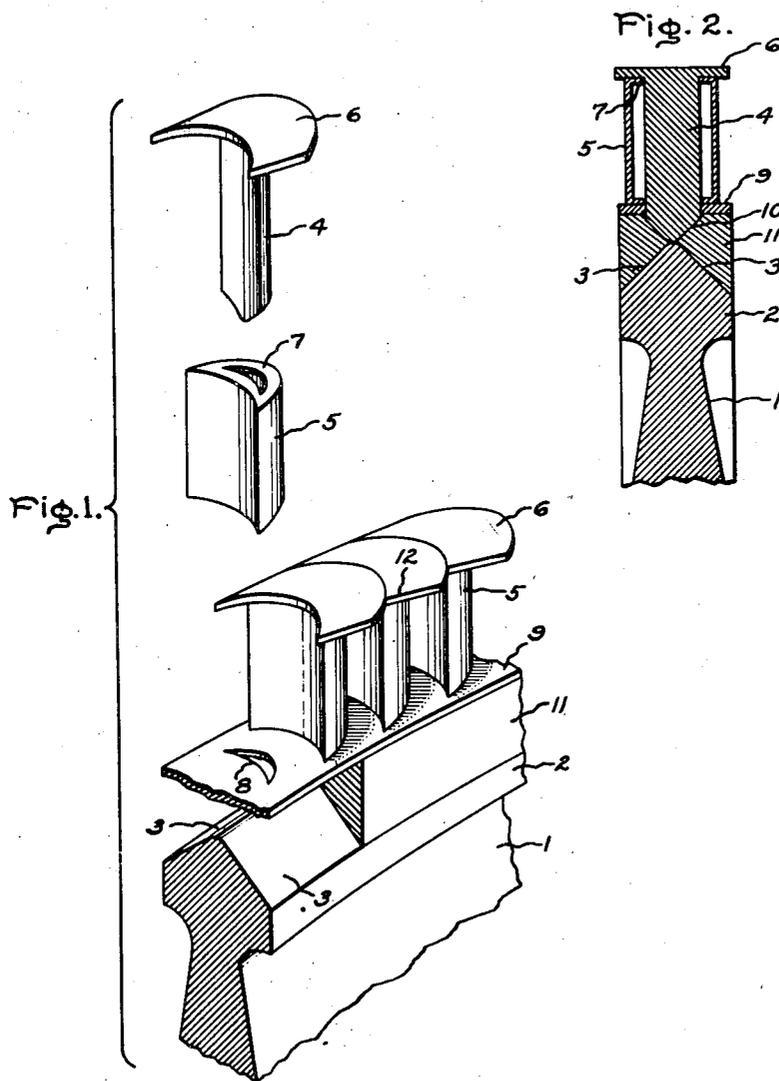
D. J. BLOOMBERG

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BUCKET STRUCTURE FOR HIGH-TEMPERATURE TURBOMACHINES

Filed Sept. 21, 1944

2 Sheets-Sheet 1



Inventor:
David J. Bloomberg,
by *Harry E. Druehm*
His Attorney.

