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(54) **MOUNTING DISC**

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(57) **ABSTRACT**

Mounting discs (**20**, **30**, **40**, **50**) are used in gas turbine engines to present turbine or compressor blades. These discs (**20**, **30**, **40**, **50**) incorporate a bore or cob end **31**, **41**, **51** which in turn previously had a flat end face surface. Such flat end face surfaces are weight efficient but can lead to reduced component life and a limitation with regard to rotational speed due to Von-Mises stresses. By providing a deviation (**39**, **49**, **59**, **69**) in the end face from a flat aspect, a reduction in axial stress is achieved with a marginal increase in hoop stress but with a net result that there is a reduction in the general operational Von-Mises stresses and therefore improvement in disc life or potential rotation speed capacity or both.

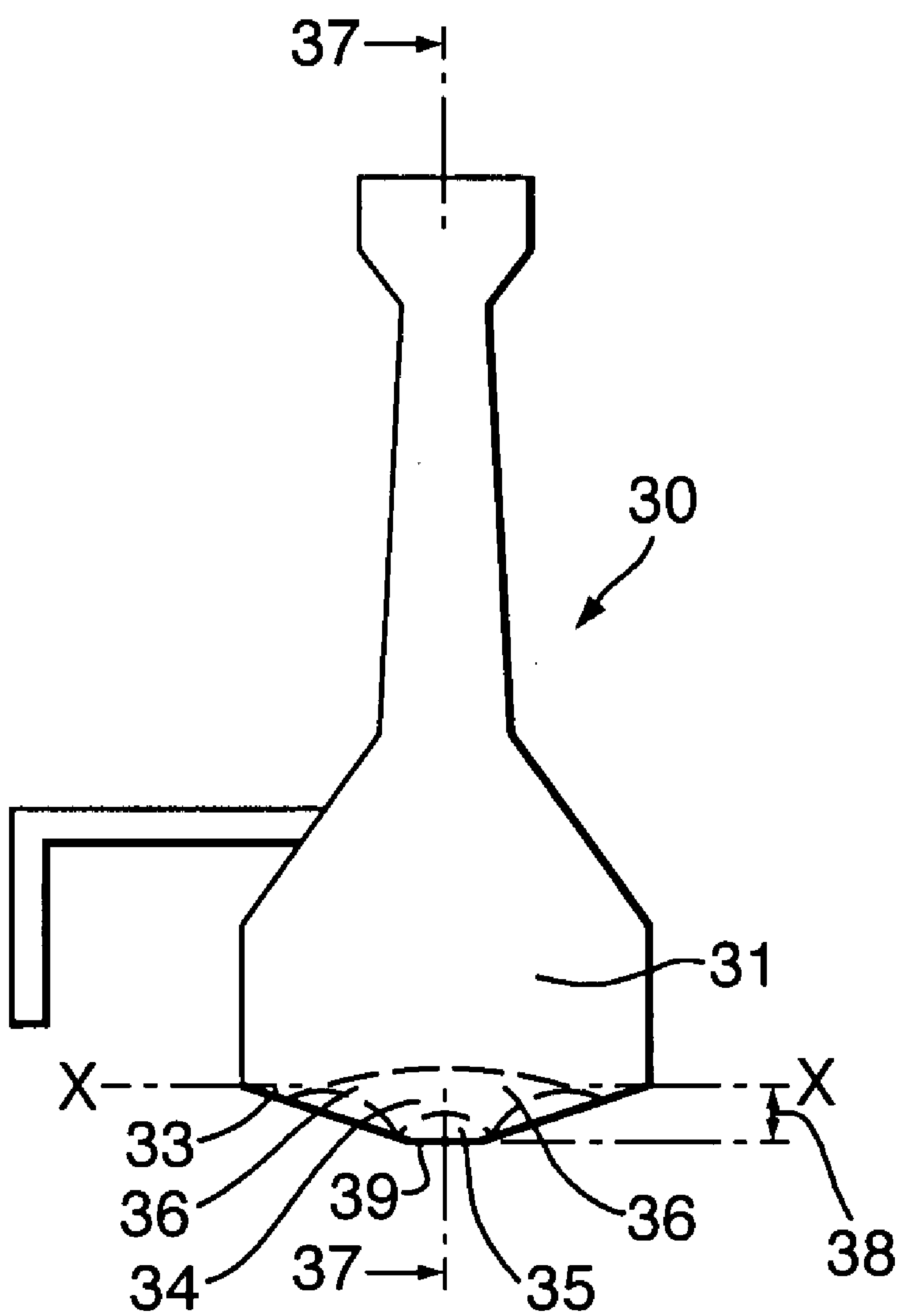


Fig.1.

