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D. J. CLARKE

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AXIAL FLOW ROTORS FOR FLUID MACHINES

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2 Sheets-Sheet 1

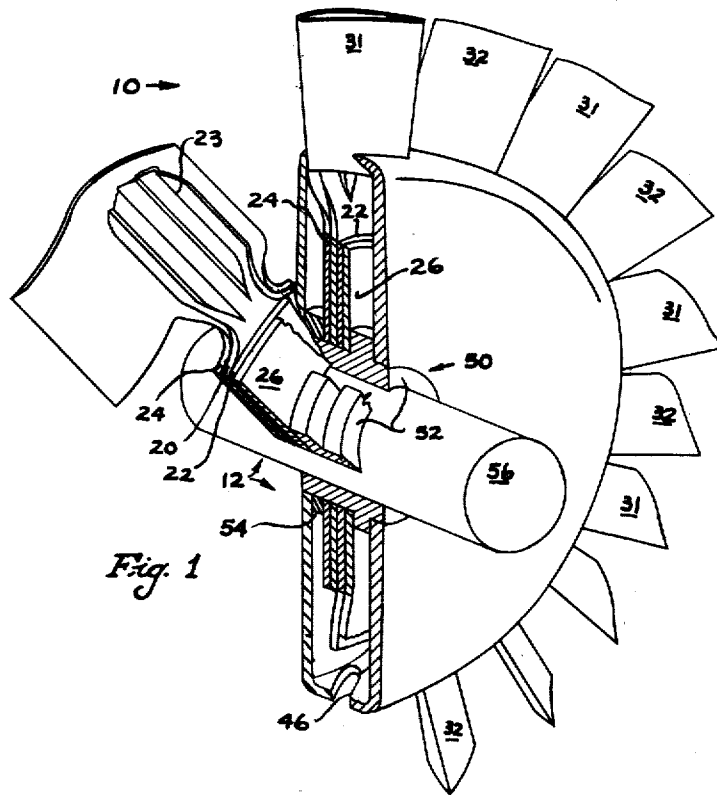


Fig. 1

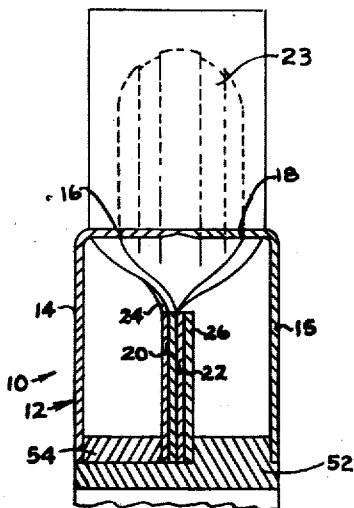


Fig. 2

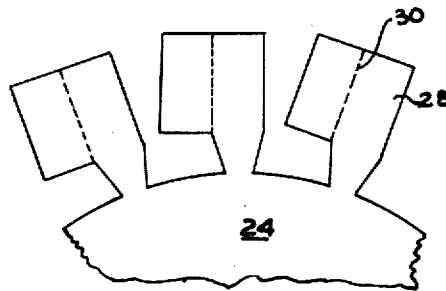


Fig. 3

INVENTOR.
Daniel J. Clarke

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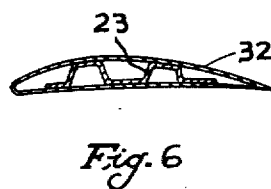
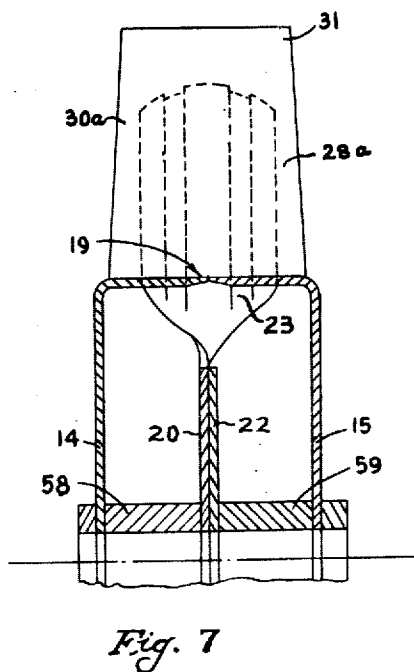
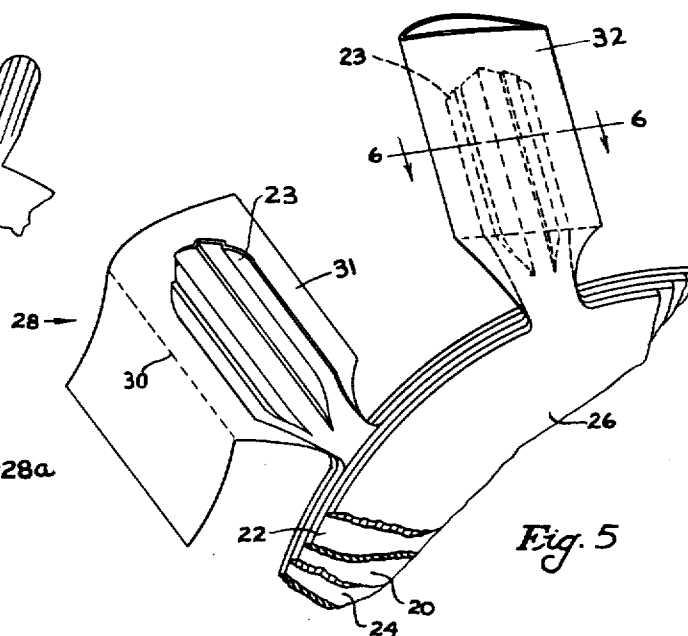
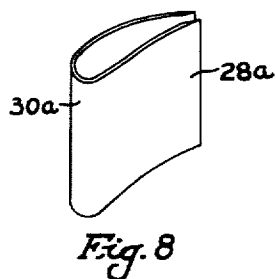
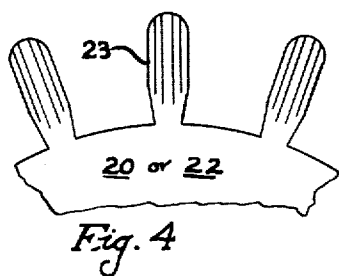
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AXIAL FLOW ROTORS FOR FLUID MACHINES

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2 Sheets-Sheet 2



INVENTOR.

Daniel J. Clarke

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AXIAL FLOW ROTORS FOR FLUID MACHINES

Daniel J. Clarke, Bay City, Mich., assignor to The Stalker Development Company, Bay City, Mich., a corporation of Michigan

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7 Claims. (Cl. 230—134)

This invention relates to rotors and stages of blades for fluid machines such as compressors and turbines and the like.

It has for an object the provision of an assembly or stage of blades which is light in weight and economical to produce.

Other objects will appear from the description, drawings and claims.

The above objects are accomplished by means which are illustrated in the accompanying drawings in which:

Fig. 1 is a fragmentary axial view of a rotor;

Fig. 2 is a fragmentary axial section of a rotor according to this invention;

Fig. 3 is a fragmentary axial view of a blade plate with the blade blanks spaced peripherally;

Fig. 4 is a fragmentary axial view of a core plate;

Fig. 5 is a fragmentary view of two rotor blades, one showing a blade blank only partially wrapped about a blade core;

Fig. 6 is a section of a blade along 6—6 in Fig. 5;

Fig. 7 is a fragmentary axial section of a rotor with individual blade blanks; and