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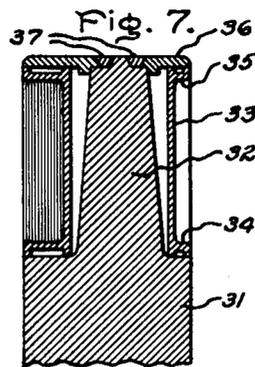
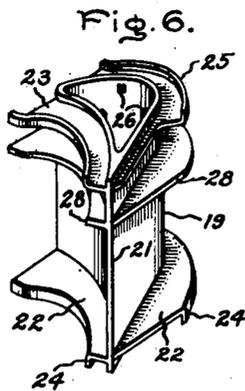
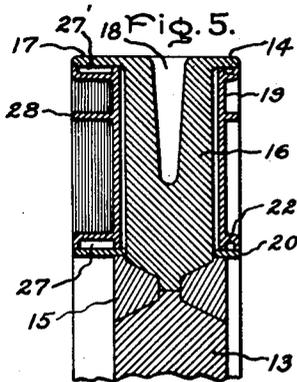
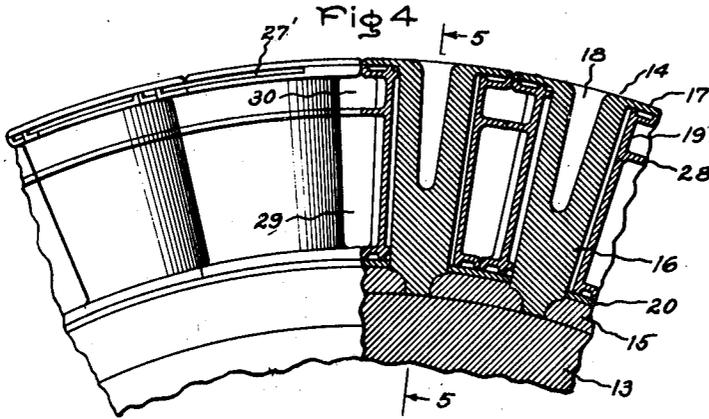
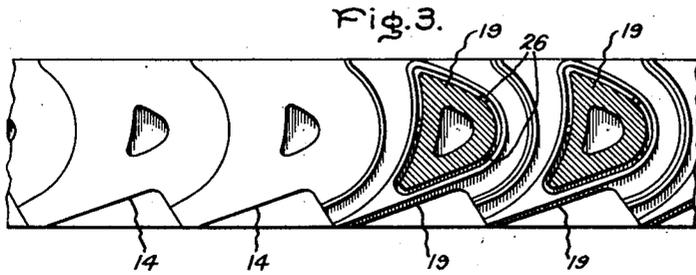
D. J. BLOOMBERG

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BUCKET STRUCTURE FOR HIGH-TEMPERATURE TURBOMACHINES

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Inventor:
David J. Bloomberg,
by *Harry E. Jenkins*
His Attorney.

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BUCKET STRUCTURE FOR HIGH-TEMPERATURE TURBOMACHINES

David J. Bloomberg, Newton, Mass., assignor to General Electric Company, a corporation of New York

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11 Claims. (Cl. 253-77)

1

The present invention relates to turbine bucket wheels and like bladed bodies having a disk or support and a plurality of circumferentially spaced buckets, partitions or like blade members attached thereto. The invention is of particular interest in connection with bucket wheels for gas turbines subject to high temperatures, for example, temperatures of the order of 2000° F. The operation at such high temperatures requires the use of special materials, for instance alloys like "Stellite" capable of withstanding high temperatures. Such materials, however, have the drawback that they either cannot be welded at all or are difficult to weld. Therefore, in the past it has been suggested that the entire bladed body or bucket wheel be made from a single integral piece, which is most difficult and expensive to produce.

The object of my invention is to provide an improved construction of bucket wheels and like bladed bodies which may be operated at high temperatures and can be readily produced at reasonable cost.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto in connection with the accompanying drawing.

In the drawing Fig. 1 illustrates a perspective view, partly in section and partly exploded, of a bucket wheel embodying my invention; Fig. 2 is a section of the wheel of Fig. 1; Figs. 3 and 4 are top and front views of a modification according to my invention; Fig. 5 is a section along line 5-5 of Fig. 4; Fig. 6 is a perspective view of a part of Fig. 4; and Fig. 7 illustrates another modification according to my invention.

The bucket wheel arrangement of Figs. 1 and 2 comprises disk or support 1 having an outer rim 2 with a V or wedge-shaped radially extending portion forming oppositely inclined walls 3. A plurality of circumferentially spaced blades are secured to the rim of the wheel. Each blade according to my invention comprises an inner stud or core 4 and an outer shell 5. In the present example the core is provided with an integral cover or shroud portion 6 and the hollow shell has end portions with inwardly extending projections or flanges 7 loosely engaging the outer surface of the core 4 and acting to position the shell 5 relative to the core 4. Each core has an inner portion projecting through one of a plurality of circumferentially spaced openings 8 in a band or ring 9, which latter acts as a spacer between the cores and a means for accurately circumfer-

