Jan. 12, 1965 B. J. ANDERSON 3,165,294

ROTOR ASSEMBLY

Filed Dec. 28, 1962

Fig 1

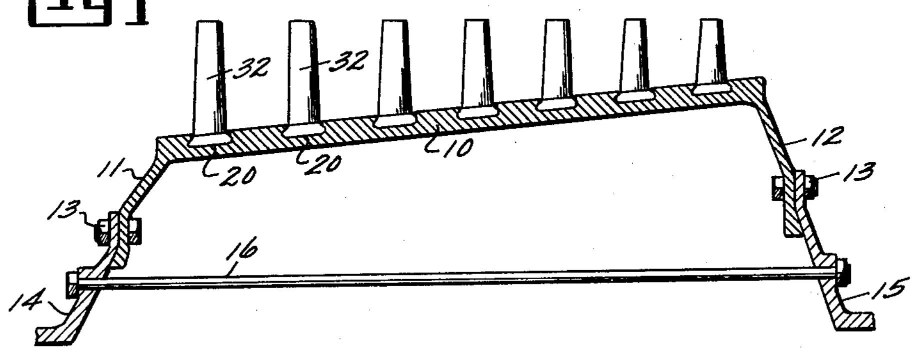


Fig 4

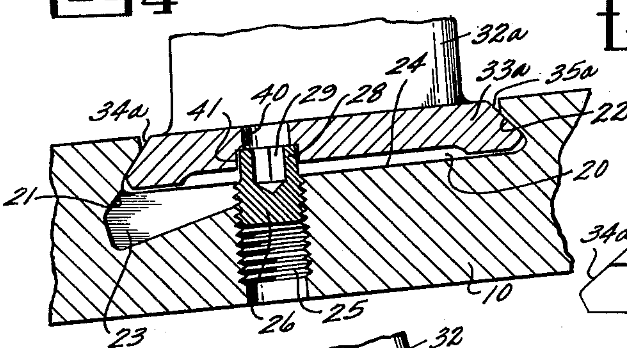
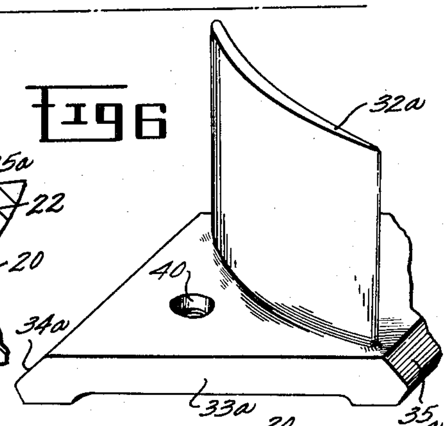
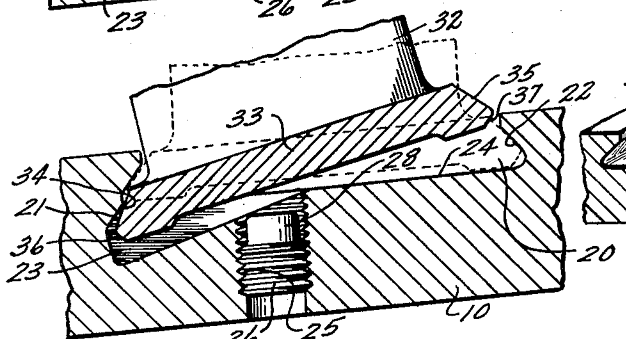


Fig 6





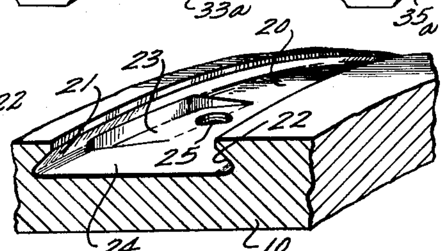
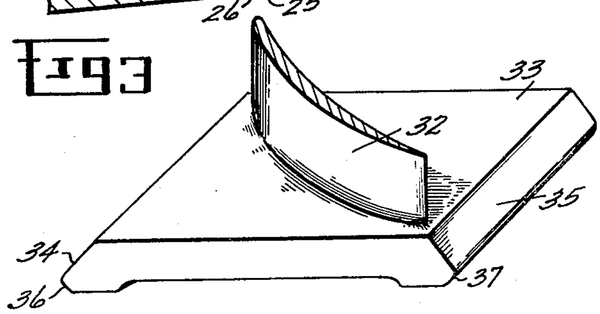


