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(54) **Turbine blades retention system and method**

(57) A retention system retains a turbine blade dovetail in a retention ring dovetail slot. The retention system includes a retention opening (20, 30) formed in the blade dovetail (16). A through hole (22) is formed in the retention ring (14), wherein the through hole is positioned such that it is aligned with the retention opening when the dovetail is assembled in the dovetail slot (18). A connector (24) is disposed in the through hole and engages the retention opening. In this manner, undesirable relative movement of parts can be reduced or eliminated, thereby preventing excessive wear.

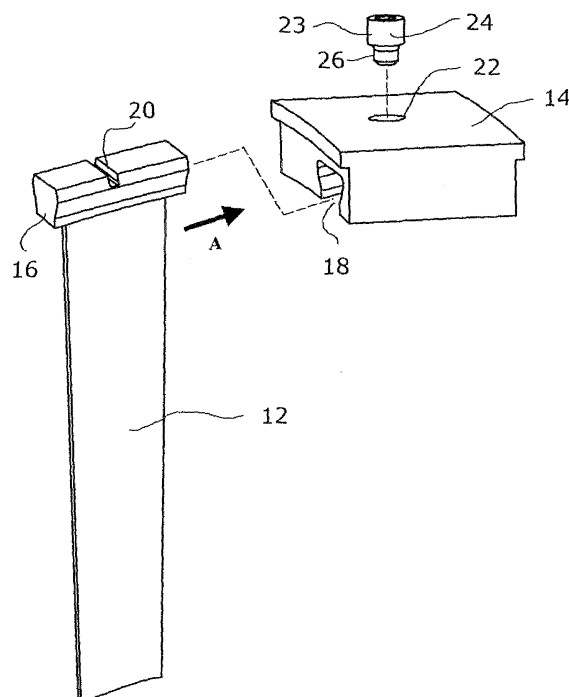


Figure 2

Description

[0001] The invention relates to a retention system used to prevent axial and/or radial movement of a shaped object in a correspondingly shaped slot and, more particularly, to a retention system and method for retaining a turbine blade dovetail in a retention ring dovetail slot.

[0002] FIG. 1 is a cross section showing turbine blades in a conventional compressor. The blades are typically secured via a dovetail section engaging a correspondingly shaped dovetail slot in a retaining ring. Conventional practice for retaining a blade to a ring is through a process called staking, which locally deforms material around the blade dovetail using a hammer with a chisel or center punch. A drawback of this practice, however, is that the staking process is manual, which thereby allows for variation and may lead to disengagement of the fit during engine startup and shutdown.

[0003] Recent field failures on compressor airfoils have shown that the staking process is not adequate to ensure proper retention of the blade in the dovetail slot. As a result, there have been incidents of heavy wear that required forced outages and replacement of failed hardware.

[0004] The fit between the blade and the dovetail slot in the ring is loose to allow for assembly and tolerances. Therefore, if the blades are not properly retained, the loose fit may allow the hardware to move in the slot, leading to excessive wear. The excessive wear would eventually fail the part, requiring the unit to be shut down until a repair can be made.

[0005] Additionally, radial movement of the blade in the dovetail slot allows for a variation of the tip radius during the machining process. Reduced variation in radial clearance could potentially increase performance and avoid excessive tip rubs.

[0006] In an exemplary embodiment of the invention, a retention system retains a shaped object, such as a turbine blade dovetail, in a correspondingly shaped slot formed in a retention member. The retention system includes a retention opening formed in the shaped object. A through hole is formed in the retention member, wherein the through hole is positioned such that it is aligned with the retention opening when the shaped object is assembled in the correspondingly shaped slot. A connector disposed in the through hole and engages the retention opening.

[0007] In another exemplary embodiment of the invention, a method of retaining a turbine blade dovetail in a retention ring dovetail slot includes the steps of forming a retention opening in the blade dovetail; forming a through hole in the retention ring, wherein the through hole is positioned such that it is aligned with the retention opening when the dovetail is assembled in the dovetail slot; and securing a connector in the through hole and engaging the retention opening.

[0008] Various aspects and embodiments of the present invention will now be described in connection

with the accompanying drawings, in which:

FIGURE 1 is a cross section of a conventional compressor assembly;

FIGURE 2 is an exploded view showing the retention system of an embodiment of the invention;

FIGURE 3 shows an assembled view of the retention system;

FIGURE 4 is a forward view looking aft of a stator ring assembly; and

FIGURES 5-12 show cross sectional views along line A-A in FIG. 4 of various embodiments of the invention.

[0009] The following detailed description of various embodiments of the present invention is applied to a gas turbine compressor blade that is retained in the flow path of an engine via a retaining ring.

[0010] This application, however, is exemplary, and the invention is not necessarily meant to be limited to the described and illustrated configuration. The retention system of various embodiments of the invention is applicable to any other device where it is desired to retain a part within a slot.

[0011] FIG. 2 is an exploded perspective view of the retention system of the invention for securing a gas turbine compressor blade 12 in a retention ring 14. The turbine blade 12 includes a dovetail 16 at an end thereof which is assembled into a correspondingly-shaped dovetail slot 18 in the retention ring 14.

[0012] In one embodiment, with reference to FIGS. 2 and 5, a retention slot 20 is formed in the blade dovetail 16. As shown in FIG. 2, the retention slot 20 is oriented substantially perpendicular to an insertion direction A of the dovetail 16 into the dovetail slot 18. A through hole 22 is formed in the retention ring 14. The through hole 22 extends through the retention ring 14 and into the dovetail slot 18. In this context, the through hole 22 is positioned in the retaining ring 14 such that it is aligned with the retention slot 20 when the dovetail 16 is assembled in the dovetail slot 18. After assembling the dovetail 16 in the dovetail slot 18, a connector 24, such as a set screw, dowel pin, cap screw, flat head screw/bolt through the ring, or the like, is secured in the through hole 22 to engage the retention slot 20. In this manner, the turbine blade 12 is retained from displacement in at least an axial direction (corresponding to direction A in FIG. 2).

[0013] In the embodiment illustrated in FIGS. 2 and 5, the connector 24 is preferably a set screw including a screw pin 26 and a head 28. As shown in FIG. 5, a diameter of the through hole 22 may be larger than a width of the retention slot 20. Alternatively, a threaded fastener could be put in from the bottom before a blade is installed and tightened up from the outside. The retention slot 20

is sized to receive the screw pin 26 either loosely, in a clearance fit, or in contact. The through hole 22 preferably includes internal threads that are engaged by corresponding external threads on the set screw head 28. Any of multiple types of set screws may be used including without limitation, a flat point, a cup point, an oval point, a cone point, a half-dog point, and the like.

[0014] The assembled turbine blade is shown in FIG. 3. The assembly provides retention of the compressor blade to prevent unnecessary movement in the slot and thereby prevent undesirable wear.

