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(54) **A rotor having an annulus filler**

(57) An annulus filler for installation between blades, such as fan blades, of the rotor of a gas turbine engine comprises a channel 13 which accommodates a post 6 defined between blade slots 4 of the disc 2. A chocking surface 24 of the annulus filler 12 contacts regions of a contact surface 26 of the post 6 to chock the head 10 of the post 6 within the channel 30. The annulus filler 12 is thus supported along the axial length of the post 6, enabling it to withstand circumferential forces generated on rotation of the disc 2.

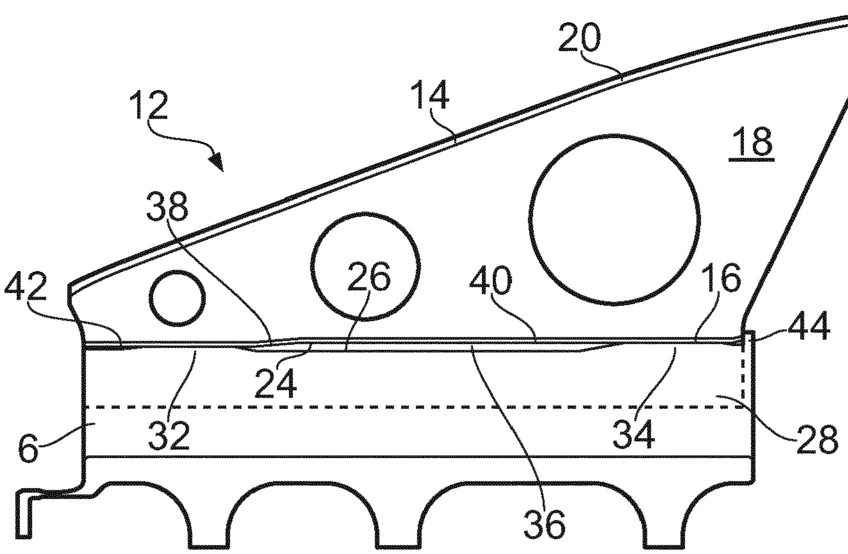

FIG. 3

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Description

[0001] This invention relates to a rotor comprising a rotor disc, an array of blades received in blade slots provided in the disc, and annulus fillers disposed between adjacent blades. The invention is particularly, although not exclusively, concerned with a rotor in the form of a fan of a turbofan gas turbine engine.

[0002] The fan of such an engine typically comprises a rotor disc which has an array of slots at its periphery, which receive individual fan blades. The regions of the disc between the slots constitute posts. It is common for annulus fillers to be provided between adjacent blades of the fan in order to provide an airwashed surface which has the desired aerodynamic profile, and provides a transition between forward and aft components such as a spinner fairing and a fan rear seal.

[0003] It is known to mount annulus fillers by securing them at their forward and aft ends to the surrounding structure. Annulus fillers are subjected to substantial centrifugal forces as the rotor rotates, and, if they are unsupported between their ends, these centrifugal forces can cause deformation. It is therefore necessary to design the annulus fillers so that they deform under rotation to provide the desired aerodynamic profile. Furthermore, the stresses imposed on the annulus filler during an operating cycle need to be analysed to ensure that the fatigue life of the component lies within acceptable limits.

[0004] The effects of centrifugal forces on the annulus fillers can be mitigated by constructing each annulus filler in the form of a structural beam, for example an I-section beam, so that it is resistant to bending. This increases the bulk, and consequently the weight, of the component. An alternative measure is to provide connections, for example in the form of hooks, between the ends of the annulus filler, which engage cooperating formations on the periphery of the rotor disc. It is possible for annulus fillers with such hook connections to be fitted incorrectly, so that they may become detached in operation. Also, the hook connections can be susceptible to Low Cycle Fatigue cracking which, again, can result in release of the annulus filler. A further disadvantage arises from the need for corresponding profiles on the rotor disc, which increase the diameter and weight of the rotor disc and the forging from which it is machined, and also increase the amount of machining required to form the finished disc. The additional diameter means that the effective depth of the blade-retaining slots is increased, which reduces the stability of the cutting tools required to form the slots. The provision of hook features on the rotor disc thus increases the cost of the rotor discs.