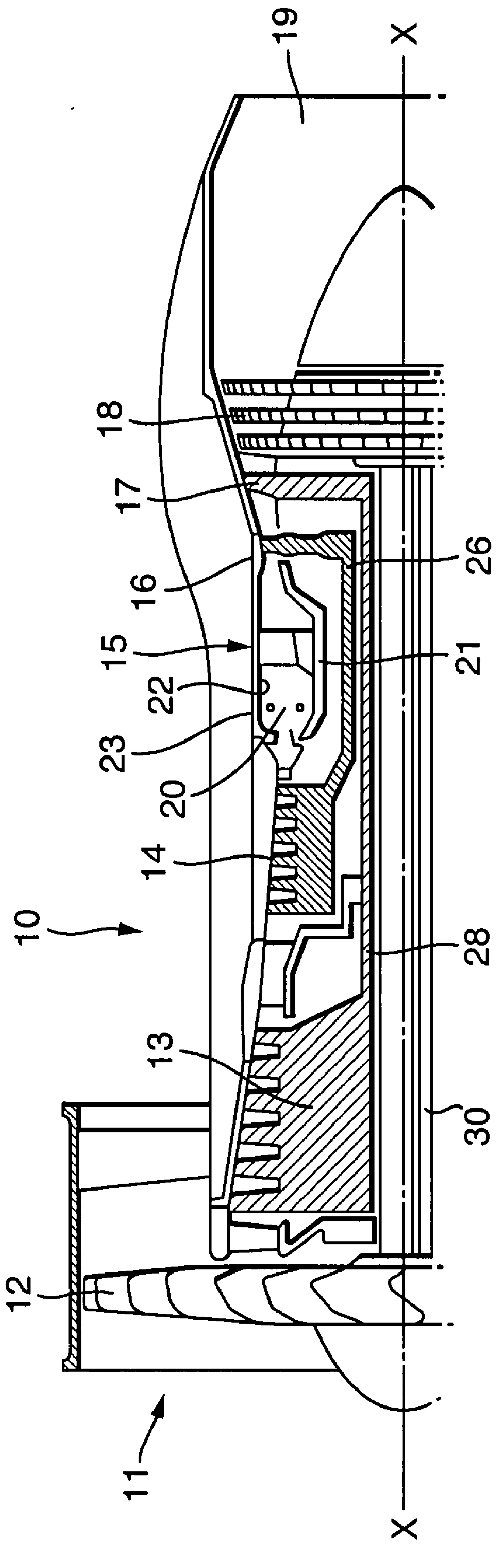


Fig.2.