[0015] FIGS. 6-12 illustrate alternative configurations of the retaining system. In FIG. 6, the retention slot 20 from the FIGS. 2 and 5 embodiment may alternatively be replaced with a hole 30 through the retention ring 14, and the illustrated connector 24 is a half-dog point set screw. This assembly can be added to an existing configuration by first drilling a hole through the retention ring 14 and into the dovetail 16, the hole 30 being sized to receive the point of the screw pin 26. A second hole sized for the set screw head 28 is then drilled in the retention ring 14. With the use of a hole 30 rather than a slot 20, the blade can be retained axially, circumferentially, and/or radially.

[0016] FIG. 7 illustrates a related embodiment wherein a length of the screw pin 26 is generally equal to a depth L of the retention opening, whether it be the retention slot 20 or the retention hole 30. In this manner, a radial load can be applied via the set screw 24 to the dovetail 16, the effect of which is described in more detail below.

[0017] In the embodiment shown in FIG. 8, the dovetail 16 does not include a slot or hole, but rather the connector 24 affixed in the through hole 22 engages a surface of the dovetail 16. FIG. 9 shows a similar embodiment using a cup point set screw as the connector 24. Although such a configuration may have only limited retention capabilities, the radial load on the dovetail 16 by the connector 24 will serve to reduce undesirable relative movement of the dovetail 16 in the dovetail slot 18. Additionally, the radial load will affect damping characteristics of the blade.

[0018] FIG. 10 illustrates an embodiment using a relatively shallow slot/hole 20, 30 and a cone or oval point set screw as the connector 24. FIG. 11 illustrates an embodiment using a V-shaped slot/hole 20, 30 and a cone point set screw as the connector 24.

[0019] FIG. 12 illustrates an alternative arrangement where the connector 24 is a dowel pin. The through hole 22 has a consistent diameter substantially equivalent to a width of the retention slot 20 or a diameter of the retention hole 30 and is sized to receive the dowel pin.

[0020] Using the retention system of various embodiments of the invention, in some embodiments as discussed above, a radial load can be applied to the dovetail 16, which causes a change in the damping characteristics of the blade. As a consequence, it has been discovered that aeromechanical damping can be tuned by controlling a radial load on the dovetail. The damping characteristics can be further controlled by using plural reten-

tion openings, through holes and connectors for each dovetail to be retained. Depending on the application, the damping may also be tuned by varying the depth and/or width of the slot or hole to retain the blade axially, circumferentially and/or radially. By varying the contact points position and number between the connector 24 and the dovetail 16, damping characteristics can be further tuned. Contact points in the exemplary embodiments are shown in FIGS. 5-12.

[0021] The retention system of various embodiments of the invention utilizes a simple connector in a compressor stator ring and blade assembly in order to fix a blade in a dovetail slot. The system is applicable for newly manufactured machines and can be added to existing machines with a simple and inexpensive process. The secure fit with the retention system prevents undesirable relative movement of parts that would result in excessive wear. Reduced variation in the radial clearance also potentially increases performance and avoids excessive tip rubs.

[0022] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

PARTS LIST

[0023]

compressor blade	12
retention ring	14
dovetail	16
dovetail slot	18
retention slot	20
through hole	22
connector	24
screw pin	26
head	28
retention hole	30

Claims

1. A retention system for retaining a turbine blade dovetail (16) in a retention ring dovetail slot (18), the retention system comprising:

a retention opening (20, 30) formed in the blade dovetail (16);
a through hole (22) formed in the retention ring (14), wherein the through hole is positioned such that it is aligned with the retention opening when the dovetail is assembled in the dovetail slot (18); and
a connector (24) disposed in the through hole

and engaging the retention opening.

2. A retention system according to claim 1, wherein the retention opening is a retention slot (20) formed in the blade dovetail (16), the retention slot being oriented substantially perpendicular to an insertion direction of the dovetail into the dovetail slot (18). 5
3. A retention system according to claim 1, wherein the retention opening is a hole (30). 10
4. A retention system according to any preceding claim, wherein the connector (24) is a set screw.
5. A retention system according to claim 4, wherein a diameter of the through hole (22) is larger than a width of the retention opening (20, 30), the set screw comprising a screw pin (26) and a head (28), wherein the retention opening is sized to receive the screw pin, and wherein the through hole is sized to receive the screw head. 15 20
6. A retention system according to any preceding claim, wherein at least one of a number of contact points and a position of the contact points between the connector (24) and the blade dovetail (16) is configured to effect tuning of turbine blade aeromechanical damping. 25
7. A retention system according to any preceding claim, wherein a diameter of the through hole (22) is equal to a width of the retention opening (20, 30), and wherein the connector (24) is sized to fit in the through hole and the retention opening. 30 35
8. A retention system according to any preceding claim, wherein the connector (24) is a dowel pin.
9. A retention system according to any preceding claim, wherein the connector (24) is sized to engage a bottom surface of the retention opening (20, 30) and thereby apply a load to the dovetail (16). 40
10. A retention system according to any preceding claim, comprising plural retention openings (20, 30), plural through holes (22), and plural connectors (24) for each dovetail (16) to be retained. 45