[0005] It is known from US 6832896 to provide a blade platform, performing the function of an annulus filler, which is made from sheet metal and is profiled to fit around the roots of the adjacent blades. The annulus filler of US 6832896 has side walls which lie in contact with the blades in the region of the blade roots, and this can undesirably alter the vibration characteristics of the blades, leading to early fatigue failure. Until the blades are fitted, the blade platforms are not securely fixed with respect to the disc.

[0006] According to the present invention there is provided a rotor disc having an array of blade slots each slot retaining a blade root, in which disc posts are defined between adjacent blade slots and annulus fillers are disposed between adjacent blade slots, each annulus filler comprising a body having an airwashed surface and an oppositely disposed chocking surface which contacts a surface of the respective disc post, the disc post having a post formation extending across the axial width of the disc post, and the annulus filler having an annulus filler formation adjacent the chocking surface which abuts both the post formation and the blade root to retain the annulus filler radially with respect to the disc; in which the chocking surface has at least one contact region (42, 44) in contact with the post formation and at least one non-contact region (24) spaced from the disc post formation.

[0007] Each disc post may comprise a stem and a head with a larger circumferential dimension than the stem, in which case the channel walls may be directed inwardly of the channel and may engage the disc post beneath the head so that the head is firmly engaged between the channel walls and the chocking surface. The channel walls may be situated at the circumferentially outer edges of the chocking surface.

[0008] The channel may extend over substantially the full axial extent of the disc post. In one embodiment, two of the contact regions are disposed at opposite axial ends of the chocking surface, with the non-contact region, or one of the non-contact regions, disposed between them.

[0009] Locating means may be provided for establishing the axial position of the annulus filler with respect to the rotor disc. The locating means may comprise an abutment provided at one axial end of the respective disc post, and engaging the respective annulus filler to limit axial displacement of the annulus filler. Alternatively, or in addition, the locating means may comprise a retaining element fixed to the annulus filler at one axial end of the annulus filler, the retaining element being secured to the rotor disc by a support ring which is releasably secured to the disc.

[0010] Another form of locating means may comprise a shear key which is fitted to the rotor disc and is accommodated within a recess in at least one of the channel walls.

[0011] The body of each annulus filler may comprise a box section having an outer wall providing the airwashed surface, an inner wall providing the chocking surface, and oppositely disposed side walls extending between the outer wall and the inner wall. The outer wall may project circumferentially beyond the side walls, and sealing means may be provided between the circumferential edges of the outer wall and respective blades fitted in the blade slots.

[0012] At least one of the inner and side walls may be provided with weight-saving apertures. Each annulus filler may be made from a composite material, for example a fibre reinforced material reinforced with carbon fibre, glass fibre, Kevlar or similar materials.

[0013] The rotor may be a fan rotor of a gas turbine engine.

[0014] The present invention also provides an annulus filler for a rotor as defined above.

[0015] For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows a section of a rotor disc fitted with an annulus filler;
Figure 2 is a sectional end view of the rotor disc and annulus filler of Figure 1;
Figure 3 is a sectional side view of the rotor disc and annulus filler of Figures 1 and 2;
Figure 4 is an enlarged view corresponding to Figure 3, showing retaining means for the annulus filler;
Figure 5 shows a variant of the annulus filler of Figures 1 to 4; and
Figure 6 is an aft axial view of the annulus filler of Figure 5.

[0016] Figure 1 shows a rotor disc 2 of a fan rotor of a gas turbine engine. It will be appreciated that the rotor disc is in the form of an annulus, only part of which is shown in Figure 1. The rotor disc 2 has a circumferential array of blade slots 4, only two of which are shown in Figure 1. Between the two slots 4, there is a disc post 6, which comprises a stem or neck 8, and a head 10 which has a larger circumferential dimension of the stem 8.

[0017] An annulus filler 12 is mounted on the post 6. The annulus filler 12 is a box-section component having a trapezoidal cross-section as shown in Figure 2, which is a sectional view taken approximately half way along the axial length of the annulus filler 12. Thus, the annulus filler 12 has an outer wall 14, an inner wall 16, and side walls 18. The side walls 18 extend substantially radially with respect to the central axis of the disc 2.

[0018] The outer wall 14 presents an airwashed surface 20 over which flows the air stream through the fan in operation. The circumferential edges 22 of the outer wall 14 project in the circumferential direction beyond the side walls 18. Seals (not shown) are provided between each edge 22 and the adjacent blade (not shown) in order to seal the gaps between the annulus filler 12 and the blades. The blades may be provided with short stub platforms which project from the blades towards the edges 22.