2

entially spacing and positioning the cores. The inner ends of the cores or studs have oppositely inclined surfaces 10 forming V-shaped grooves on opposite sides of the cores and the rim, which grooves are filled with welding material 11 to fuse and integrally unite the cores with the rim 2 of the disk 1. The outer ends of the shells 5 engage the corresponding cover portions 6 of the cores and the inner ends of the shells engage the outer surface of the band 9. When assembled the cover portions 6 form a continuous band or cover for the bucket wheel, which bands together with the walls of adjacent buckets and the inner band 9 define bucket passages for receiving and conducting gases or like elastic fluid. Often such gas turbines are operated not only at high temperatures but also at high speeds of the order of 20,000 R. P. M., for example, when used as parts of turbosuperchargers for aircraft. In order to reduce the centrifugal stresses on the core to a minimum, portions of the covers 6 are cut away near the outlets of the bucket passages. More specifically, portions of the covers beyond the throats of the bucket passages are removed because the passage beyond the bucket throat does not do any work during operation and the outer cover beyond the throat therefore is not needed. Thus, the covers form a continuous band or shroud with a continuous circular inlet edge and a discontinuous or saw-toothed outlet edge. Each saw-tooth has an edge portion 12 which extends substantially perpendicularly between the outlet edge of one bucket toward the back of an intermediate portion of an adjacent bucket.

With an arrangement of this kind the best material suited for the shell and core respectively may be selected. The shell, which is subject to high temperatures and high compressive stresses, is preferably made from a high temperature-resistant material having good compressive strength, such as an alloy like "Stellite." Such material need not be capable of being welded because the shell is loosely held between the cover 6 and the ring 9. The core or stud, on the other hand, is preferably made from a material with high tensile strength suitable for welding and for withstanding moderately high temperatures, such as a ferrous alloy. The ring 9, which acts as a means for spacing the buckets and to separate the shells from the weld 11, may be made from any suitable material that can be readily welded, such as a ferrous alloy. The bucket shell 5 is mainly subjected to compression stress whereas the core is mainly subjected to tensile and bending stresses caused by centrifugal force

3

and by forces transmitted to the cover 6 by the shell. The air space between the shell and the core acts as a heat insulator between the two, protecting the core or stud from the high temperatures to which the shell is subjected. Those skilled in the art will understand that in operation the wheel disc 1 is strongly cooled (as illustrated for instance in United States patents to Gibson 2,234,757 and Clarke 2,269,181), and heat flows readily from the studs 4 to the wheel disc. This conduction cooling, plus the "high resistance heat path" from shell to stud (by reason of the air-space between and the small area of metal-to-metal contact), gives the desired temperature differential.

During manufacture the shells are first assembled with the cores and the cores then are inserted into openings 8 of the ring 9. At this stage the space between the ends of the studs 10, projecting thru band 9, are welded together, forming a continuous ring. This ring is then machined to shape as shown in Fig. 2. Thereupon the assembled bucket ring structure is placed around the rim 2 and the opposite grooves between them are filled with welding material to produce the welds 11.

The modification of Figs. 3 to 6 inclusive comprises a support or disk 13 and a plurality of bucket assemblies 14 secured to the disk 13 by a weld 15. Each bucket assembly comprises a core 16 corresponding to the core 4 of Fig. 2 and provided with an integral cover 17 corresponding to the cover 6 of Fig. 2. Each core has a central opening 18 such that the cross-sectional area of the core increases radially inward. A core of this kind is light in weight and can be designed to have substantially uniform stress characteristics throughout its length. The bucket structure in addition includes a shell 19 surrounding the core 16 and held between the cover 17 and an inner perforated ring 20 corresponding to the ring 9 of Fig. 2.

In the arrangement of Figs. 1 and 2 the bucket passages were partly formed by the covers of the cores and the ring 9 which both are preferably made from a ferrous material not particularly suited for high temperature operation. In contrast thereto in the arrangement of Figs. 3 to 6 inclusive the bucket passage is defined solely by walls made from high temperature-resistance material, such as an alloy like "Stellite." To this end each bucket shell has flanged portions which together with corresponding portions of an adjacent shell form bottoms and tops or roofs of the bucket passage. Thus, the shell, as best shown in Fig. 6, comprises a blade or body portion 21 which has inner and outer flanges 22 and 23 respectively slightly spaced from the inner and outer ends of the blade portion 21. Each flange has a turned end portion; the inner flanges 22 have inwardly turned end portions 24 and the outer flanges 23 have outwardly turned portions 25 which when assembled engage corresponding flange portions of adjacent shells and also the outer cover 17 and the inner ring 20 respectively. The shell is spaced from the core by means of circumferentially spaced projections 26 within the hollow blade portion 21. The inner flanges 22 and the inwardly turned portions 24 thereof together with the inner ring 20 form spaces 27 so as to reduce the direct metal-to-metal contact between the shell and band 28 and thereby reduce heat transfer from the shell to the inner ring 20. Likewise, the outer flanges 23 and the upwardly turned portions 25 form together with the cover 17 spaces 27