Fig. 8 is a perspective view of an individual blade blank after folding.

The invention of this application represents a further development of the inventions described in the applications filed by Edward A. Stalker, Serial No. 38,904, now Patent No. 2,649,278, and Serial No. 167,981, now Patent No. 2,772,851.

This invention provides a bladed rotor which is light in weight and economical to produce. For instance it may weigh only about 40% of solid blade rotors and can be produced at about 25% of the cost.

The saving in weight in the blades by making them hollow while significant is not the major effect. However by saving weight in the blades the structure supporting the blades may be made light since the principal load coming on this hub structure is due to centrifugal force.

The very great saving in weight is achieved by making the blades of thin walls. Then each blade is attached directly to the hub structure without the intervening agency of a blade hub which would add weight and require a heavy rotor hub structure. In fact a blade hub requires conventionally a heavy hub rim for attachment of the blade, if the machine is to be a high speed machine. A heavy rim in turn requires a still thicker and heavier rotor disk. When the blade is made hollow and the heavy blade hub is eliminated so that the rotor plates are again saved from stress, these plates may be simple sheet metal structures comprising thin disks or flanged stampings from sheet metal.

The rotor plates may have a thickness of the order of the thickness of the blade walls or cores. They do not need to increase in thickness near the peripheries of the plates.

In a typical case the rotor plates are of the order of ten times thickness of the blade walls or less.

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Axial flow compressor blades operating at high tip speeds have very small nose radii of the order of ten thousandths of an inch at the tip sections and larger radii at the root sections.

It is difficult to machine radii which vary from root to tip in any case and especially difficult if the blades are integral with a common hub structure.