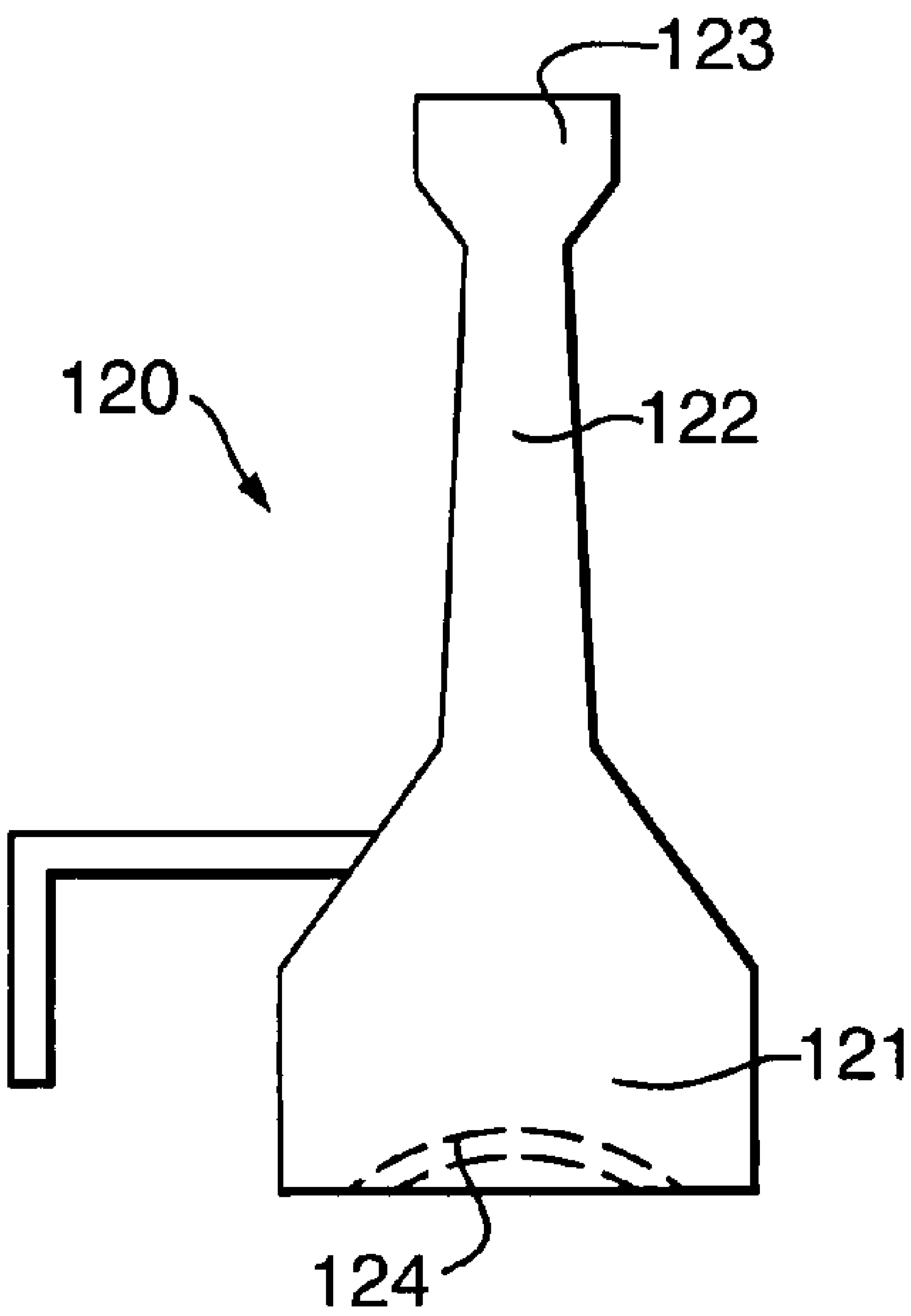


Fig.3.

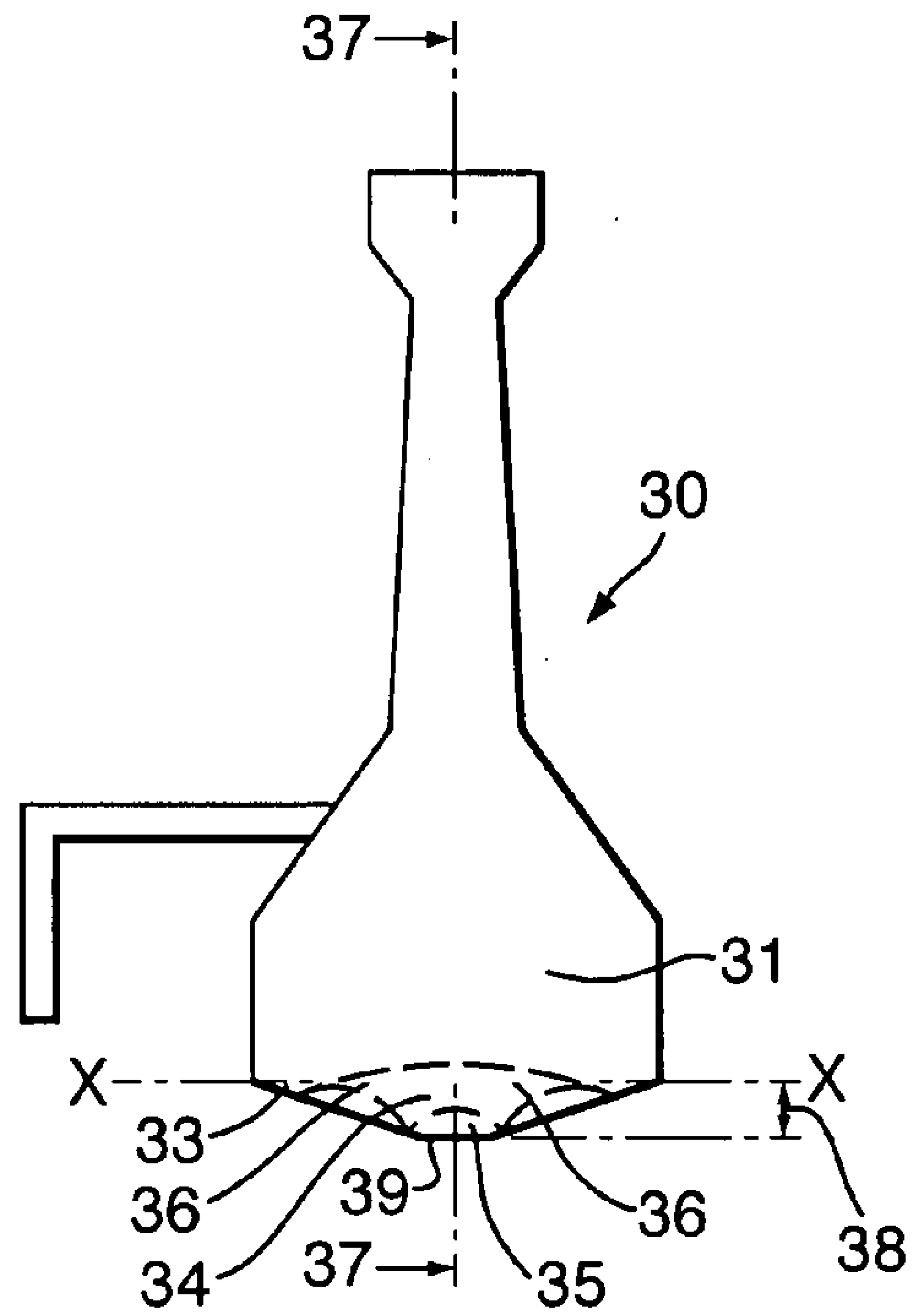


Fig.4.

