

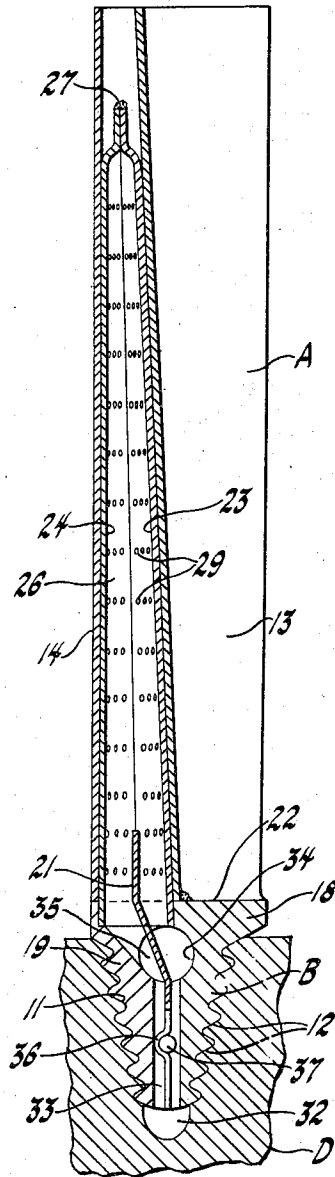
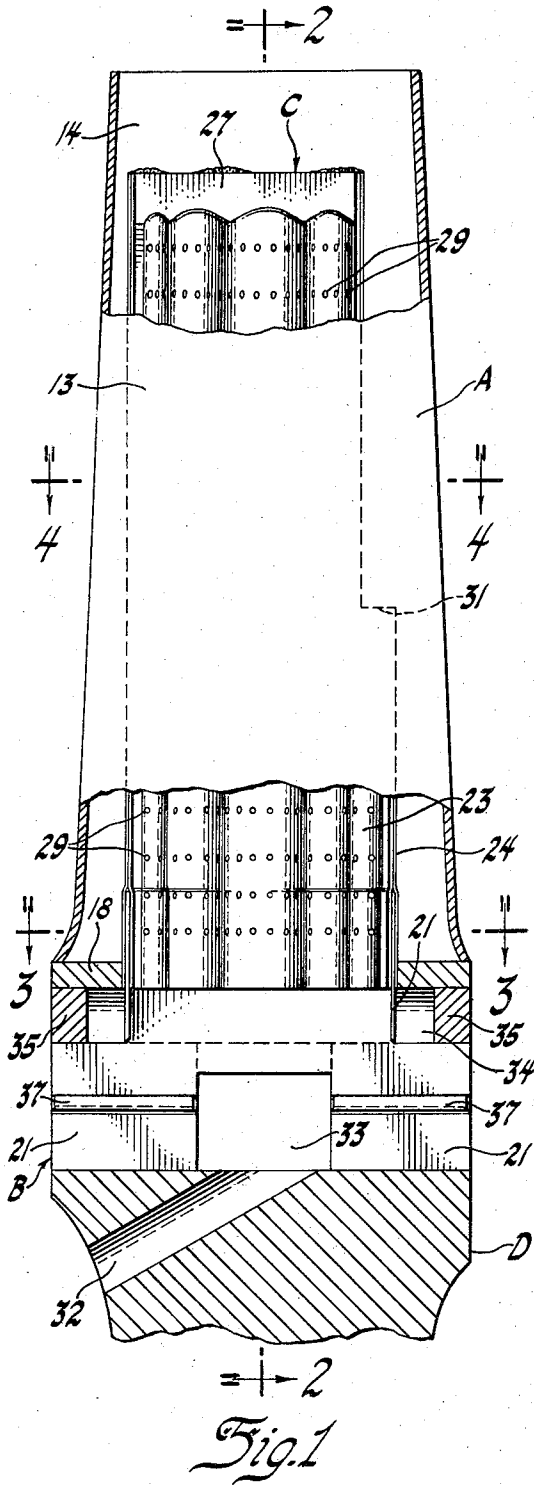
Feb. 17, 1959

T. O. WIESE ET AL
TURBINE BLADE COOLING

2,873,944

Filed Sept. 10, 1952

2 Sheets-Sheet 1



INVENTORS
Theodore O. Wiese &
Stuart Wilder, Jr.
BY Willits, Helwig & Paulko
ATTORNEYS