[0019] The inner wall 16 provides a chocking surface 24 which faces the radially outer periphery 26 of the post 6. Channel walls 28, which can be regarded as extensions of the side walls 18, extend from the circumferentially outer edges of the chocking surface 24. The channel walls 28 define, with the chocking surface 24, a channel 30 which accommodates the head 10 of the post 6. The channel walls 28 are profiled to conform closely to the contours of the head 10, and consequently are directed inwardly of the channel 30 towards their free edges.

[0020] As shown in Figure 3, the chocking surface 24 does not contact the outer surface 26 of the post 6 at all axial locations. The outer surface 26 is profiled to provide two pedestals 32, 34, between which there is a recess 36, visible also in Figure 2. Also, the inner wall 16 of the annulus filler 12 includes a joggle 38, which means that the aft region 40 of the inner wall 16 is spaced radially outwardly with respect to the forward region 42. As shown in Figure 3, the result is that the chocking surface 24 contacts the outer surface 26 of the post 6 only at the pedestals 32, 34. Nevertheless, the channel walls 28 engage the head 10 of the post 6 over substantially the full axial length of the post 6, so that the annulus filler 12 is retained on the disc 2 in the radial direction, over the full axial length of the inner wall 16.

[0021] By providing contact between the chocking surface 24 and the outer surface 26 only at the separate regions of the pedestals 32, 34, and providing the recessed region 36 between them, installation of the annulus filler 12 is assisted. The annulus filler 12 is fitted to the post 6 by sliding from the forward direction towards the aft direction, and the configuration shown in Figure 3 reduces the frictional resistance to this sliding movement until the raised region 40 of the inner wall 16 contacts the aft pedestal 34. The forward ends of the pedestals 32, 34 are ramped in order to guide the annulus filler 12 so that sequential engagement of the chocking surface 24 first with the pedestal 32 and then with the pedestal 34 is assisted. When fitted, the head 10 of the post 6 is firmly engaged within the channel 30 by the chocking action extended between the chocking surface 24 and the channel walls 28.

[0022] Axial displacement of the annulus filler in the aft direction is limited by an abutment 44 on the head 10. When the annulus filler 12 is fully installed, the aft edge of the inner wall 16 contacts the abutment 44, so defining the correctly installed position. This abutment, along with the frictional engagement created by the chocking effect between the chocking surface 24 and the channel walls 28, may be sufficient to retain the annulus filler 12 in the correct position on the disc 2. Nevertheless, additional or alternative fastening measures may be employed, if required.

[0023] Figure 4 shows an alternative securing means which may be used with, or instead of, the abutment 44. In the embodiment shown in Figure 4, a forward extension 46 is provided on the disc 2. A support ring 48 is secured to the extension 46 and extends around the entire disc 2. The support ring serves to mount further structure on the disc 2, for example a spinner fairing which follows the line of the outer wall 14 of the annulus filler 12 and encloses the forward end of the disc 2.

[0024] As shown in Figure 4, a retaining element in the form of an axial stop lug 50 is secured, for example by adhesive bonding or integral moulding, to the inner wall 16, and is trapped between the disc 2 and the support ring 48. The stop lug 50 thus serves to prevent axial displacement of the annulus filler 12 on the disc 2.

[0025] Figure 5 shows an alternative retaining measure, in the form of a recess or cut-out 52 in each channel wall 28. In some gas turbine engines, a shear key may be provided which acts as a bridge between the disc 2 and the root of a blade accommodated in one of the slots 4. By way of example, a slot 54 for a shear key is shown in Figure 1. In use of the embodiment of Figure 5, the shear key extends into the cut-out 52, to anchor the annulus filler 12 axially with respect to the disc 2.

[0026] Figure 6 is a view from the aft end of the annulus filler 12 shown in Figure 5, and illustrates the curvature which an annulus filler may have in order to conform to the profiles of adjacent blades. Figure 6 also shows weight-saving apertures 56 provided in the side walls 18 and the inner wall 16 in order to reduce the weight of the annulus filler.

