June 24, 1958 R. A. PAETZ 2,840,299

AXIAL FLOW COMPRESSOR ROTOR

Filed Sept. 22, 1952

Fig. 1

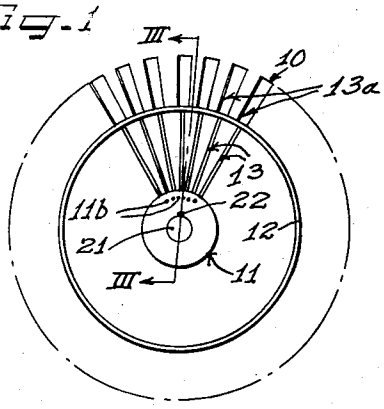


Fig. 2

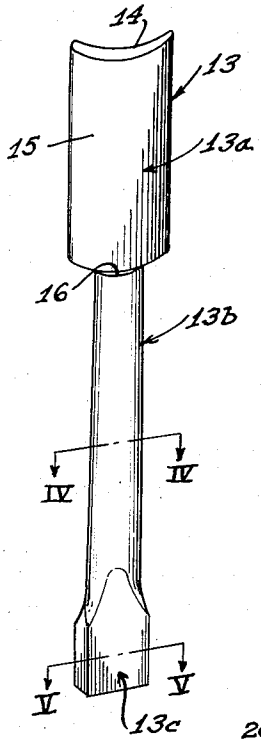


Fig. 4

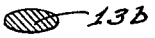


Fig. 3

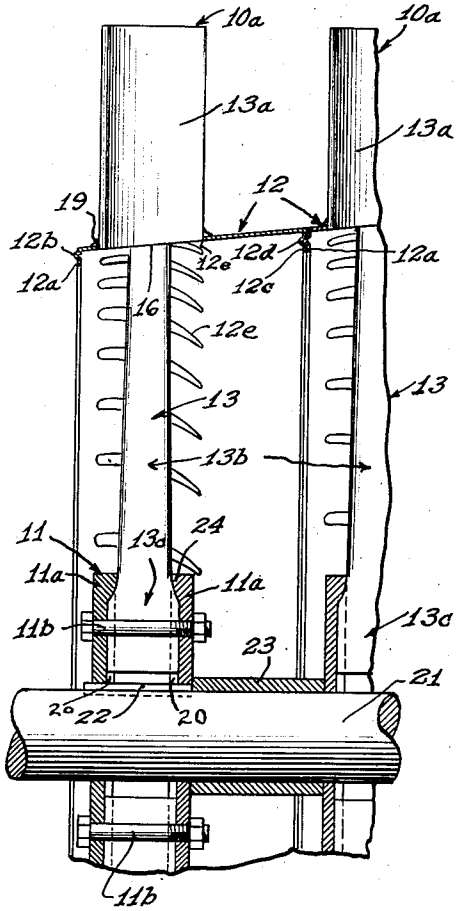


Fig. 5.

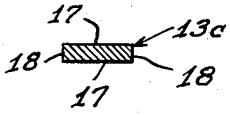
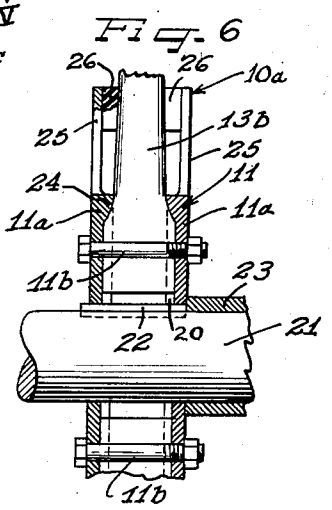


Fig. 6



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United States Patent Office 2,840,299
Patented June 24, 1958

2,840,299

AXIAL FLOW COMPRESSOR ROTOR

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Application September 22, 1952, Serial No. 310,867

5 Claims. (Cl. 230—134)

This invention relates to a vaned rotor such as is used in axial flow air compressors for turbo-jet engines wherein each vane has an integral spoke anchored to a hub and to a rim. Specifically, the invention deals with a lightweight low inertia axial flow compressor rotor having individual spoked blades.

While this invention will be hereinafter specifically described as embodied in an axial flow air compressor for turbo-jet engines, it will be appreciated that the principles of this invention are generally applicable to vaned wheels and therefore the invention is not limited to the illustrated preferred embodiment.

Heretofore, rotors for axial flow air compressors in turbo-jet engines have been built up from a series of heavy solid disks with the blades or vanes radiating from the peripheries thereof and anchored thereto as by means of a dove-tailed lock. These disks materially added to the weight of the rotor and increased its inertia.