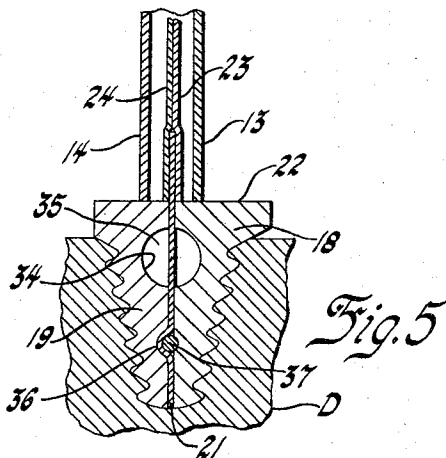
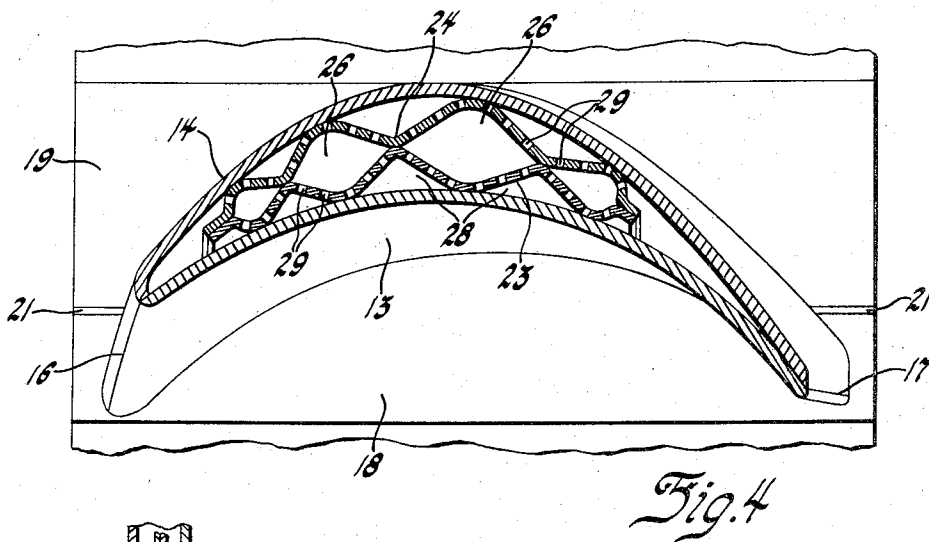
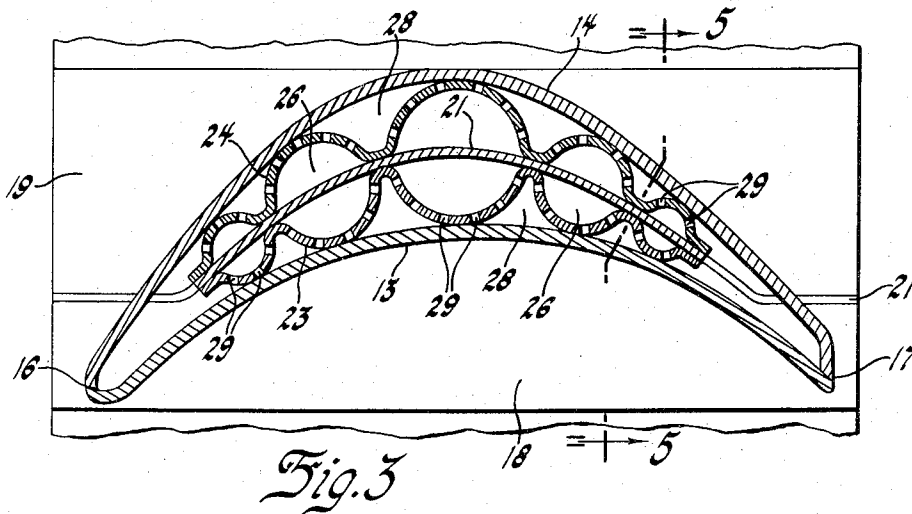
Feb. 17, 1959

T. O. WIESE ET AL
TURBINE BLADE COOLING

2,873,944

Filed Sept. 10, 1952

2 Sheets-Sheet 2



INVENTORS
Theodore O. Wiese &
Stuart Wilder, Jr.
BY Willits, Helwig & Mills
ATTORNEYS

1

2,873,944

TURBINE BLADE COOLING

Theodore O. Wiese and Stuart Wilder, Jr., Indianapolis, Ind., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application September 10, 1952, Serial No. 308,754

9 Claims. (Cl. 253—39.15)

Our invention is directed to the improvement of fluid-directing elements of turbomachines and the like, such elements being commonly referred to as buckets, blades, and vanes. The invention is particularly concerned with effective cooling of such elements for use in high temperature machines such as gas turbines.