4

for reducing heat transfer from the outer flanges to the covers 17. When assembled the inlet edges of the covers 17 and the corresponding edges of the outer flanges 23 are aligned whereas the outlet edges of the cover 17 and the flanges 23 are cut away or saw-toothed in the manner described in connection with Figs. 1 and 2 in order to relieve the cover 17 from excessive tensile and bending stresses.

In certain cases it is desirable to subdivide radially the bucket passages, that is, to separate inner and outer portions of said passages and to pass fluids of different temperatures through the separated portions of the passages. This may be readily accomplished in the present example by providing the bucket shell or blade with intermediate flanges. Thus, in the present example the blade portion 21 has intermediate flanges 28 on opposite sides thereof arranged to engage corresponding intermediate flanges of adjacent shells, thereby defining with the remaining portions of the shells an inner passage 29 and an outer passage 30 (Fig. 4). A bucket shell of this kind is a rather complicated structure but may be produced by modern precision casting methods.

As in the arrangement previously described, the shell with its integral inner, outer, and intermediate flanges is made from a cast material of high heat-resistance, such as "Stellite," whereas the core and disk are made from ferrous alloys having good tensile strength and ductility.

The modification of Fig. 7 comprises a disk 31 with a plurality of circumferentially spaced cores 32 integrally formed with the disk and preferably made from a ferrous alloy with high tensile strength. Each core is surrounded by a shell 33 suitably positioned relative to the core and made from high temperature-resistant material. The shell has inner and outer flanges 34 and 35 for engaging the corresponding flanges of adjacent shells to produce complete bucket passages therewith. In this arrangement the various shells are held radially inward by means of a separately manufactured bucket cover or shroud 36 fused to the cores 32 by welds 37. During manufacture the shells are first assembled on the cores and thereafter the cover 36 is fused to the cores by the provision of the welds 37.

Having described the method of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Turbo-machine bucket wheel comprising a disk, a ring with a plurality of circumferentially spaced openings concentrically spaced from the disk, a plurality of buckets each including a core with an integral cover and an inner end portion projecting through one of said openings and secured to the disk, and a shell located between the ring and the cover surrounding and spaced from the core to define a heat insulating air-space therebetween.

2. Turbo-machine bucket wheel comprising a disk, a ring with a plurality of circumferentially spaced openings concentrically spaced from the disk, a plurality of buckets each including a core with an integral cover and an inner end portion projecting through one of said openings and secured to the disk, and a shell located between the ring and cover and surrounding and spaced from the core to define a heat insulating air-space

5

therebetween the covers of adjacent buckets engaging each other to form a shroud band with a continuous inlet edge and a saw-toothed outlet edge.

3. A bucket wheel comprising a disk with a rim, a ring with circumferentially spaced openings concentrically spaced from the rim, a plurality of circumferentially spaced buckets each having a core with an outer cover and an inner portion projecting through an opening towards the rim, and a shell surrounding the core and spaced therefrom to define a heat insulating air-space and having inner projections engaging the core to maintain proper spacing therebetween, each shell having laterally extending inner, outer and intermediate flanges engaging corresponding flanges of adjacent shells and forming therewith separate radially spaced bucket passages, the inner flanges having inwardly turned edges engaging the ring and forming insulating spaces therewith and the outer flanges having outwardly turned edges engaging the respective covers and forming insulating spaces therewith, and welds fusing the inner ends of the cores to the rim and the ring.

4. In a bladed body for use as a turbo-machine bucket wheel and the like, the combination of a support member and a blade structure, said blade structure including a plurality of circumferentially spaced buckets each having a core with a cover secured to one end, a shell surrounding and spaced from the core to define a heat insulating air-space therebetween, a ring member arranged concentric with and radially spaced from the support member and having circumferentially spaced openings through which the other ends of the cores project, and circumferential welds securing said other ends of the cores to the support member and to the ring, said ring being adapted to both space the ends of the cores and to serve as a dam during the welding operation.