In this invention the radii are provided by folding a sheet of metal along the blade leading edge over a mandrel. A thin enough sheet is selected to obtain the desired nose radii at the tips of the blades. This sheet is not strong enough to provide the proper rigidity between the leading and trailing edges of the blade. Accordingly a core member is inserted before the trailing edge is sealed.

This core member preferably has radially extending corrugations which contact the walls of the blade. The corrugations are coated with a solder and fused to the blade walls.

The corrugated core or stem comprises ribs spaced apart chordwise defining grooves of trough-shaped recesses therebetween. Accordingly the stem passes from one wall to the other of the blade and is fixed to the walls along the ribs.

Referring now to the drawings the rotor is indicated generally by 10. The hub structure 12 includes the side plates 14 and 15, each having the inwardly turned flanges 16 and 18 respectively which together form a rim 19 at the root ends of the blades capable of sustaining the substantial change in density and pressure which occurs in operation between the leading and trailing edges of the blades. The blade supporting or core plates are 20 and 22, having the corrugated cores 23 spaced peripherally about the hub structure. The blade plates 24, 26 have a plurality of blade blanks 28 integral therewith and spaced peripherally about the perimeter. The blanks are folded about the leading edge line 30 to form blades 31 and 32.

After the blade blanks are folded, a core member is inserted in each blade by spreading the blade walls apart at the rear. The blade material is sufficiently elastic to permit this without deformation.

Since the blades are spaced peripherally close together two core plates are used with the respective cores interdigitating. For other blade spacings even more core plates may be used. For the same reason a plurality of interdigitating blade plates are employed as shown in Figs. 1 and 2.

In Fig. 1 the blade blanks for blades 31 are integral with blade plate 24. The blade blanks for the blades 32 are integral with blade plate 26. The core plate 20 carries the blade cores for blades 31 while core plate 22 carries the cores for blades 32.

The stems 23 encompassed by the blade blanks as shown particularly in Figs. 1 and 2 are twisted so that the cores or stems will extend generally transversely with respect to the plates 20 and 22 to give the blades a pitch angle with respect to the plane of rotation.

The rotor blades of the hub structure include the side plates 14 and 15 as well as the core and blade plates. The side plates have axially directed flanges suitably notched to accommodate the root ends of the blades as shown in Fig. 1. That is the blades extend outward beyond the perimeters of the side plates through the openings 46 in the flanges 16 and 18. The roots of the blades are bonded to the flanges preferably by brazing.

The plates are bonded to a suitable hub means 50 comprising the hub elements 52 and 54 which serve for mounting the rotor on a shaft 56.

In an alternate form of the invention shown in Fig. 7 the blade blanks are individual. Each blade blank 28a is first folded about the leading edge line 30a and

then the folded blank is slipped over a blade core. The blank is then fused together at the trailing edge and to the core and to the side plates at the root end of the blade. The hub elements are shown at 58, 59.

Preferably the fusing or soldering process is executed in a furnace while all the parts are supported in proper relation. The integral nature of the core plate keeps the number of supporting fixtures to a minimum.

The rotor plates are supported in spaced relation by hollow hub structure comprising the parts 14 and 15 which are brazed to them.

In a bladed rotor of the axial flow type adapted to interchange energy with a fluid, the leading and trailing edges both extend radially outward adapting the blades to be bathed by fluid flowing across these edges in the general axial direction.

Compressor and turbine rotors have rotor hub rims which extend axially along the axial length of the blades from their leading to trailing edges to direct the flow of elastic fluid through between the blades and sustain the substantial change in fluid density and pressure between leading and trailing edges which is characteristic of these rotors. The pressures are commonly several times higher than the atmospheric or outside pressures.

Compressor and turbine rotors also operate in elastic fluids which have high temperatures due to the compression and in the latter due also to the addition of heat. The temperature due to compression requires that the parts of the rotors be made of metal.

While I have illustrated specific forms of my invention, it is to be understood that variations may be made therein and that I intend to claim my invention broadly as indicated by the appended claims.

What is claimed is:

1. In combination in a bladed axial flow compressor rotor, a hollow sheet metal hub structure including a side plate and a hub rim, a plurality of sheet metal core members spaced peripherally about said hub structure each having an integral root portion extending inward through said rim, said root portion being fixed to said hub structure inward from said rim by a joint in radial shear, each of said core members being formed to provide a plurality of radially extending ribs spaced apart chordwise, a sheet metal blade blank encompassing each said core member therewithin to define a hollow blade, each said rib extending along a major portion of the span of its respective said blade, each of said blade blanks being fixed to said ribs therealong by fused metal to provide for support by said core members of said centrifugal forces developed in use in said sheet metal blades.