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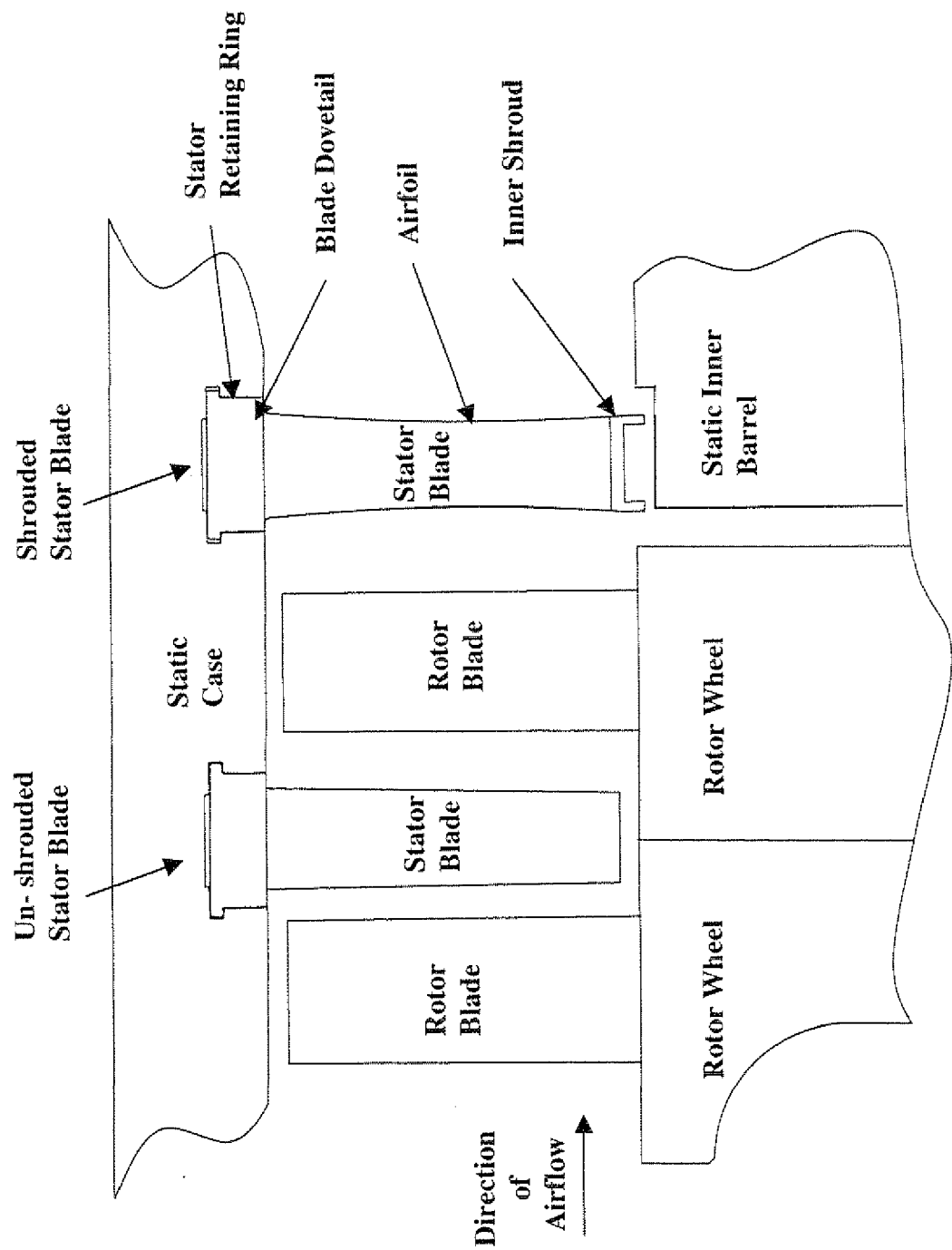