According to the present invention, each vane or blade of the rotor is now equipped with its own spoke and the spoked units are anchored at the inner ends of the spokes to a hub and at the inner ends of the blade portions to a rim. This rim is composed of lightweight sheet metal and not only confines the air flow in the same manner as the peripheries of the heretofore used disks but also is extended to space the successive spoked wheels apart in correct relation for receiving the stator blades therebetween in each stage of the compressor. The spoked wheels of this invention materially reduce the weight of the rotor without sacrificing strength or rigidity and thereby provide a low inertia rotor assembly which is capable of fast acceleration. Heretofore required disk forging, machining, dove-tail locking and the like expensive structures and assembly methods are avoided. The new wheels are easily assembled by inserting the blades through slots in the rims and by anchoring the spokes to the hub. If desired, the vanes can be welded to the rim around the rim slots. The hub can be composed of a pair of clamping rings receiving the root ends of the spokes therebetween preferably in radial slots thereof. The spoke blade units can be manufactured on roll forming machines, forged, or formed in any suitable manner from any desired material such as steel, aluminum, or alloy. It is also possible to form these units from powdered metal such as powdered iron infiltrated by copper. The rim can be a ring of aluminum or other lightweight sheet metal or can be machined from a forging of lightweight metal. The hub clamping rings can be aluminum, steel or the like metal.

It is then an object of this invention to provide a low inertia stress-resisting bladed rotor adapted for an axial flow air compressor of a turbo-jet engine.

Another object of this invention is to provide a bladed rotor wherein the blades have their own individual spokes and are anchored in a rim and a hub.

Another object of the invention is to provide a bladed rotor having a plurality of annular rows of blades each

equipped with a single rim and a plurality of spoked blade units anchored in the rim.

Another object is to provide a vaned wheel composed of spoked vanes.

A still further object of the invention is to eliminate the heretofore required disks in axial flow compressor rotors.

A still further object of the invention is to provide an inexpensive lightweight bladed rotor.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheet of drawings which, by way of a preferred example only illustrate one embodiment of the invention.

Figure 1 is an end elevational view of a spoked blade rotor according to this invention;

Figure 2 is an isometric view of one of the spoked blade units in the rotor of Figure 1;

Figure 3 is a fragmentary enlarged vertical cross-sectional view, with parts in side elevation, of the rotor assembly taken along the line III—III of Figure 1;

Figure 4 is a transverse cross-sectional view taken along the line IV—IV of Figure 2;

Figure 5 is a fragmentary transverse cross-sectional view taken along the line V—V of Figure 2; and

Figure 6 is a fragmentary view similar to Figure 5 but showing a modification including a vibration dampener.

As shown on the drawings:

In Figure 1, the reference numeral **10** designates generally an axial flow air compressor rotor assembly for a turbo-jet engine. The rotor assembly **10** is composed of a plurality of spoked wheels **10***a* as shown in Figure 3. Each wheel **10***a* includes a hub **11**, a plurality of spoked blade units **13** radiating from the hub, and a rim **12** at the base end of the blade portions of the spoked units **13**. It will be appreciated that the rim **12** comprises an annular drum having circumferentially spaced arcuate slots, as will hereinafter become more apparent.

As best shown in Figure 2, the spoked blade units **13** are each composed of a blade portion **13***a*, a spoke portion **13***b* and an anchoring base **13***c*. The blade portions **13***a* have a desired aerodynamic contour with a concave front face **14**, and a convex back face **15** there being a shoulder **16** between each blade and the spoke **13***b* formed on the spoke and extending outwardly from the faces **14** and **15**. The spoke **13***b* has a contour designed for structural strength. As shown in Figure 4 an oval shape is illustrated for the spoke **13***b* but any desired solid or hollow section can be used. The root **13***c* can be rectangular as shown in Figure 5 and have flat front and back faces **17** with end flat edges **18**.

The rim **12** is a sheet metal band of frusto-conical contour and may have a leading end of smaller diameter than the trailing end. This contour may be provided if in successive stages of the axial flow compressor to be built up from the wheels **10***a*, the air flow passage is to be decreased in width. The smaller leading end of each rim **12** may have an inturned flange **12***a* with an outturned bead **12***b* projecting axially therefrom. The larger trailing end of each rim may have a similar depending inturned flange **12***c* but this flange is equipped with a groove **12***d* for receiving the bead or projection **12***b* of the adjacent rim flange. Alternately, of course, the bead could be provided on the flange **12***c* and the groove could be provided on the flange **12***a*.

At spaced intervals around the periphery of the rim **12**, slots **12***e* are provided for receiving the blades **13***a* therethrough. These slots are contoured to snugly receive the blades and the shoulder **16** will abut against the inner face of the rim on opposite sides of the blade **13***a* to correctly limit the extent of radial projection of

the blade beyond the rim. As shown in Figure 3, the inner edge of the blade fits in the slot **12***e* and a weld or braze bond **19** is provided between the rim and this inner end of the blade to integrally unite the rim with the blade and to also seal off the pressure side of the compressor to prevent leakage and circulation. In assembly, the blades **13***a* are slipped through the slots **12***e* until the shoulders **16** abut the inner faces of the rim whereupon the blades are automatically positioned and the braze or weld bonds **19** are applied.