Fig 2

Fig 3

Fig 5



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ROTOR ASSEMBLY

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This invention relates to rotor assemblies for fluid flow machines such as compressors and, more particularly, to a locking arrangement for holding the blading of such machines in assembled position.

There are two main types of conventional rotor assemblies. The first type of conventional rotor structure is the built-up or disc type comprised of a plurality of elements axially bolted or otherwise secured together to form an integral structure. In this type of rotor assembly, it is generally not possible to remove individual blades without disassembling the entire rotor since the blades are generally held in axially extending dovetail slots in the periphery of the disc. The second type of conventional rotor assembly is the drum type rotor assembly such as shown by United States Patent No. 2,931,625 to Lechthaler et al., issued April 5, 1960, and assigned to the assignee of this application. In the drum type rotor assembly the blades are generally held in circumferentially extending dovetail slots and may be inserted or removed without disassembling the entire rotor. In addition to permitting easy insertion and removal of rotor blades, the drum type rotor assembly is relatively lightweight. The light weight construction in combination with adequate strength makes the drum type rotor assembly particularly suited for use in gas turbine engines used for aircraft propulsion. The present invention is intended as a further improvement on drum type rotor assemblies such as shown by Lechthaler et al. It will be obvious, however, that the invention can be used also on disc type rotor assemblies having circumferential dovetail slots.

It is an object of this invention to provide an improved lightweight rotor assembly having adequate strength for use on gas turbine engines used for aircraft propulsion.

Another object is to provide a rotor assembly in which the blade holding member is of substantially uniform strength throughout.

A further object of this invention is to provide an improved rotor assembly in which none of the blades or blade roots are of special design or shape.

A still further object of this invention to to provide a rotor assembly in which the blades of a given stage are consecutively positioned, the entire row of blades then being locked into position without additional movement of the blades being required.

An additional object is to provide an improved rotor assembly not requiring the use of complicated or unusual locking devices or tools.

Yet another object of this invention to to provide a rotor assembly which is simple and inexpensive to assemble, disassemble, service and manufacture, but yet is rugged and durable and requires a minimum of maintenance.

Briefly stated, in accordance with the illustrated embodiment of the invention, a rotor drum is provided with circumferentially continuous walls defining a dovetail slot in the periphery thereof. A loading recess is provided in the radially inward surface of the slot. A plurality of identically shaped dovetail rotor blade roots are consecutively inserted into the dovetail slot at the loading recess and then moved circumferentially into abutting relationship within the slot, the dovetail shapes of the slot and the blade roots preventing radial movement of the blade roots relative to the rotor drum. The last blade root inserted is positioned radially outward of the loading recess. A locking means engages the last blade root to hold it in the dovetail slot and to prevent circumferential movement of the blade roots within the slot.

While the invention is distinctly claimed and particularly pointed out in the claims appended hereto, the invention, both as to organization and content, will be better understood and appreciated, along with other objects and features hereof, from the following detailed description taken in conjunction with the drawing, in which:

FIGURE 1 is a partial cross sectional view of a drum type rotor assembly constructed in accordance with this invention;

FIGURE 2 is a perspective view of a portion of the rotor assembly of FIGURE 1 showing one of the dovetail slots and its associated loading recess;

FIGURE 3 is a view in cross section of the dovetail slot of FIGURE 2 illustrating in addition one of the rotor blades in its loading position and the locking means in its unlocked position;

FIGURE 4 is a view similar to FIGURE 3 showing the locking blade positioned in the dovetail slot and the locking means in its locked position;

FIGURE 5 is a perspective view of the rotor blade shown in FIGURE 3; and

FIGURE 6 is a perspective view similar to FIGURE 5 showing the locking blade of FIGURE 4 in detail.