5. A turbo-machine bucket wheel for high temperature operation comprising a disk, a ring with a plurality of circumferentially spaced openings concentrically spaced from the disk, a plurality of buckets each including a core with a cover portion and an inner end portion projecting through one of said openings, means securing said inner end portion to the rim of the disk, and a shell supported between the ring and the cover and surrounding and spaced from the core to define a heat insulating air-space therebetween, said shell being made from high heat-resistant material and having portions engaging the core to hold the shell in spaced relation with the core with a minimum contact area therebetween.

6. In a turbo-machine blade structure for high temperature operation, the combination of a blade support member and a circumferential row of bucket structures each including a core with one end secured to the support member, a cover member secured to the other end of the core, and a shell member held between the cover and the support member and surrounding and spaced from the core substantially around the periphery thereof to reduce heat conduction therebetween, the shell having portions engaging the core and related parts with minimum contact area and being made of high temperature resisting material.

7. In a turbo-machine blade structure for high temperature operation, the combination of a blade support member and a circumferential row of bucket structures, a band having a plurality of circumferentially spaced openings and arranged concentric with and radially spaced from the sup-

6

port member, each of said bucket structures including a core with a first end portion projecting through one of said openings and secured to the support member and a second end portion carrying a cover member, a shell held between the cover and the band and surrounding the core and spaced therefrom to define a heat-insulating air-space, the shell having end portions engaging the core and related parts with a minimum contact area and adapted to maintain the shell properly spaced therefrom while keeping the conduction of heat therebetween to a minimum.

8. In a turbo-machine blade structure for high temperature operation, the combination of a blade support member, a ring member having a plurality of circumferentially spaced openings and arranged concentric with and radially spaced from the support member, a plurality of buckets each having a core with a first end portion projecting through one of the openings in said ring and secured to the support member, a cover member secured to the other end of the core, and a shell member held between the cover and the ring and surrounding the core and spaced therefrom to define a heat-insulating air-space therebetween, the shell having radially inner and outer flanges extending laterally from the shell and cooperating with corresponding flanges of adjacent shells to form the radially inner and outer walls of the fluid flow path respectively.

9. In a turbo-machine blade structure for high temperature operation, the combination of a blade support member and a plurality of circumferentially spaced bucket structures each including a core secured at one end to the support member, a cover member secured to the other end of the core, and a shell surrounding the core and spaced therefrom to define a heat-insulating air-space therebetween substantially around the periphery of the core, the shell having inner and outer laterally extending flanges adapted to cooperate with corresponding flanges of adjacent shells to form the radially inner and outer walls respectively of the bucket passage, said flanges having raised edge portions for engaging the cover and support member respectively with a minimum contact area to form additional heat-insulating air-spaces therebetween.

10. In a turbo-machine blade structure for high temperature operation, the combination of a support member with a circumferential row of bucket members each including a core with a first end portion secured to the support member and a second end portion secured to a cover member, and a shell of temperature resisting material held between the support member and the cover and surrounding and spaced from the core substantially around the periphery thereof to define a heat-insulating air-space therebetween, the shell having portions engaging the core and related parts to maintain proper spacing therebetween while providing a minimum contact area to reduce transfer of heat by conduction.

11. A bucket wheel comprising a disk with a rim, a ring with circumferentially spaced openings surrounding and radially spaced from the rim, a plurality of circumferentially spaced buckets each including a core with an outer end portion secured to a cover member and an inner end portion projecting through one of said openings toward the rim, and a shell member surrounding the core and having inwardly extending portions engaging said core to maintain proper spacing therebetween, the shell having laterally extending inner and outer flanges cooperating

7

with corresponding flanges of adjacent shells to form the respective inner and outer walls of the bucket flow paths, the inner flange having edge portions turned radially inwardly and engaging the ring to form insulating air-spaces therewith and the outer flange having radially outwardly turned edge portions engaging the cover and forming insulating air-spaces therewith, and welds fusing the inner ends of all the cores to the rim and to the ring.

DAVID J. BLOOMBERG.

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8

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10

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