Figure 1

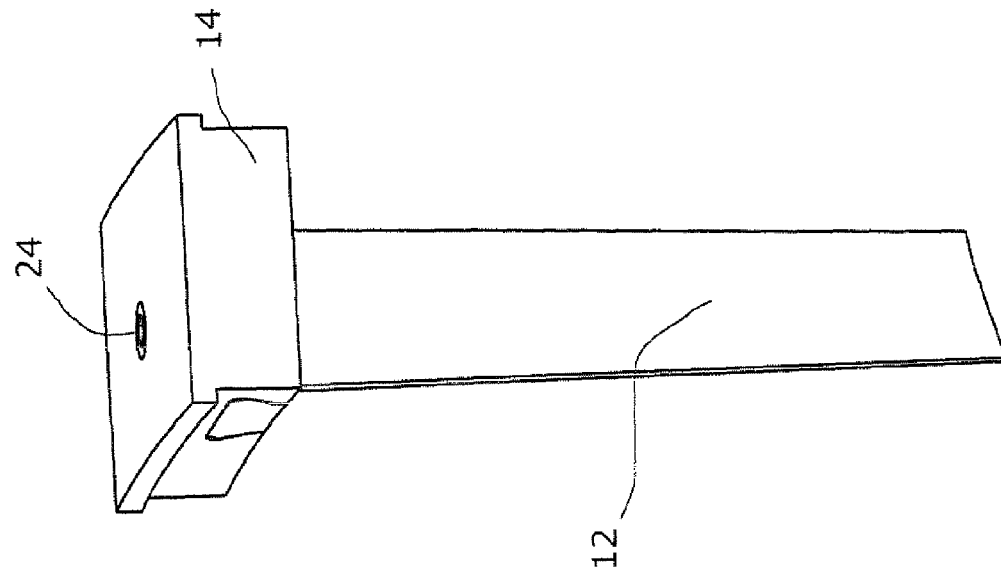


Figure 3

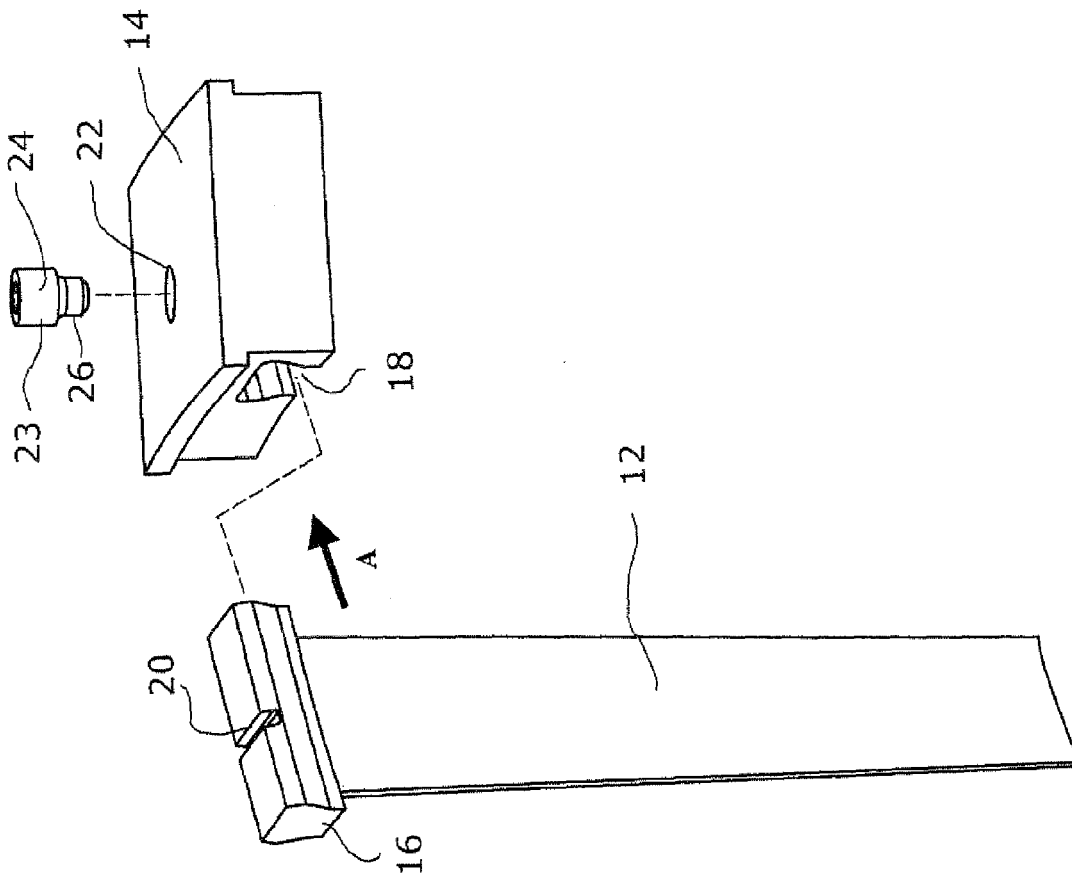


Figure 2

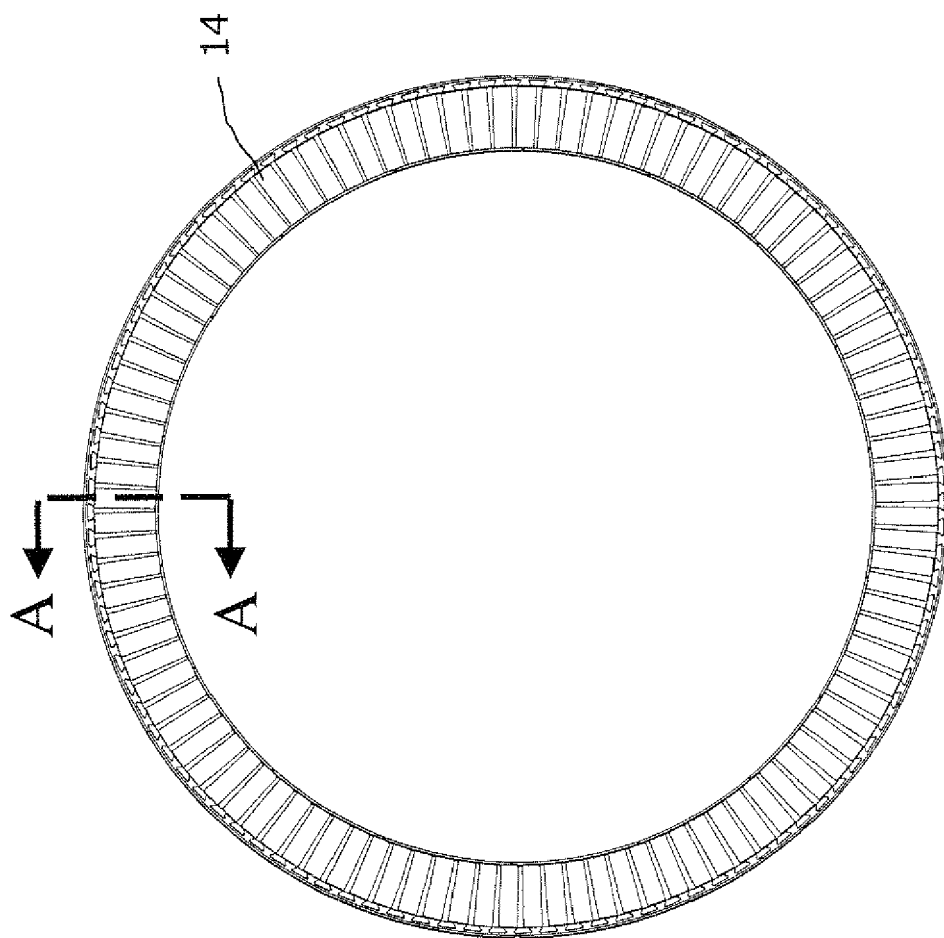


Figure 4.