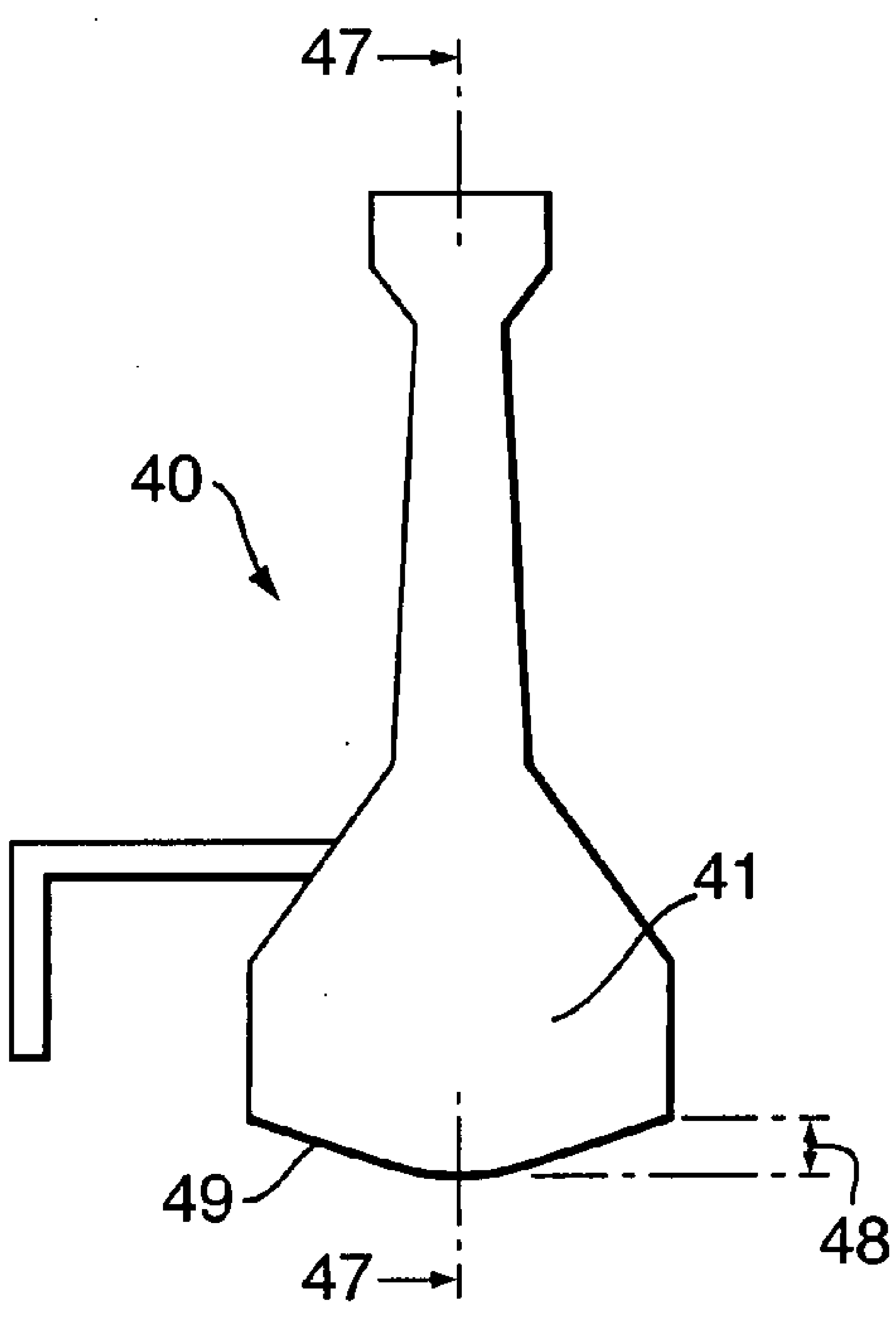


Fig.5.