Referring first to FIGURE 1, a generally cylindrical blade holding member or rotor drum **10** is partially illustrated, the drum **10** having inwardly extending radial flanges **11** and **12** at its ends. The flanges **11** and **12** are secured by suitable fastening means, such as a plurality of circumferentially spaced bolt connections **13**, to flanges **14** and **15**, respectively. To increase the rigidity of the rotor drum construction, the flanges **14** and **15** are connected by a plurality of circumferentially spaced axial tie bolts **16**. The flanges **14** and **15** are connected to shaft portions (not shown) to form a complete rotor assembly, the shaft portions being suitably mounted in bearings (not shown) to support and permit rotation of the rotor assembly. As this description proceeds, it will become obvious to those skilled in the art that the structure described above may be changed or modified substantially without departing from the true spirit and scope of the invention, which will now be described.

The rotor drum **10** is provided with a plurality of axial spaced circumferentially extending slots **20**, one of the slots **20** being shown in greater detail by FIGURES 2–4. As shown by FIGURES 2–4, the slot **20**, which may be machined or otherwise provided in the periphery of the rotor drum **10**, has side walls **21** and **22** which are undercut to give the slot **20** a dovetail shape. The side walls are continuous with no interruptions therein. A loading recess **23** is provided in the radially inward wall **24** of the dovetail slot **20**, the recess **23** having its deepest point adjacent slot side wall **21** so that the recess **23** essentially forms a radially inward continuation of the side wall **21**. A radially extending threaded or tapped hole **25** is provided adjacent the loading recess **23**, a threaded member of plug **26** being received therein. As shown by FIGURE 4, the head **28** of the threaded plug **26** is provided with a recess **29** for receiving a tool such as, for example, an Allen wrench for screwing the threaded plug **26** into and out of the tapped hole **25** between the extreme positions shown by FIGURES 3 and 4.

Returning briefly to FIGURE 1, it will be seen that a circumferential row of blades **32** is supported from each of the dovetail slots **20**. The manner in which these blades **32** are positioned, supported, and locked in position will now be described in detail. One of the blades 32 is illustrated by FIGURE 5, the blade having a root portion 33 of dovetail configuration. The root 33 has side walls 34 and 35 inclined so as to form leading and trailing toe portions 36 and 37, respectively. The dovetail configurations of the slot 20 and the root 33 are the same with the root 33 being sufficiently smaller in size than the slot 20 to be slidably received therein, the fit between the root 33 and the slot 20 being as snug as practicable.

Referring now to FIGURE 3, the threaded plug 26 is screwed into the tapped hole 25 to the position shown and then a first one of the blades 32 and its associated root 33 is tipped into the position shown by solid lines, the leading toe 36 of the root 33 extending into the recess 23. With the leading toe 36 extending into the recess 23, the trailing toe 37 can be moved radially into the slot 20. The blade 32 and its associated root 33 may then be tipped into the position shown by dotted lines and moved circumferentially in the dovetail slot 20 to a desired position. With the root 33 and the slot 20 having the same dovetail configuration and a snug fit, the blade 32 is restrained against radial movement with respect to the drum 10. Other blade roots may be positioned in a similar fashion. At this point it will not only be obvious that the circumferential extent of the recess 23 must be sufficient to receive the roots 33, but also be obvious that the circumferential extent should be no greater than required in order to restrain the maximum number of blades against radial movement. Therefore, it can be stated that the circumferential extent of the recess 23 is sufficient to receive only one of the root portions 33.