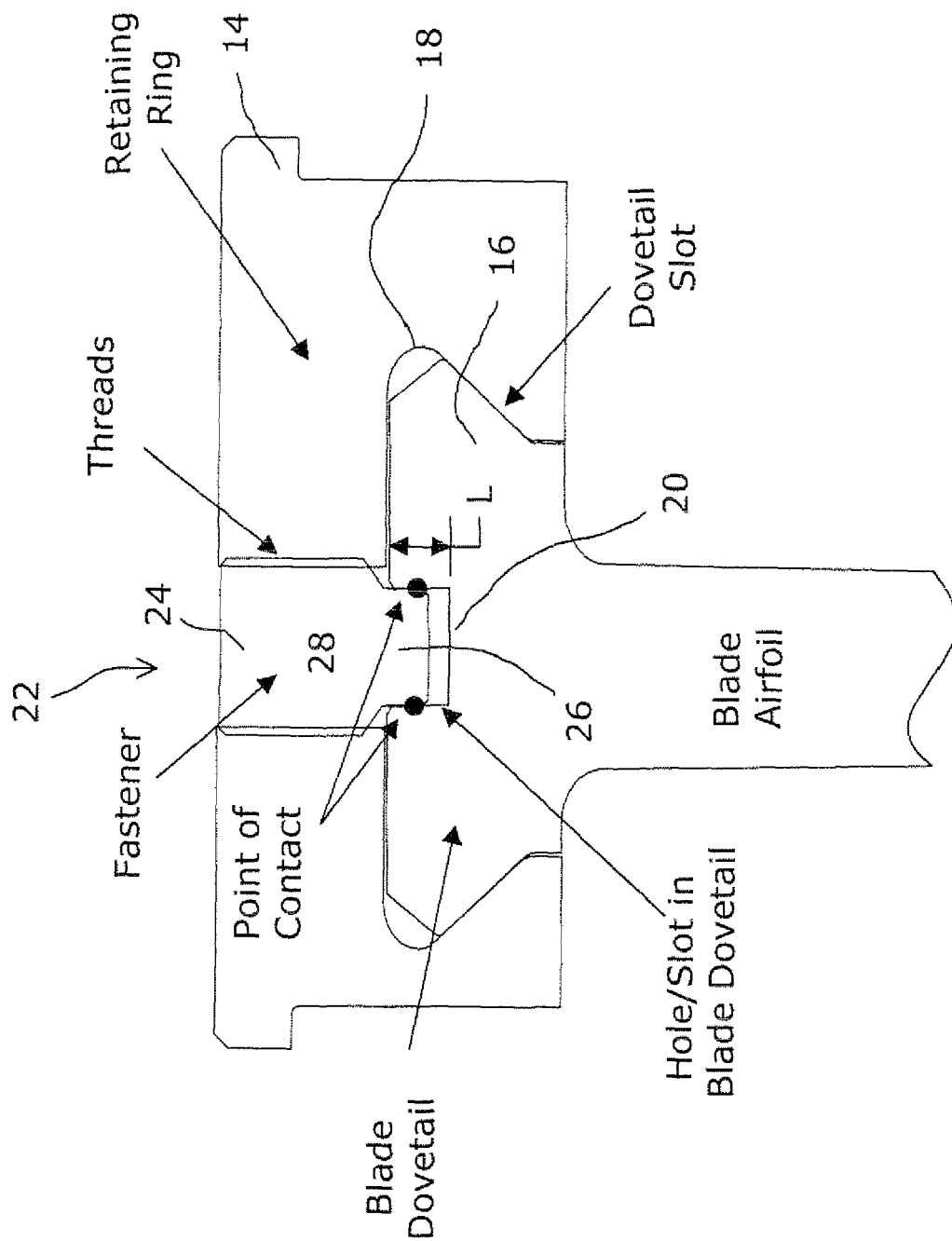


Figure 5

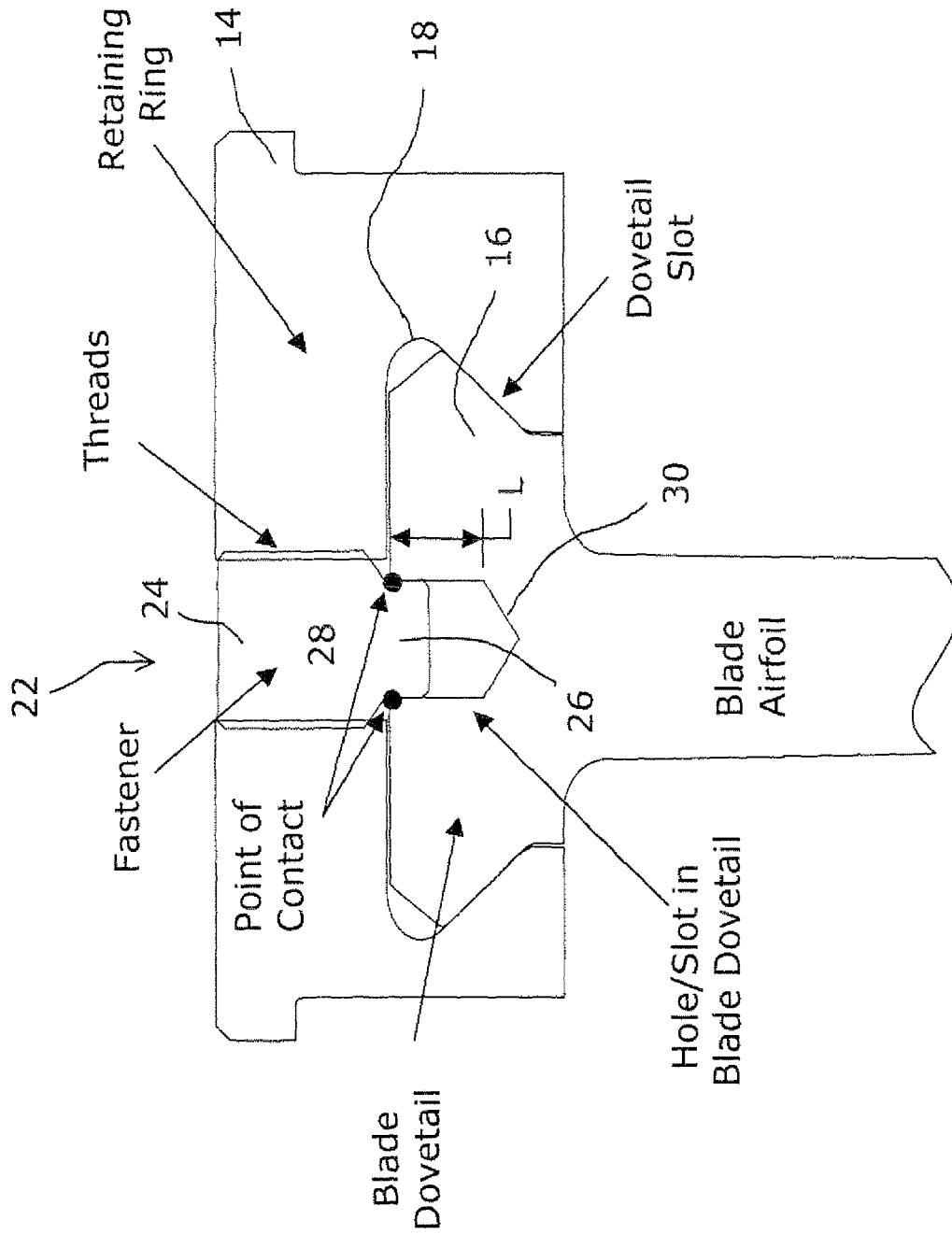


Figure 6