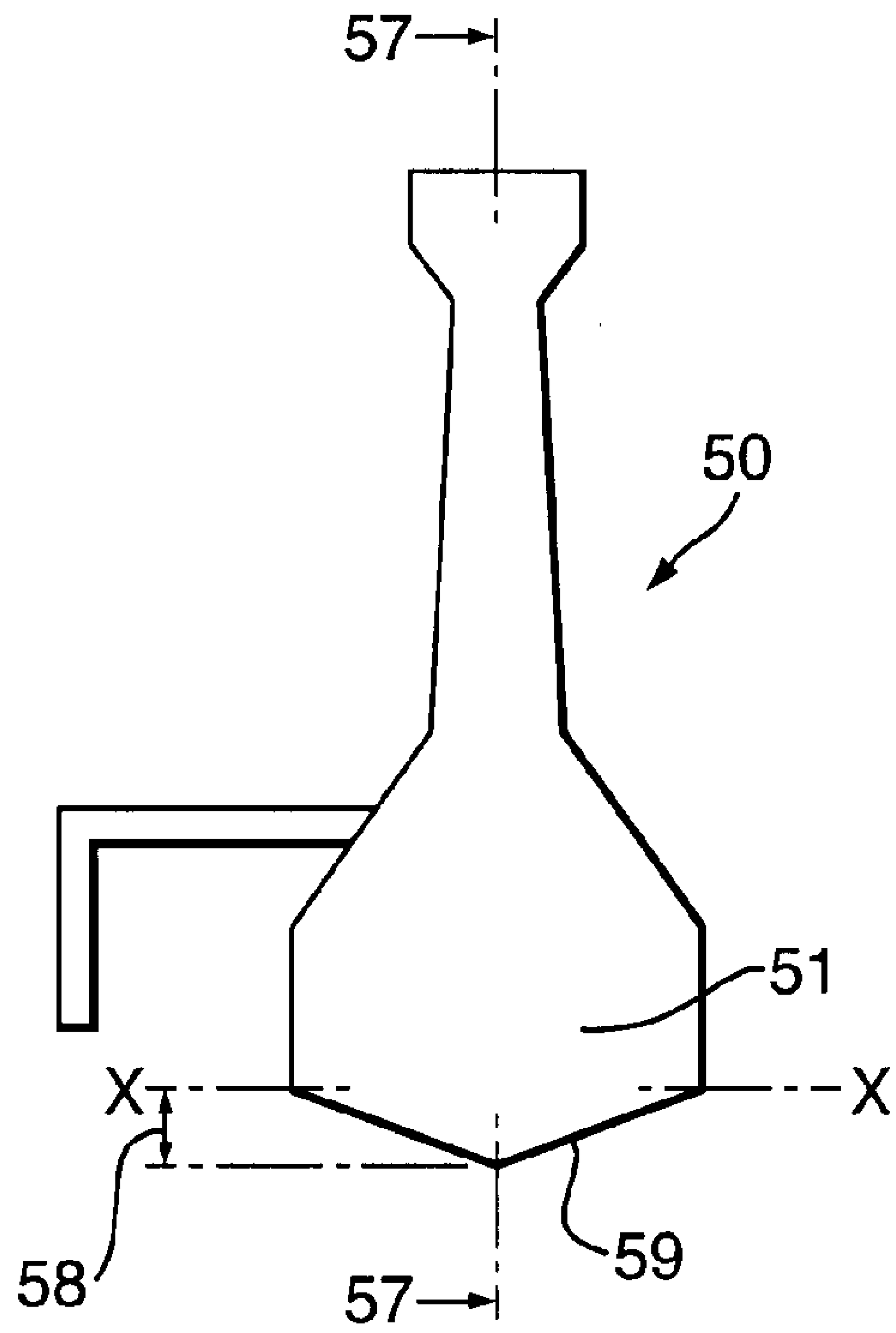
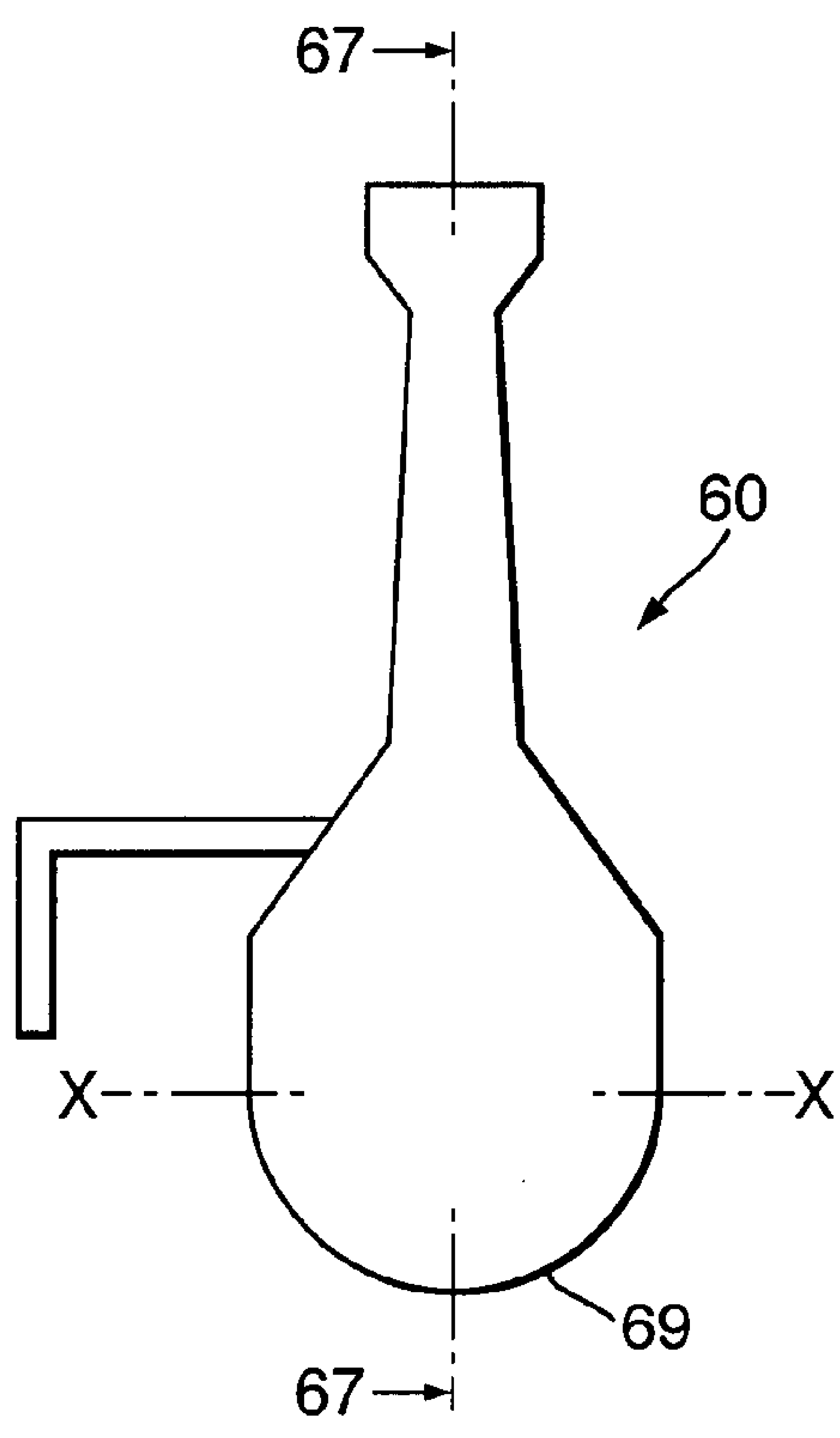