While it has long been realized that effective cooling of the nozzle vanes and buckets of such machines could greatly improve the performance of the machines, progress in providing satisfactory cooling has been slow. This is particularly true of rotating buckets because of the very high centrifugal loading on such buckets. Also, the rather involved shape of such elements contributes to the difficulty of providing an effective cooled structure which is practicable from the manufacturing standpoint and which is reliable from the operating standpoint.

In brief outline, our invention involves the provision of a hollow blade which may be bonded to a base or root by which it is supported and which has within it a generally tubular member, preferably formed from sheet metal, which conducts air or other cooling fluid into the blade and discharges it against the wall of the blade through a large number of perforations in the wall of the tubular liner.

The principal objects of the invention are to improve the performance of gas turbines and other turbomachines, to provide improved blade cooling, and to provide a cooled blade which is particularly well adapted to withstand the strains of use and which is practicable from the standpoint of fabrication.

The nature of our invention, the manner in which the objects are realized, and the advantages thereof, will be more fully apparent from the following detailed description of the preferred embodiment of the invention and the accompanying drawings, in which:

Fig. 1 is a longitudinal view of a turbine bucket in accordance with the invention, mounted in the rim of a turbine wheel, the wheel and the blade root being sectioned and parts being cut away;

Fig. 2 is a longitudinal sectional view of the same taken on the plane indicated by line 2—2 in Fig. 1;

Fig. 3 is a transverse sectional view of the same taken on the plane indicated by line 3—3 in Fig. 1;

Fig. 4 is a transverse sectional view of the same taken on the plane indicated by line 4—4 in Fig. 1;

Fig. 5 is a sectional view taken on the plane indicated by line 5—5 in Fig. 3.

The illustrated embodiment of the invention is a fluid-directing element of the type commonly called a turbine bucket mounted on a rotor wheel of a turbine. The element comprises three principal parts or portions; a blade portion A, a base portion B, and a liner C. The turbine wheel, only a fragmentary portion of which is shown, is indicated generally as D. The turbine wheel is slotted in a direction generally parallel to the axis and formed to provide multiple dovetail grooves or slots 11, which are of conventional form. The root or base portion B of the blade is provided with multiple serrations 12

2

on both faces to engage the slot 11 in the rotor. It will be understood that other types of blade mountings may be employed.

The blade portion A may comprise two suitably formed metal sheets 13 and 14, each defining one face of the blade, these sheets being united at the leading edge 16 and trailing edge 17 by welding or high temperature brazing to form a hollow blade which is open at the free end and is fixed to the base B at the other end. The base B is formed of two parts 18 and 19 respectively, each constituting one side or face of the base portion. The two pieces 18 and 19 are opposed to each other over most of the length of the base (transversely of the wheel rim) and are provided with mating surfaces between which is sandwiched a sheet metal member 21 which is united to both pieces of the base, preferably by high temperature brazing, thus providing a solid base structure. The sheet 21 extends above the upper face 22 of the base and serves as a retaining member portion of the blade liner C which is subjected to high centrifugal forces in the operation of the machine.

The portion of the liner C which extends through the blade is preferably formed of two sheets 23 and 24 of metal which may be of light gauge and which are corrugated generally as shown, so that when the two sheets are opposed passages 26 are formed extending longitudinally of the blade between the sheets 23 and 24. As will be most clearly apparent from Figs. 3 and 5, the ridges on the sheets 23 and 24 are disposed on opposite sides of the free end of the tension member 21. The sheets 23 and 24 are brazed or welded to the tension member 21 and to each other along the forward and rear edges of the sheets and preferably where the ridges of the corrugations are in contact. The outer end of the liner is flattened and the sheets 23 and 24 are welded together at 27 so that the passages 26 are closed at the outer ends. The base ends of the sheets 24 and 23 extend slightly into the base and the base portions are formed at the blade end of the base with projections 28 which conform to the liner so that the passages 26 through the liner, apart from any slight incidental leakage, form the only path for conduction of cooling air from the root into the blade. The faces 23 and 24 of the blade liner are provided with a large number of perforations 29 distributed along the liner and distributed around the circumference of each of the tubular passages 26 so that cooling air supplied to the liner escapes from the liner through the perforations and is directed against the inside of the blade. As will be apparent, this is highly advantageous in that relatively cool air is distributed from the liner over the entire surface of the blade, and thus the cooling fluid in the central part of the span of the blade and near the tip is cooler than it would be if all of the cooling air flowed continuously along the inside surface of the blade or continuously through channels in the structure of the blade itself.