[0027] The annulus filler 12 may be made from any suitable material such as an aerospace metallic alloy or a composite material. The configuration of the annulus filler 12 lends itself particularly to manufacture from a composite material, for example by lay-up using pre-impregnated pre-forms, or dry pre-forms impregnated with resin in a resin transfer moulding process, or using automated fibre placement techniques. The composite material may comprise carbon fibre, glass fibre, or Kevlar reinforcements. If carbon fibre is used, provision for protection against galvanic corrosion will be required where the annulus filler 12 interfaces with aluminium alloy components.

[0028] The annulus filler 12 could alternatively be manufactured by an extrusion operation followed by pultruding or hydroforming to shape, or by injection moulding.

[0029] An annulus filler as described above is locked firmly with respect to the disc post 6, and is further retained in position by blade roots accommodated in the blade slots 4 on assembly of the complete fan rotor. Radial loading on the annulus filler 12 is distributed over the full axial length of the disc post 6, so reducing stresses in the annulus filler 12 and enabling significant weight savings. As shown in Figure 2, the side walls 18 extend radially of the disc 2, with the result that the side walls 18 are able to withstand centrifugal forces without bending stresses, further enabling weight reduction.

[0030] Incorrect fitting of the annulus filler 12 is difficult and, if mis-fitting occurs, is visually noticeable.

[0031] The geometry of the annulus filler 12 described above is relatively simple compared with known annulus filler components, and consequently manufacturing costs can be reduced. Similarly, the elimination of any requirement for projecting features at the periphery of the fan disc 2 reduces the diameter of the fan disc forging, and reduces the time required for machining complex features such as retaining hooks. Where a shear key is provided, the absence of any hook feature provides greater freedom for the positioning of the shear key slot 54, since it is not necessary to avoid alignment of the shear key slot with the hook features.

[0032] As shown in Figure 6, the annulus filler 12 need not be straight, but could be arcuate, provided that the general cross-section of the disc post 6 is substantially constant over its full length. The local flexibility of the annulus filler can be controlled by varying the thickness of the cross-sections of the outer and inner walls 14, 16 and the side walls 18 in order to accommodate blade rock.

[0033] Appropriate formations may be provided on the annulus filler 12, such as pips, bumps or ridges, in order to avoid water retention and to mitigate contact fretting.

[0034] Although the annulus filler described above comprises the channel 30 which accommodates the head 10 of the disc post 6, other means of retaining the annulus filler 12 radially with respect to the disc 2 may be employed. For example, the post 6 may be a secondary dovetail or retaining post in or on the head 10 for engagement by a complementary formation provided on the annulus filler 12 adjacent the chocking surface 24.

Claims

1. A rotor comprising a rotor disc (2) having an array of blade slots (4) each slot retaining a blade root, in which disc posts (10) are defined between adjacent blade slots and annulus fillers (12) are disposed between adjacent blade slots, each annulus filler comprising a body having an airwashed surface (20) and an oppositely disposed chocking surface (24) which contacts a surface of the respective disc post, the disc post having a post formation (26) extending across the axial width of the disc post, and the annulus filler having an annulus filler formation (28) adjacent the chocking surface which abuts both the post formation and the blade root to retain the annulus filler radially with respect to the disc; in which the chocking surface has at least one contact region (42, 44) in contact with the post formation and at least one non-contact region (24) spaced from the disc post formation.

2. A rotor as claimed in claim 1, in which the annulus filler formation comprises a pair of channel walls (28) extending from the chocking surface and defining with the chocking surface a channel which receives the respective disc post.

3. A rotor as claimed in claim 2, in which the disc post comprises a stem (8) and a head (6) with a larger circumferential dimension than the stem.

4. A rotor as claimed in claim 3, in which the channel walls are directed inwardly of the channel and engage beneath the head of the disc post.

5. A rotor as claimed in any one of claims 2 to 4, in which the channel walls extend from circumferentially outer edges of the chocking surface.

6. A rotor as claimed in any one of claims 2 to 5, in which the channel extends substantially the full axial extent of the disc post.

7. A rotor as claimed in any preceding claim, in which two of the contact regions (32, 34) are disposed at opposite axial ends of the chocking surface, with the non-contact region, or one of the non-contact regions, disposed between them.

8. A rotor as claimed in any one of the preceding claims, in which an abutment (44) is provided at one axial end of the disc post, the annulus filler engaging the abutment to limit axial displacement of the annulus filler.