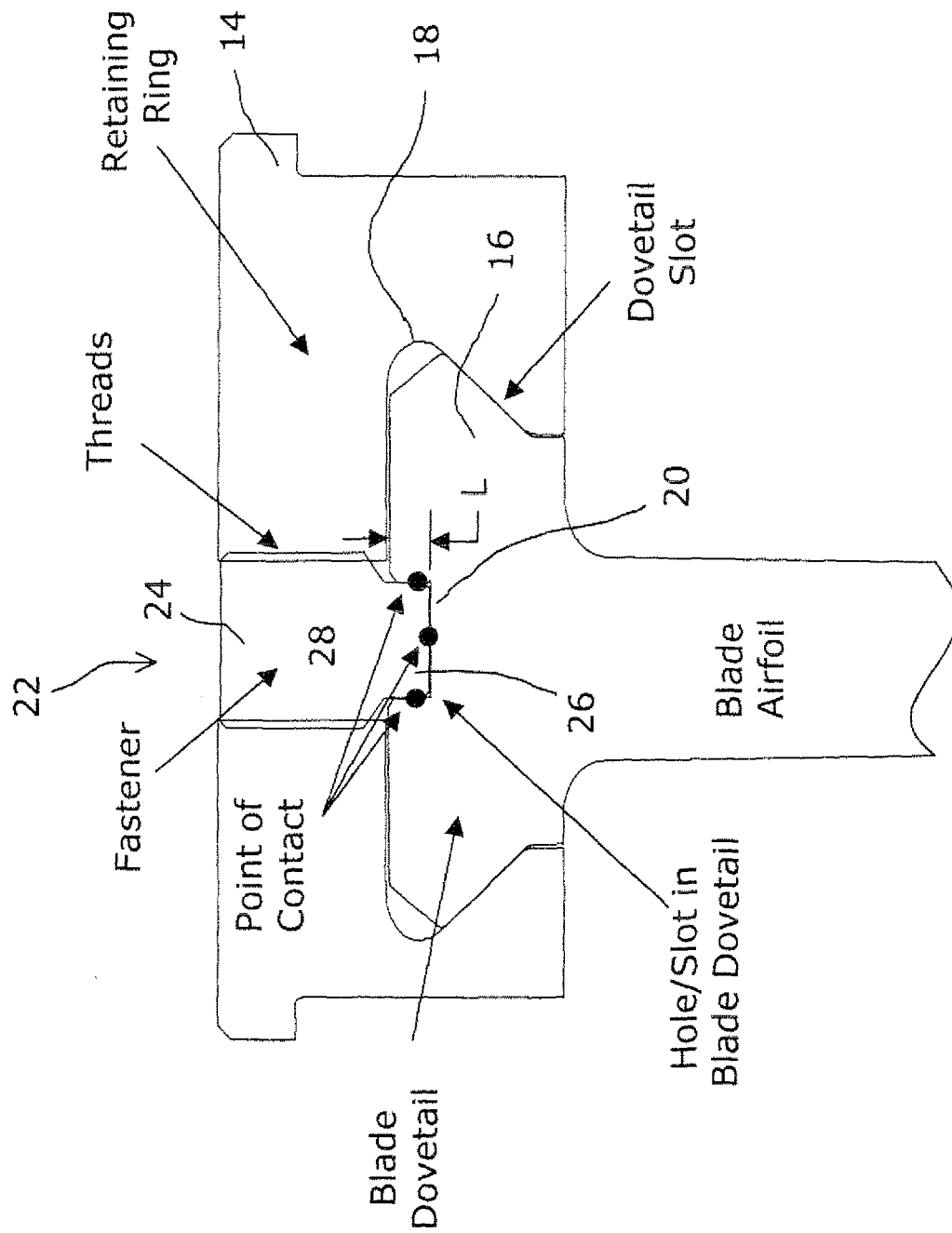


Figure 7

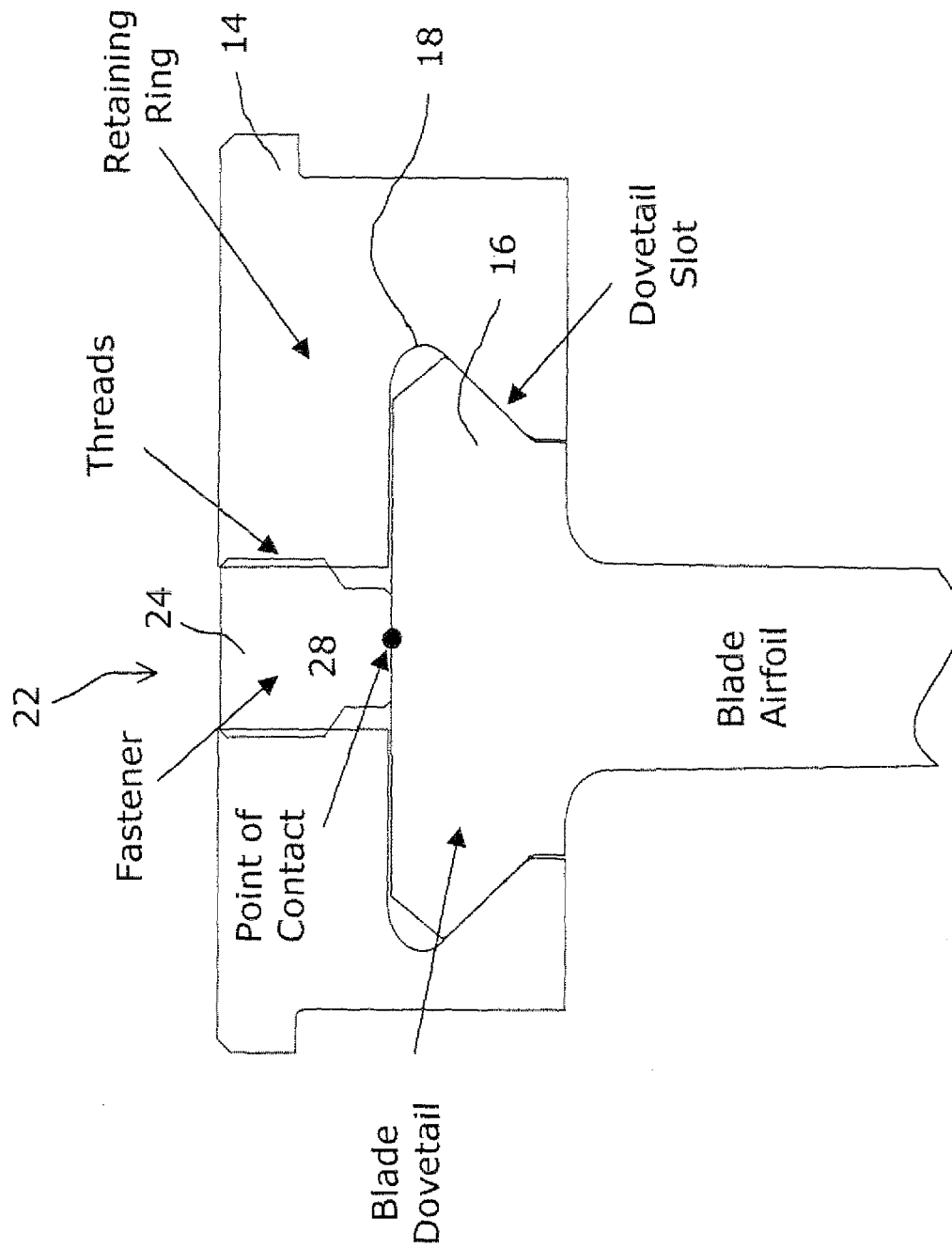


Figure 8