Fig.6.



MOUNTING DISC

[0001] The present invention relates to mounting discs and more particularly to a mounting disc utilised to secure rotating blades in compressor or turbine stages of a gas turbine engine.

[0002] Referring to FIG. **1**, a gas turbine engine is generally indicated at **10** and comprises, in axial flow series, an air intake **11**, a propulsive fan **12**, an intermediate pressure compressor **13**, a high pressure compressor **14**, a combustor **15**, a turbine arrangement comprising a high pressure turbine **16**, an intermediate pressure turbine **17** and a low pressure turbine **18**, and an exhaust nozzle **19**.

[0003] The gas turbine engine **10** operates in a conventional manner so that air entering the intake **11** is accelerated by the fan **12** which produce two air flows: a first air flow into the intermediate pressure compressor **13** and a second air flow which provides propulsive thrust. The intermediate pressure compressor compresses the air flow directed into it before delivering that air to the high pressure compressor **14** where further compression takes place.

[0004] The compressed air exhausted from the high pressure compressor **14** is directed into the combustor **15** where it is mixed with fuel and the mixture combusted. The resultant hot combustion products then expand through, and thereby drive, the high, intermediate and low pressure turbines **16**, **17** and **18** before being exhausted through the nozzle **19** to provide additional propulsive thrust. The high, intermediate and low pressure turbines **16**, **17** and **18** respectively drive the high and intermediate pressure compressors **14** and **13** and the fan **12** by suitable interconnecting shafts.

[0005] In view of the above, it will be understood that a gas turbine engine incorporates a number of compressor and turbine stages. The blades for those compressor and turbine stages are secured upon mounting discs such that the blades can rotate as appropriate. The mounting discs are secured to the rotating shaft through a disc cob. It will be appreciated relatively high temperatures are generated within a gas turbine engine such that the engine thermo dynamic cycle dictates to a significant extent the disc cob size. The weight efficient solution to meet an over speed requirement is to provide a flat cob end for the mounting disc. Rotational speed and mass dictate size whilst thermal gradients worsen stressing for large disc sizes.

[0006] In order to increase efficiency, it is generally desirable to provide smaller and faster engine cores. Such smaller and faster engine cores result in relatively large mounting disc cob sizes to meet expected over speed requirements. It will be appreciated as the cob disc size increases, the potential for large thermal gradients across the disc cob end also increases. It will be understood that a disc cob end essentially comprises a relatively thick section and therefore high thermal gradients between surface portions of the mounting disc and the centre of that disc cob can be created. It is not unusual for there to be a differential of several hundred degrees centigrade with a result that there is high biaxial stress across the cob end of the mounting disc. This high biaxial stress becomes a fatigue life limiting feature of a mounting disc. In any event, provision of a plain flat cob end, that is to say a flat end perpendicular to the radial plane, results in relatively low disc operational life at a desired rotational speed or a shaft speed limit or both. It will be understood that biaxial stress relates to both centrifugal stress (hoop) and axial stress within the cob end. Furthermore, accumulation of significant axial compressive stress in conjunction with high hoop stress results in a considerable fatigue life reduction when compared to a uniaxial stress field of the same magnitude. Such a combination of hoop and axial stress is generally combined into a single stress measure called Von-Mises stress and it is accepted that the higher the Von-Mises stress, the sooner a fatigue crack will be initiated resulting in a lower fatigue life.

[0007] In accordance with aspects of the present invention there is provided a disc for mounting rotating components, the disc characterised in that the bore end has an outward deviation from a flat perpendicular aspect relative to the radial plane.

[0008] Typically, the deviation is outward.

[0009] Typically, the deviation is a convex curve. Generally, the convex curve has a consistent convex radius. Potentially, the convex radius has a maximum radius equivalent to half of the axial width of the disc across the radial plane. Generally, the convex curve is a smooth curve. Potentially, the convex curve is conic. Potentially, the convex curve is semi circular.

[0010] Alternatively, the deviation comprises a trapezoidal shape for the cob or bore end. Potentially, the trapezoidal shape has a side projection relative to the radial plane having an angle in the range 5-45°.