9. A rotor as claimed in any one of the preceding claims, in which a retaining element (50) is provided at one axial end of the annulus filler, the retaining element being engaged by a support ring (48) which is releasably secured to the rotor disc.

10. A rotor as claimed in any one of the preceding claims, in which a shear key is fitted to the rotor disc and is accommodated in a recess (52) in the annulus filler.

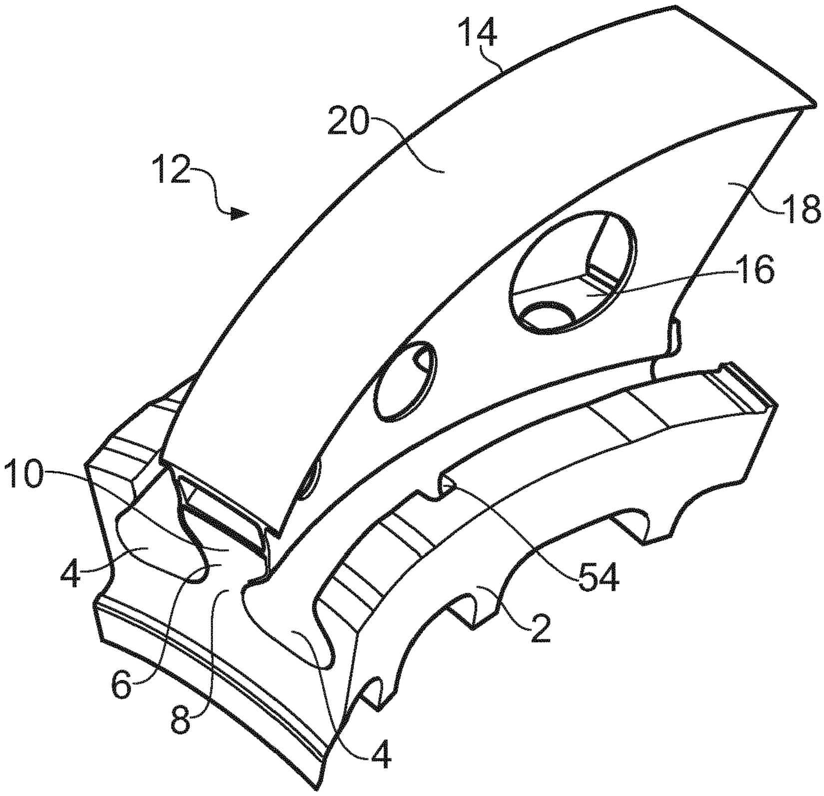
11. A rotor as claimed in any one of the preceding claims, in which the body comprises a box section having an outer wall providing the airwashed surface, an inner wall providing the chocking surface, and side walls extending between the inner wall and the outer wall.

12. A rotor as claimed in claim 11, in which the outer wall projects circumferentially beyond the side walls.

13. A rotor as claimed in claim 11 or 12, in which at least one of the inner and side walls is provided with weight-saving apertures.

14. A rotor as claimed in any one of the preceding claims, in which the annulus filler is made from a composite material.

15. A rotor as claimed in any one of the preceding claims which is a fan rotor of a gas turbine engine.


14
20
12
18
16
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4
54
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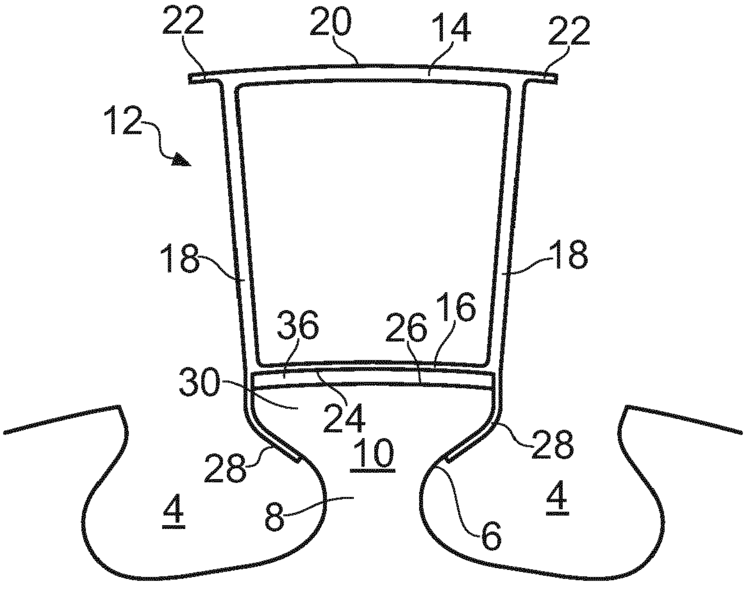
6
8
4