2. In combination in a bladed axial flow compressor rotor, a hollow sheet metal hub structure including a side plate and a hub rim, a plurality of sheet metal centrifugal stress-carrying core members spaced peripherally about said hub structure each having a root portion extending inward through said rim, said root portion being fixed to said hub structure inward from said rim by a joint in radial shear, each of said core members being formed to provide a plurality of radially extending ribs spaced apart chordwise, a sheet metal blade blank encompassing each said core member therewithin to define a hollow blade, each said rib extending along a major portion of the span of its respective said blade, each of said blade blanks being fixed to said ribs therealong by fused metal, said rim having a thickness of the same order of magnitude as said side plates and said core members.

3. In combination in a bladed axial flow compressor rotor, a hollow sheet metal hub structure including a pair of side plates having integral flanges thereon forming a generally cylindrical hub rim, a plurality of centrifugal stress carrying core members spaced peripherally about said hub structure each having a root portion extending inward through said rim, said root portion being fixed to said hub structure inward from said rim by a

joint in radial shear, each of said core members being formed to provide a plurality of radially extending ribs spaced apart chordwise, a sheet metal blade blank encompassing each said core member therewithin to define a hollow blade, each said rib extending along a major portion of the span of its respective said blade, each of said blade blanks being fixed to said ribs therealong by fused metal, said blank extending inward through said rim and being fixed thereto by fused metal.

4. In combination in an axial flow compressor rotor, a rotor hub structure including a hub element, axially spaced sheet metal side plates having parts integral therewith forming a rotor rim extending axially and capable of sustaining a substantial change in the density and pressure of the working fluid, a plurality of radially extending centrifugal stress carrying core members spaced peripherally about said rim and extending therethrough radially inward between said plates, means fixing the inner ends of said core members and said side plates to said hub element at localities substantially inward from said rim by joints in radial shear, a hollow sheet metal blade blank encompassing each said core member within its interior and extending radially inwardly of said rim, each said core member having a trough-shaped portion extending along a major portion of said blade radial length, said blade blank being fixed to said core member portion along a major part of the radial length thereof.

5. In combination in an axial flow compressor rotor, a hollow rotor hub structure including axially spaced sheet metal side plates having parts integral therewith forming a rotor rim extending axially and capable of formation by stamping, said rim providing for sustaining a substantial change in the density and pressure of the working fluid between the leading and trailing edges of the rotor blades, a plurality of radially extending centrifugal stress carrying core members spaced peripherally about said rim and having an inner portion extending therethrough radially inward between said plates, means fixing said inner portion of said members to said side plates at localities inward from said rim by joints in radial shear, the outer portions of said core members being a corrugated metal sheet with the ribs thereof extending radially, a hollow sheet metal blade blank encompassing each said outer portion within its interior and fixed to the corrugations thereof, said outer portions extending along a major portion of the radial length of each said blade.

6. In combination in an axial flow fluid rotor, a rotor hub structure including a generally cylindrical rim surface, a plurality of centrifugal stress carrying cores spaced peripherally about said surface and extending radially outward, said cores each having a portion extending radially inward beyond said rim surface fixing said cores to said hub structure, each said core having a plurality of spanwise ribs spaced apart chordwise defining a plurality of grooves therebetween, and a plurality of hollow sheet metal blade blanks each encompassing a said core therewith and contacting said ribs, each said blank extending into said rim but terminating short of the inner end of said cores so that said cores chiefly transmit the centrifugal load from said blade blank to said hub structure, each said core extending along a major portion of the radial length of its respective said blade blank, each said blade blank being fixed to said ribs within by fused metal.

7. In combination in an axial flow compressor rotor adapted to change substantially the density of a fluid flowing therethrough, a hub structure comprising a sheet metal side plate and a sheet metal rim peripherally disposed thereabout, a plurality of hollow sheet metal axial flow blades spaced peripherally about said structure, each said blade having sheet metal walls of a thickness of the order of magnitude of the nose radius of said blade adjacent the tip thereof, a sheet metal centrifugal stress carrying core fixed to said blade walls within the interior of each said blade of limited thickness of the order of

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thickness of said blade walls, each said core having an inner plate portion extending radially inward through said rib to said hub structure and being fixed thereto by a joint in radial shear, said blade and core of limited thickness and weight adapting said inner plate portion to have limited thickness and weight of the order of thickness of said core, said rim extending axially along the axial length of said blades adapting said rotor to change substantially the density of said fluid between leading and trailing edges of said blades.

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