The entire circumferentially extending dovetail slot 20 can be filled with blade roots 33 in the manner described above, the roots 33 being inserted into the slot 20 at the loading recess 23 and then being moved circumferentially into abutting relationship. The last blade root inserted, however, fills the space in the dovetail slot 20 radially outward of the loading recess 23 and is not moved circumferentially within the slot 20. This last blade is not held against radial movement relative to the rotor drum 10 solely by the dovetail configuration of the slot 20 since the circumferential extent of the recess 23 is necessarily greater than that of the last blade root in order to permit insertion of the blade roots 33 into the dovetail slot 20. Locking means must be provided for holding the last blade or locking blade in the slot 20. To effectively lock the last blade against radial movement relative to the rotor drum 10, a slightly modified structure is used for the last or locking blade 32A as illustrated by FIGURES 4 and 6. Referring first to FIGURE 6, blade 32A is identical to blades 32 and has a root 33A identical in dovetail shape to roots 33. The only difference between the roots 33 and the root 33A is that an access passage 40 is provided through the root 33A. Passage 40 is provided with a counterbore 41 as best shown by FIGURE 4.

The root 33A of the locking blade 32A is inserted into the dovetail slot 20 in the same manner as roots 33 and then is positioned in the dovetail slot 20 as shown by FIGURE 4, the access passage 40 being radially aligned with the threaded plug 26 which comprises the locking means. With the root 33A positioned in the slot 20, a suitable tool is inserted through the passage 40 into the cavity 29 in the threaded plug 26 to screw the plug 26 outwardly into the locking position shown by FIGURE 4. The counterbored portion 41 of the passage 40 is sufficiently large to receive the head 28 of the plug 26, the remainder of the passage 40 being smaller in diameter than the head 28. With the head 28 of the plug 26 received in the counterbored portion 41 of the passage 40, the blade 32A is held against radial movement relative to the rotor drum 10. It will be obvious that the threaded plug 26 also

holds the entire row of abutting blade roots 33 and 33A against circumferential movement in the dovetail slot 20. During rotation of the rotor drum 10 during compressor operation, centrifugal force urges the threaded plug 26 out of the tapped hole 25 in the locking direction.

The blades 32A and 32 can be removed from the rotor drum 10 in reverse order to that described above by first screwing the plug 26 into the tapped hole 35 to its retracted position shown by FIGURE 3.

The rotor assembly described above has several distinct advantages. As pointed out previously, the side walls 21 and 22 of the dovetail slot 20 are continuous with no interruptions therein. This means that each of the blade roots, including root 33A of the locking blade 32A, is restrained against radial movement with respect to the rotor drum 10 across the entire wall surfaces 34 and 35, or 34A and 35A, of the root. As a result, the relatively shallow dovetail slot 20 may be utilized since there is no weak area in which a deeper slot must be utilized to gain sufficient strength. The means, in turn, that the relatively thin walled rotor drum 10 can be used to provide a lighter weight structure than heretofore possible. Also, the root 33A differs from roots 33 only in that an access passage 40 is provided therein. Since a dovetail of special or unusual form is thus not required for the locking blade 32A, a more economical and uniform rotor assembly results. In addition, there is no requirement that the entire row of blades be moved circumferential as a unit at any time. This obviously greatly increases ease of assembly and disassembly.

It will be understood that the invention is not limited to the specific details of construction and arrangement of the embodiment illustrated and described herein since changes and modifications will be obvious to those skilled in the art. For example, the dovetail slots 20 may be provided in the periphery of a disc type rotor assembly instead of in the rotor drum 10 of a drum type assembly. Also, it may be desirable on occasion to eliminate the access passage 40 in the root 33A and operate the locking means from within the interior of the rotor drum 10. It is therefore intended to cover in the appended claims all such changes and modifications which may occur to those skilled in the art without departing from the true spirit and scope of the invention.

What is claimed as new and desired to secure by Letters Patent of the United States is:

1. A bladed rotor assembly for an axial fluid flow machine comprising a generally cylindrical blade holding member, said blade holding member having circumferentially continuous walls defining at least one circumferentially extending dovetail shaped slot in the periphery thereof, a plurality of blades all having identically shaped dovetail roots slidably received in said slot, said blade roots circumferentially filling said slot with adjacent roots in abutting relationship, the dovetail shapes of said slot and said blade roots being such that the roots are restrained against radial movement with respect to said blade holding member, a loading recess in the radially inward surface of the slot, a selected one of said blade roots positioned in said slot radially outward of said loading recess, and locking means engaging the radially inward portion of said selected blade root to maintain said selected blade root in said slot and to prevent circumferential movement of said plurality of blade roots in said slot.