FIG. 1


22
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6

FIG. 2

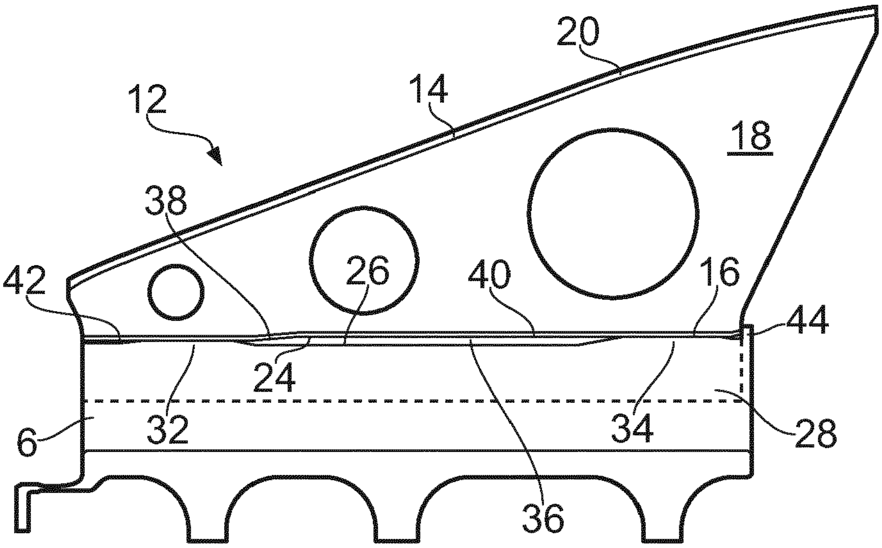

FIG. 3

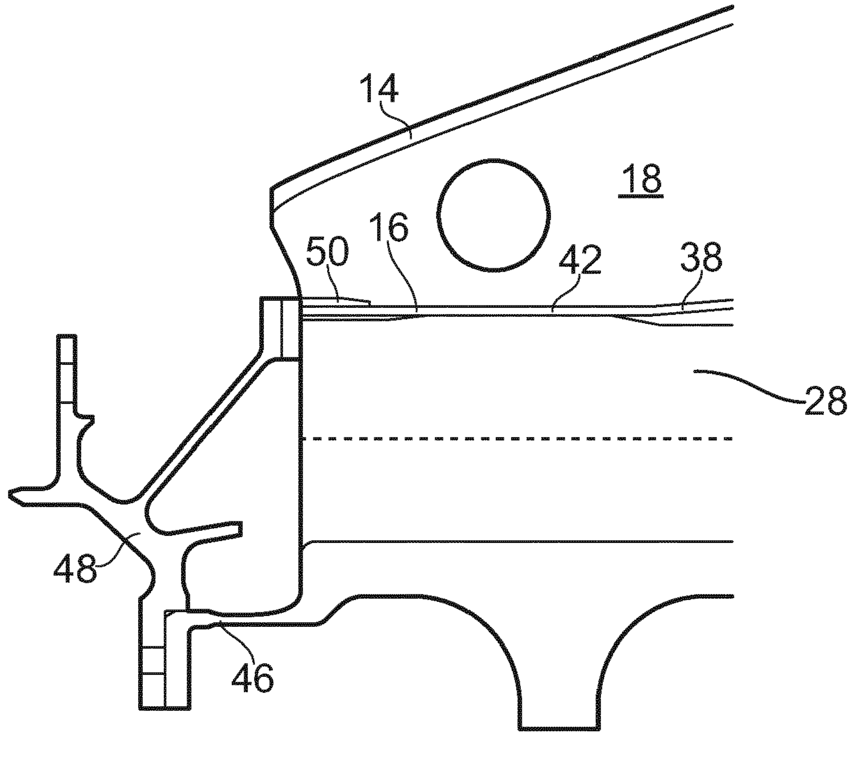