The showing of the perforations 29 in the drawings is merely illustrative and is not intended to define the exact location, spacing, and size of the perforations. The size and spacing of the perforations will be governed in any particular case by the size and shape of the blade, the amount of air supplied, and the cooling pattern desired.

The relationship between the size and the spacing of the perforations controls the amount of air discharged through any given part of the area of the liner C. The liner may be constructed so as to provide substantially uniform air flow at all comparable areas of the liner.

In many cases, however, greater cooling may be desired at certain areas of the blade because of temperature stratification of the motive fluid or more critical combinations of stress and temperature at certain parts of the blade. In such cases, greater flow of the cooling

fluid may be provided in these areas by increasing the size of, or decreasing the spacing between, the perforations to make the liner more pervious adjacent such areas of the blade than it is adjacent other less critical areas.

It will be noted that the passage 26 adjacent the trailing edge 17 of the blade terminates at 31 because of the decreasing core of the blade. This passage may be closed at its upper end or may be left partly open so that some air is distributed from the end of it. The air discharged from the liner flows along the inner surface of the walls of the blade and is discharged through the open tip of the blade.

Air may be brought to the blade in any suitable manner, as by a passage 32 in the rim of the turbine wheel entering the bottom of the blade slot 11. A passage 33 extends upwardly through the base of the blade from the passage 32 to conduct the coolant to a distributing chamber 34 extending generally parallel to the wheel axis. Passages 33 and 34 may be defined by recesses in the faces of the base parts 18 and 19 and the ends of the chamber 34 may be closed by plugs 35. Each of the passages 26 through the blade liner communicates with the distributing chamber 34. Thus, the air supplied to the blade is all introduced into the liner and not directly into the space between the blade and liner. The lower end of the tie member 21 is cut away so that two tongues are left on the member 21 extending between the opposed faces of the parts 18 and 19 of the base. In addition to the brazing to secure the member 21 in place, it is deformed as indicated at 36, and pins 37 force the deformed part 36 against the base portion 19 of the blade, the pins 37 bearing against the portion 18. The pins 37 may be brazed in place in the same operation in which the parts 18, 19, and 21 are brazed together. The pins 37 additionally serve as a locating means for the parts as they are assembled.

The outer part of the sheet 21 is deformed, as is most clearly apparent in Figs. 2 and 3, so that it extends approximately along the main camber line of the blade.

The blade surfaces 13 and 14 may be welded to the top of the blade root. The parts may be made of any material suited to the temperatures and stresses involved in the particular environment, but it will be realized that because of cooling the requirements for a given installation are less rigorous than if cooling were not employed. High temperature brazing techniques are known which are capable of forming a bond between the parts which will resist the temperatures encountered. The forming, assembling, and welding or brazing together of the parts may follow techniques known to those skilled in the art, which need not be described here.

As will be apparent to those skilled in the art, the structure of the preferred embodiment of the invention is well adapted to production and will provide a strong, rigid blade. Because of the corrugated or tubular construction of the liner, it is of considerable strength and rigidity and makes possible the employment of thinner sections for the walls of the blade by acting to prevent vibration of the walls. If desired, the liner may be brazed to the blade where the two are in engagement. The liner is adequately anchored in place to withstand centrifugal force.

It will be apparent also that the invention introduces the cooling air into the blade in a manner providing for a very uniform distribution of cooling air and, by introducing the cooling air through tubes or manifolds separate from the walls of the blade, provides relatively cool air over the entire blade surface. While the air introduced toward the tip of the blade must mix with the air flowing longitudinally of the blade, a more even temperature and more balanced cooling is obtained than when all of the air flows so that it is all progressively heated from the base of the blade toward the tip.

The invention has been illustrated as embodied in a

bucket provided with a foot, since this is a more complicated structure than a nozzle vane or stator blade, such vanes and blades being ordinarily supported at both ends in shroud rings or the like. In the case of such a fixed blade, ordinarily the root would be omitted and, due to the absence of centrifugal force, the retention of the liner no longer presents any significant problem. It will be apparent that the combination of a nozzle vane, which may be generally similar in appearance to the rotor blade illustrated, with a liner of the type illustrated from which the cooling air is distributed evenly over the surface of the vane, is highly advantageous. Thus, such a fixed blade may be similar to the blade illustrated without the base portions.