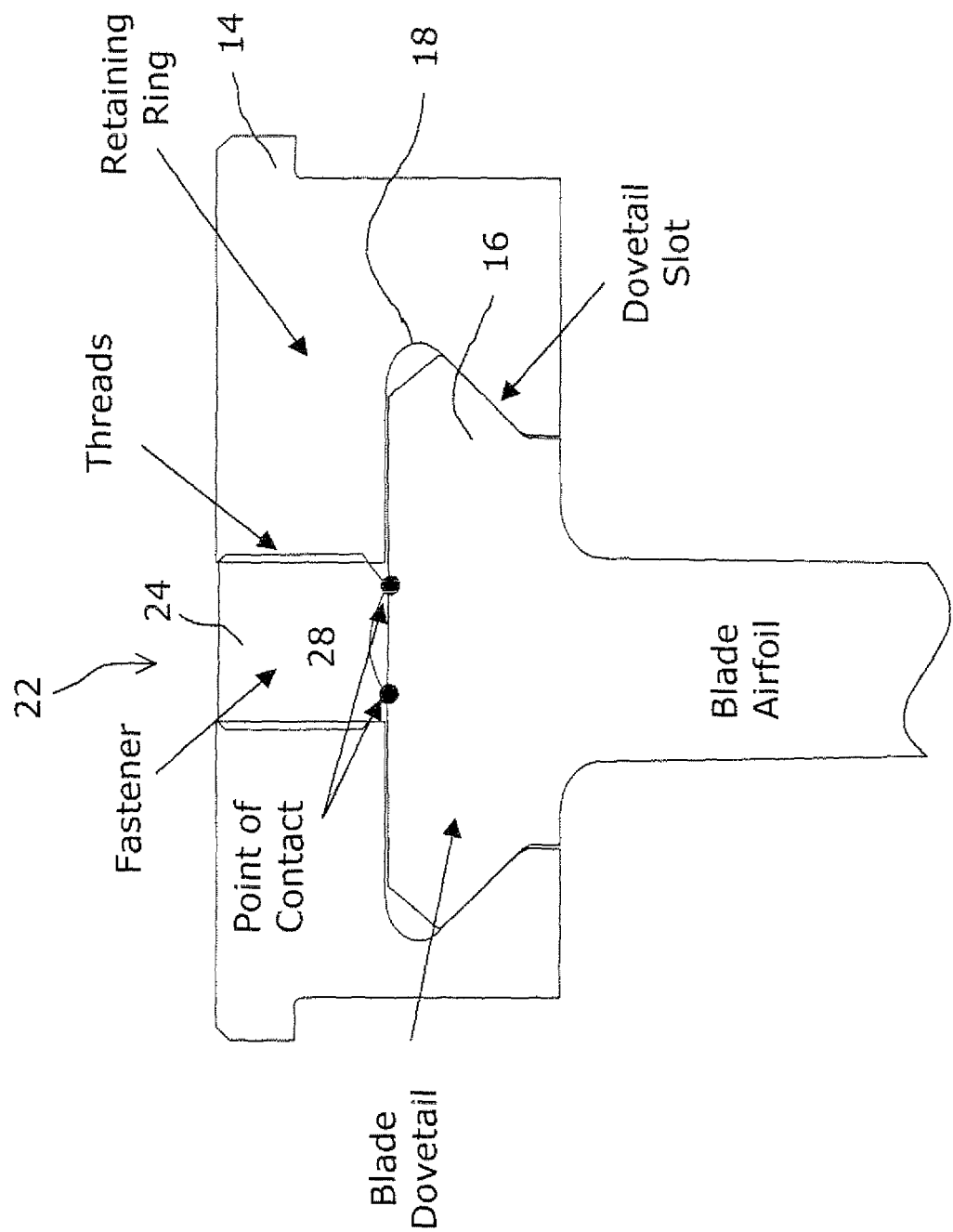


Figure 9

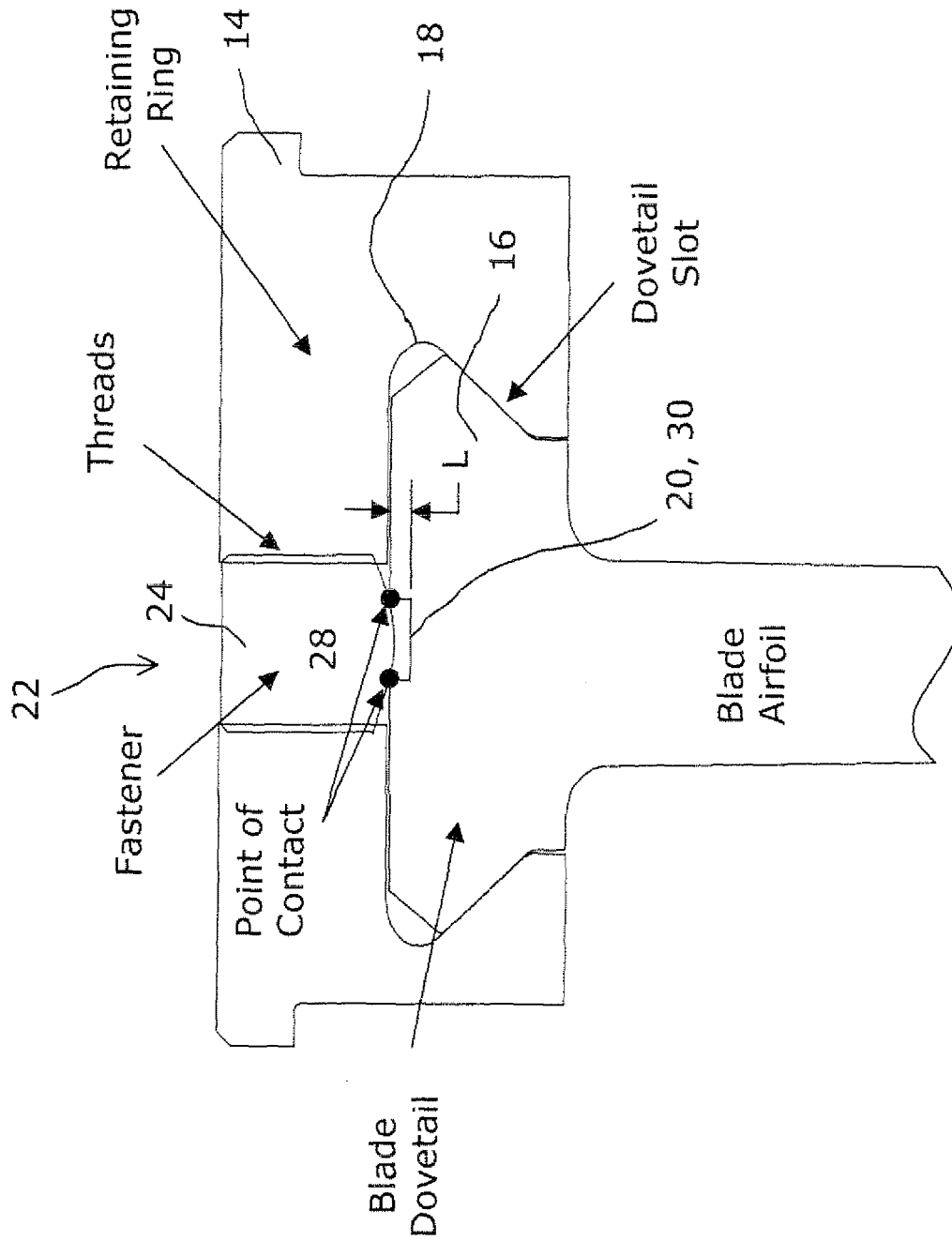


Figure 10