[0011] Possibly, the deviation is triangular. Advantageously, an apex for the triangular deviation is rounded.

[0012] Further alternatively, the cob or bore end has a stepped portion to achieve a desired weight distribution in the disc.

[0013] Possibly, a ratio of the depth of the deviation divided by width of the mounting disc across from the flat perpendicular to the radial plane is in the range 0.03 to 0.5.

[0014] Possibly, the shape and extent of deviation provided is subject to material and rotational speed determined to substantially provide zero compression axial stress differential across the mounting end.

[0015] Embodiments of the present invention will now be described by way of example and with reference to the accompanying drawings in which:

[0016] FIG. **1** illustrates a sectional side view of the upper half of a gas turbine engine;

[0017] FIG. **2** is a schematic illustration of a prior flat end mounting disc;

[0018] FIG. **3** is a schematic cross section of a first embodiment of a mounting disc in accordance with aspects of the present invention;

[0019] FIG. **4** is a schematic illustration of a second embodiment of a mounting disc in accordance with aspects of the present invention;

[0020] FIG. **5** is a schematic illustration of a third embodiment of a mounting disc in accordance with aspects of the present invention; and,

[0021] FIG. **6** is a schematic illustration of a fourth embodiment of a mounting disc in accordance with aspects of the present invention.

[0022] As indicated above, as desired engine core speeds increase whilst the size of the cores becomes smaller, potential problems with respect to fatigue failure as a result of stress and in particular Von-Mises stress, become problematic. Traditionally, weight, particularly with regard to aeronautical applications of gas turbine engines, has been a significant factor and therefore provision of a flat end surface for a bore end of a mounting disc has been considered the most efficient solution.

[0023] FIG. **2** illustrates a typical flat or plain end mounting disc configuration. It will be appreciated that only one side of the mounting discs is illustrated with an annular disc secured upon a rotating shaft. The mounting disc **120** has three major portions namely, a bore or cob end **121**, a diaphragm portion **122** and a rim portion **123**. The bore end **121** essentially allow the mounting disc **120** to be secured to a shaft. In use it will be appreciated that mounting discs **120** are utilised with respect to turbine blades and compressor blades in a gas turbine engine. Particularly with respect to high pressure turbine blades it will be understood that increasing thrust increases the level of hot gasses adjacent to the mounting disc and therefore heating of the cob area **121**. As this cob area **121** has a relatively thick cross section thermal inertia ensures that peripheral surface portions of the cob end **121** heat up much quicker than central parts of the cob end **121** resulting in a temperature differential of a few hundred degrees centigrade across the cob end **21**.

[0024] The stresses on the cob or bore end are a combination of axial stress due to rotation of the mounting discs and associated blades as well as circumferential. These stresses are combined as Von-Mises stresses.

[0025] Broken line **124** schematically illustrates a typical axial stress band in a flat or plane face mounting end **121**. As indicated, these stresses can result in premature failure or a design limitation on shaft speed or both. Ideally, an objective is to optimise in terms of shape the mounting end **121** to minimise or control Von-Mises stress. However, it should be understood that it is the net effect in reducing Von-Mises stress that is desirable in order to achieve an increased life at the bore surface. Thus, selecting a profile which significantly reduces the level of compressive axial stresses although slightly increasing the circumferential stress would be acceptable in terms of achieving a net reduction in Von-Mises stresses or vice versa. A further advantage is with regard to separating the location of peak hoop stress and peak axial stress within the disk **120**. As indicated, by achieving a net reduction in Von-Mises stress, a greater disc fatigue life and potentially higher shaft speeds will be possible.

[0026] Aspects of the present invention relate to providing a deviation from a flat surface as depicted in FIG. **2**. In such circumstances, by providing a convexed or other outward deviation from a flat perpendicular aspect relative to a radial plane will allow material to expand more readily reducing barriers to expansion and therefore stresses.

[0027] FIG. **3** illustrates a trapezoidal cob or bore end **31** in a disc **30**. It has been found by re-distributing the material in the cob end **31**, as indicated above, there is an overall increase in allowability with respect to expansion such that stress distribution shown by broken line **34** results in a peak hoop stress at an area **35** and peak axial stress at an area **36**. It has been found that the axial compression stress is lowered whilst there is an increase in the hoop stress but overall the net result is a Von-Mises stress level which is lower and therefore a net improvement in operational performance. By creating the deviation from a flat perpendicular aspect shown by the plane X rearwardly the benefits with respect to reduction of Von-Mises stresses is achieved. It will be understood that the disc **31** has a general radial plane **37** through its centre line and the cob or mounting end **31** extends either side of this radial plane **37**. In such circumstances, it is the deviation in a face **39** of the cob or mounting end **31** along the radial plane **37** which is determinant as to the stress variation. It can be seen that this deviation has a depth depicted between arrowheads **38** along the radial plane **37** and, as indicated, generally takes a trapezoidal shape in the first embodiment depicted in FIG. **3**. The angle **33** at the sides may be in the range of 5-45° dependent upon requirements.