2. A bladed rotor assembly as defined in claim 1 in which the circumferential extent of said loading recess is sufficient to receive only one of said blade roots.

3. A bladed rotor assembly for an axial fluid flow machine comprising a generally cylindrical blade holding member, said blade holding member having circumferentially continuous walls defining at least one circumferentially extending dovetail shaped slot in the periphery thereof, a plurality of blades all having identically shaped

dovetail roots slidably received in said slot, said blade roots circumferentially filling said slot with adjacent roots in abutting relationship, the dovetail shapes of said slot and said blade roots being such that the roots are restrained against radial movement with respect to said blade holding member, a loading recess in the radially inward surface of said slot, the circumferential extent of said loading recess being sufficient to receive only one of said blade roots, and radially movable locking means carried by said blade holding member, a selected one of said blade roots positioned in said slot radially outward of said loading recess, said locking means being movable radially outwardly to engage said selected blade root so as to maintain said selected blade root in said slot and to prevent circumferential movement of said plurality of blade roots in said slot and movable radially inwardly so as to permit insertion and removal of said blade roots into and from said slot.

4. A bladed rotor assembly for an axial fluid flow machine comprising a generally cylindrical blade holding member, said blade holding member having circumferentially continuous walls defining at least one circumferentially extending dovetail shaped slot in the periphery thereof, a plurality of blades all having identically shaped dovetailed roots slidably received in said slot, said blade roots circumferentially filling said slot with adjacent roots in abutting relationship, the dovetail shapes of said slot and said blade roots being such that the roots are restrained against radial movement with respect to said blade holding member, a loading recess in the radially inward surface of said slot, the circumferential extent of said loading recess being sufficient to receive only one of said blade roots, and radially movable locking means comprising a threaded member rotatably received in a radially extending threaded hole in the radially inward surface of said slot, a selected one of said blade roots positioned in said slot radially outward of both said loading recess and said threaded member, said threaded member being movable radially outwardly to engage said selected blade root so as to maintain said selected blade root in said slot and to prevent circumferential movement of said plurality of blade roots in said slot and movable radially inwardly so as to permit insertion and removal of said blade roots into and from said slot.

5. A bladed rotor assembly as defined in claim 4 in which said selected blade root has a passage extending therethrough for providing access to said threaded member.

6. A bladed rotor assembly as defined in claim 5, said passage radially aligned with said threaded member, and the radially inward portion of said passage counterbored, said threaded member extending into said counterbored portion when said threaded member is in its radially outward position.

7. A bladed rotor assembly for an axial fluid flow machine comprising a thin walled cylindrical drum, said cylindrical drum having circumferentially continuous walls defining a plurality of shallow axially spaced circumferentially extending dovetail shaped slots in the periphery thereof, a plurality of blades all having identically shaped dovetail roots slidably received in each of said slots, said blade roots circumferentially filling each of said slots with adjacent roots in abutting relationship, the dovetail shapes of said slots and said blade roots being such that the roots are restrained against radial movement with respect to said drum, a loading recess in the radially inward surface of each of said slots, the circumferential extent of each of said loading recesses being sufficient to receive only one of said blade roots, and radially movable locking means associated with each of said slots comprising a threaded member rotatably received in a radially extending threaded hole in the radially inward surface of each of said slots, a selected one of said blade roots in each of said slots positioned radially outwardly of the respective loading recess and threaded members, said threaded members being movable radially outwardly to engage the associated selected blade root so as to maintain said selected blade root in said slot and to prevent circumferential movement of said plurality of blade roots in said slot and movable radially inwardly so as to permit insertion and removal of said blade roots into and from said slot.

8. A bladed rotor assembly as defined in claim 7 in which each of said selected blade roots has a passage extending therethrough for providing access to the associated threaded member, said passage radially aligned with said threaded member, and the radially inward portion of said passage counterbored, said threaded member extending into said counterbored portion when said threaded member is in its radially outward position.

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