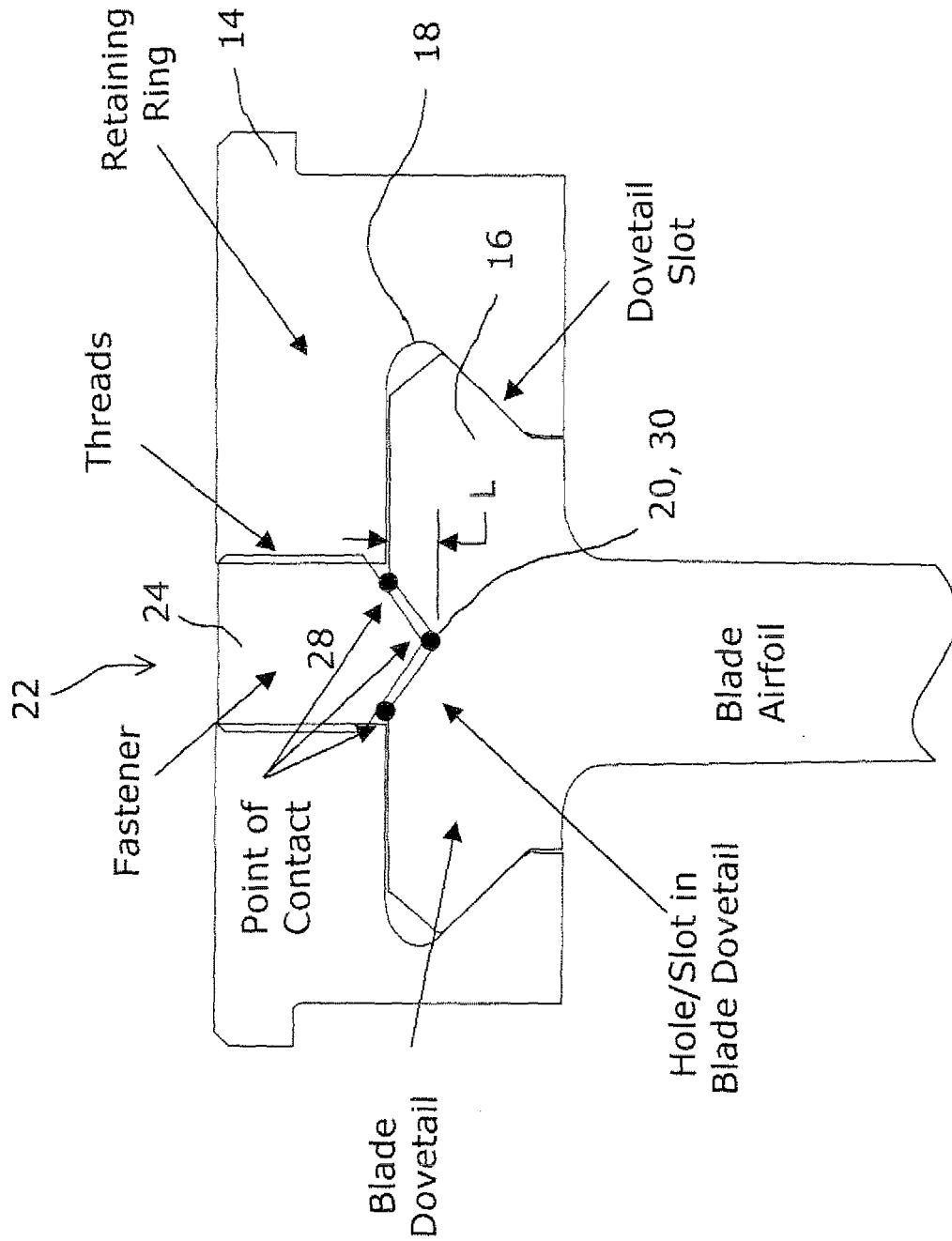


Figure 11

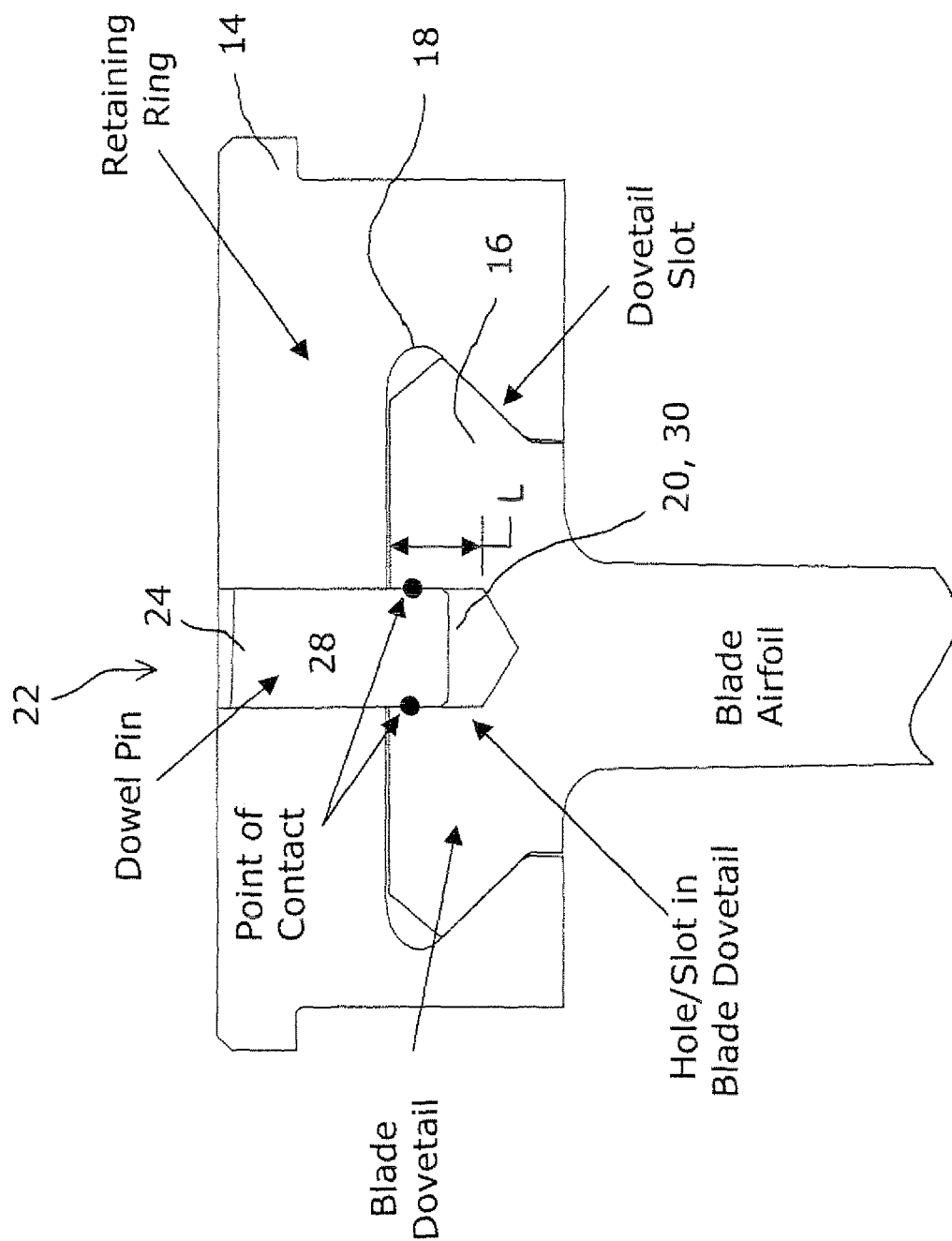


Figure 12