The preferred embodiment of the invention has been described in detail in order to explain the principles of the invention. This description is not to be regarded as limiting or restricting the invention, since many modifications of form and structure may be made by the exercise of skill in the art within the scope of the invention.

We claim:

1. A fluid-directing element for turbomachines and the like comprising a hollow blade and a liner extending through the blade, the liner comprising opposed sheets corrugated longitudinally of the blade with the corrugations aligned, the two sheets being in engagement along a plurality of lines extending longitudinally of the blade intermediate the edges of the liner and being mutually spaced between the said lines to define passages for a cooling fluid and the liner being perforated to discharge the cooling fluid from the passages against the walls of the blade.

2. A fluid-directing element as recited in claim 1 in which the liner is of varying perviousness over the area thereof.

3. A fluid-directing element for turbomachines and the like comprising a thin-walled hollow blade open at at least one end and a tubular blade liner therein open at at least one end to receive a cooling fluid, the liner having external corrugations engaging the walls of the blade and defining spaces extending spanwise of the blade between the walls of the blade and the corrugations, and the liner being perforated at points distributed along the span of the blade to discharge the cooling fluid therefrom into the said spaces along the span of the blade.

4. A fluid-directing element as recited in claim 3 in which the liner is of varying perviousness over the area thereof.

5. A fluid-directing element for turbomachines and the like comprising a thin-walled hollow blade open at one end and a tubular blade liner therein open at the other end to receive a cooling fluid, the liner having external corrugations engaging the walls of the blade and defining spaces extending spanwise of the blade between the walls of the blade and the corrugations, and the liner being perforated at points distributed along the span of the blade to discharge the cooling fluid therefrom into the said spaces along the span of the blade.

6. A fluid-directing element for turbomachines and the like comprising a thin-walled hollow blade open at at least one end and a blade liner therein open at at least one end to receive a cooling fluid, the liner comprising two sheets having external corrugations engaging the walls of the blade and defining spaces extending spanwise of the blade between the walls of the blade and the corrugations, the sheets engaging each other to define tubular passages therebetween, and the liner being perforated at points distributed along the span of the blade to discharge the cooling fluid from the passages into the said spaces along the span of the blade.

7. A fluid-directing element for turbomachines and the like, said element comprising a hollow blade portion, a base portion at one end of the blade portion, and a hollow blade liner extending into the blade portion from the base portion and defining a number of parallel pas-

sages in the liner extending spanwise of the blade portion, the liner having walls meeting along spanwise lines between the passages to separate the passages, the liner being closed at the end remote from the base portion and being perforated to discharge a cooling fluid from the said passages against the walls of the blade portion, the base portion defining passage means connected to the liner to conduct the cooling fluid into the liner passage.

8. A fluid-directing element for turbomachines and the like comprising a hollow blade, a base at one end of the blade comprising two opposed portions, and a liner, the liner comprising a portion extending between and bonded to the portions of the base and a portion extending through the blade comprising opposed sheets corrugated longitudinally of the blade with the corrugations aligned, the two sheets being in engagement along a plurality of lines extending longitudinally of the blade intermediate the edges of the liner and being mutually spaced between the said lines to define passages therebetween for a cooling fluid, at least some of the passages being closed at the end remote from the base and the liner being perforated to discharge the cooling fluid from the passages against the walls of the blade, and the base

defining duct means connected to the passages in the liner to distribute a cooling fluid thereto.

9. A fluid-directing element as recited in claim 8 in which the liner is of varying perviousness over the area thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

10	2,220,420	Meyer	Nov. 5, 1940
	2,256,393	Klein	Sept. 16, 1941
	2,447,095	Schmidt	Aug. 17, 1948
	2,559,131	Oestrich	July 3, 1951
	2,648,520	Schmitt	Aug. 11, 1953
15	2,650,803	Roskopf	Sept. 1, 1953
	2,656,146	Sollinger	Oct. 20, 1953
	2,746,671	Newcomb	May 22, 1956

FOREIGN PATENTS

20	237,475	Switzerland	Sept. 1, 1951
	602,530	Great Britain	May 28, 1948
	611,650	Great Britain	Nov. 2, 1948
	619,634	Great Britain	Mar. 11, 1949