The hub **11** may be composed of a pair of opposed ring plates **11***a* clamped together by draw bolts **11***b*. Each plate **11***a* may be radially slotted at **20** to receive the edges **18** of the anchoring ends **13***c* of the spokes. The plates may be received on a shaft **21** and be notched to receive a key **22** uniting the shaft and plates for co-rotation. Any other suitable driving connection utilizing either shaft or the rim can be used. Spacer sleeves such as **23** on the shaft **21** may be positioned between adjacent hubs **11** so as to correctly space the successive wheels **10***a* constituting the rotor assembly **10**.

In assembling the spoked units into the hub, the inner plate **11***a* may be bottomed against the spacer sleeve **23**, the anchoring ends **13***c* of the spokes depending from the rim are seated in successive grooves **20**. The opposite hub plate **11***a* can then be placed on the shaft **21** so that the opposed edge **18** of each anchoring portion **13***c* may be received in a corresponding groove or slot **20**. The draw bolt assemblies **11***b* can be inserted and tightened for securely clamping the portions **13***c* in affixed relation to the hub.

Alternately, the anchoring ends **13***c* of the spoke could be brazed or welded to the hub.

If desired, the outer ends of the grooves **20** can terminate inwardly from the periphery of the plates **11***a* so as to provide lugs **24** overlying the portion **13***c* and snugly receiving the spoke portion **13***b* therebetween. These lugs will prevent radial displacement of the anchoring portions **13***c*.

As shown in Figure 6, in the event it is found desirable to dampen out vibrations without materially adding to the weight of the rotor assembly, the hub plates **11***a* of each wheel **10***a* can have fingers **25** radiating therefrom to carry rubber blocks **26** or other plastic vibration dampening material, against the spokes **13***b* at areas to stop vibration. Any suitable vibration dampener can be used including hubs of increased diameter to shorten the required spoke length.

It will be understood that successive wheels **10***a* in the rotor assembly **10** can have conical rims **12** of successively increasing diameter so as to provide a rotor rim with a small leading end and a large trailing end. It will further be understood that the blades **13***a* in the successive wheels **10***a* decrease in height from the first or inlet stage of the compressor.

From the above description, it will thus be understood that this invention now provides a rotor especially adapted for the axial flow compressors of turbo-jet engines wherein a series of successive spoked wheels have mating rim flanges and are each composed of spoked vanes or blades anchored in the rims and also in a hub. The rotor of this invention is a lightweight strong and rigid low inertia unit.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. In an axial flow compressor including a central rotating member, a rotor including a central hub carried on said rotating member, a plurality of circumferentially spaced radially extending blades, a cylindrical drum with circumferentially spaced arcuate slots, each slot having a contour complemental to the cross section of a blade, each blade having an individual supporting spoke of thicker cross section than that of said blade and forming a shoulder for abutting the inner surface of said drum around the edge of the associated arcuate slot, means fastening said spokes to said hub for holding each blade against radial displacement in said slot and for co-rotation of the rotating member and blade, and fluid dampening means interposed between said central rotating member and said spoke to dampen vibration.

2. The axial flow compressor of claim 1 further characterized by said hub having finger structure bearing against said spoke and vibration dampening material disposed between said finger structure and said spoke.

3. In an axial flow compressor including a drive shaft, a series of adjacent abutting rotors carried on said axial flow compressor, each rotor having a series of spaced spokes radiating from and fastened to said drive shaft, each spoke having a radially outer end extension comprising a radially extending blade, a separate one-piece continuous annular band-like rim disposed circumferentially around said spokes having spaced axial peripheries with the spokes interiorly thereof and having a series of circumferentially spaced slots, each with one of said blades projecting therethrough and therebeyond, said rim being held centered by and bottomed against said spokes about said drive shaft and otherwise free from said drive shaft and with the rim cooperating with said spokes in maintaining said blades in radially spaced relation with their outermost ends projecting freely beyond the external surface of the rim, and means to connect said rim peripheries of the adjacent abutting rotors, thereby providing a continuous unbroken outer surface defined by said rims.

4. In an axial flow compressor including a central rotating member, a rotor including a central hub carried on said rotating member, a plurality of circumferentially spaced radially extending blades, a cylindrical drum with circumferentially spaced arcuate slots, each slot having a contour complemental to the cross section of a blade, each blade having an individual supporting spoke of thicker cross section than that of said blade and forming a shoulder for abutting the inner surface of said drum around the edge of the associated arcuate slot, and means fastening said spokes to said hub for holding each blade against radial displacement in said slot and for co-rotation of the rotating member and blade.

5. In an axial flow compressor for a turbo-jet engine including a rotor wheel mounted on a drive shaft which comprises a plurality of circumferentially spaced spoked blades having spoke and blade portions, said rotor wheel having a hub connecting hub ends of said spoke portions to said drive shaft, a cylindrical drum with circumferentially spaced arcuate shaped slots, each slot having a contour complemental to the cross-section of a blade portion, said spoke portion having a thicker cross-section than that of said blade portion and forming a shoulder at the junction of the blade and spoke portions with the shoulders on said spoke portion abutting the inner surface of said drum around the edge of the associated arcuate slots and with said drum being secured to said spoked blades and being otherwise out of contact with said rotor wheel and said drive shaft.

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