FIG. 4

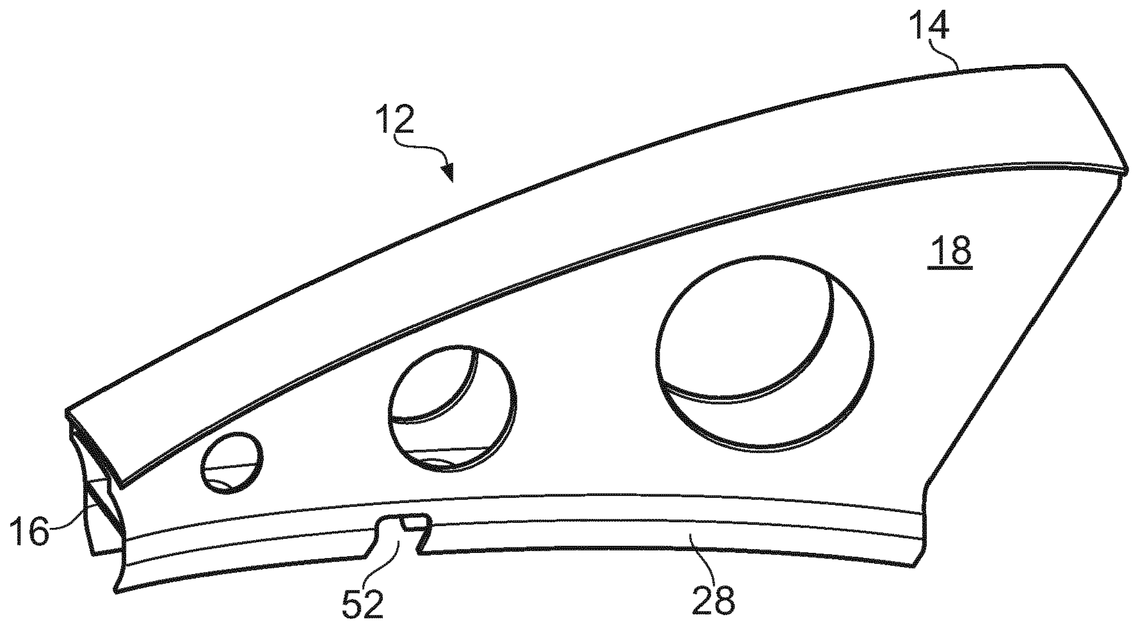

FIG. 5

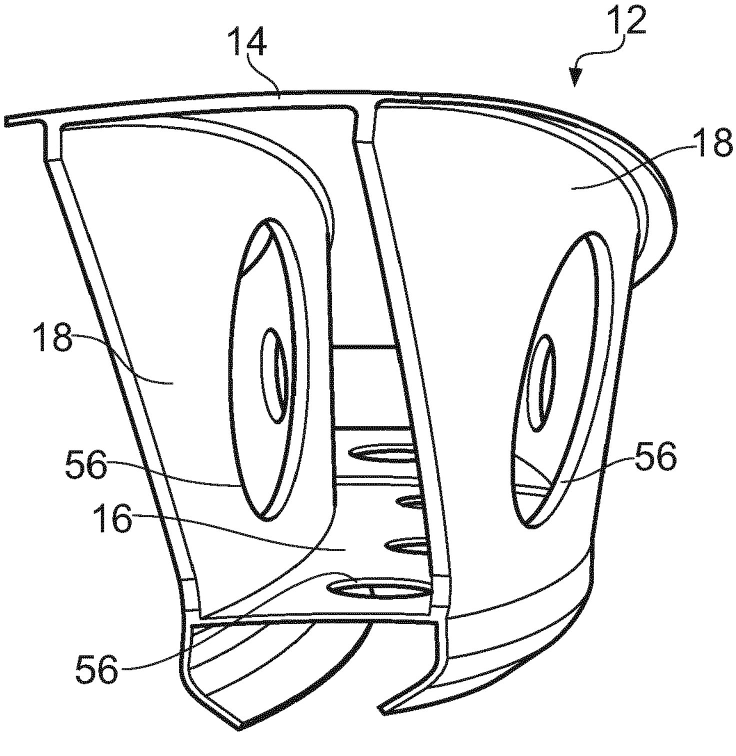

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6832896 B **[0005]**