[0028] FIG. **4** illustrates a typical convex end face **49** to a cob or bore **41** of a disc **40**. Again, as can be seen, the disc **40** has a radial plane **47**. The face **49** deviates by a depth **48** with a smooth convex curve. In such circumstances, again by shaping of the face expansion is more readily allowed so reducing Von-Mises stress and therefore operational effectiveness of the disc **40**.

[0029] FIG. **5** illustrates a third embodiment of a disc in accordance with aspects of the present invention. As previously, the disc **50** has a cob or mounting end **51** with an end face **59** which deviates to the depth **58** for a continual flat perpendicular aspect X-X relative to a radial plane **57** for the disc **50**. In the third embodiment depicted in FIG. **5** a face **59** substantially reflects a triangle which again through shaping allows easier expansion and therefore reduction in Von-Mises stresses within the end **51** resulting in a longer operational life and/or potentially higher rotational speeds for the disc **50**. It will be noted the triangular nature of the end **51** is exaggerated for illustration purposes.

[0030] It will be understood in order to provide a minimum hoop stress, generally a maximum amount of material in the cob end should be towards the radial plane of the disc. In such circumstances as depicted in FIG. **6** with regard to a fourth embodiment of aspects of the present invention, it will be appreciated that a fully semi circular end face **69** would be ideal in a disc **60** in order to provide the desired material distribution. Thus, within a cob or mounting end **61** the end face **69** would be ideal in a disc **60** in order to provide the desired material distribution. Within the cob or mounting end **61** the end face **69** extends away from notional flat perpendicular plane to a radial plane **67** of the disc **60**.

[0031] In view of the above, it will be appreciated that aspects of the present invention provide through the deviation to the face for the bore or cob end potential for adjusting the Von-Mises stress effects. By creating a cob end which deviates from a flat surface, as indicated, generally there will be a reduction in the axial stress but an increase in hoop stress. However, by judicious choice of the deviation a net reduction cross over point can be provided where the benefits of a reduction in axial stress outweigh the potential increases in hoop stresses.

[0032] As indicated above, the particular degree and shape of deviation in the cob or mounting end will depend upon operational requirements in terms of material available, acceptability of weight penalties and desired or expected rotational speeds. However, where the deviation is a convexed face (FIG. **4**) it is expected that the maximum radius of the curvature will be half the axial width of the bore, that is to say the width of the disc extending either side of the radial plane of that disc. Where the deviation is a trapezium it is expected the side angles will be in the range 5-45° leading to a flat bottom surface of narrower width. It will be understood, as indicated, that the cob end may incorporate a triangular end face with an apex end of that triangle rounded. It will also be understood that the cob end may incorporate, as indicated, a smooth convex surface and that this smooth surface may be conic in section.

[0033] The depth of deviation (**38** in FIG. **3**, **48** in FIG. **4**, **58** in FIG. **5**) will be in the ratio whereby the deviation depth divided by the width of the cob or mounting end relative to the radial plane will be in the range 0.03 to 0.5.

[0034] It will be appreciated that generally the deviation depth relative to width will be chosen to reduce maximum compressive axial stress differential across the disc bore in comparison with a disc bore with no deviation depth, that is to say flat or plain.

[0035] Generally, as indicated above, by altering the face surface of the cob or mounting end, adjustments in axial and hoop stresses can be made which on balance and net lead to an improvement in component life and/or a potential for higher rotational speeds.

[0036] Modifications and alterations to aspects of the invention described above will be appreciated by those skilled in the art. Thus, as indicated, in order to achieve minimum hoop stress the maximum amount of metal should be presented towards the centre line or radial plane of the disc.

[0037] Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

We claim:

1. A disc for mounting rotating components, the disc characterised in that the bore end has an end face with deviation from a flat perpendicular aspect relative to radial plane.

2. A disc as claimed in claim **1** wherein the deviation is a convex curve.

3. A disc as claimed in claim **2** wherein the convex curve has a consistent convex radius.

4. A disc as claimed in claim **2** wherein the convex radius has a maximum radius equivalent to half of the axial width of the disc across the radial plane.

5. A disc as claimed in claim **2** wherein the convex curve is a smooth curve.

6. A disc as claimed in claim **2** wherein the convex curve is conic.

7. A disc as claimed in claim **2** wherein the convex curve is semi circular.

8. A disc as claimed in claim **1** wherein the deviation comprises a trapezoidal shape for the bore end.

9. A disc as claimed in claim **8** wherein the trapezoidal shape has a side projection relative to the radial plane having an angle in the range 5-45°.

10. A disc as claimed in claim **1** wherein the deviation is triangular.

11. A disc as claimed in claim **10** wherein an apex for the triangular deviation is rounded.

12. A disc as claimed in claim **1** wherein the cob end has a stepped portion to achieve a desired weight distribution in the disc.

13. A disc as claimed in claim **1** wherein a ratio of the depth of the deviation divided by width of the mounting disc across from the flat perpendicular to the radial plane is in the range 0.03 to 0.5.

14. A disc as claimed in claim **1** wherein the shape and extent of deviation provided is subject to material and rotational speed determined to substantially provide zero compression axial stress differential across the mounting end.

15. A disc as claimed in claim **1** wherein the deviation is outward.

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