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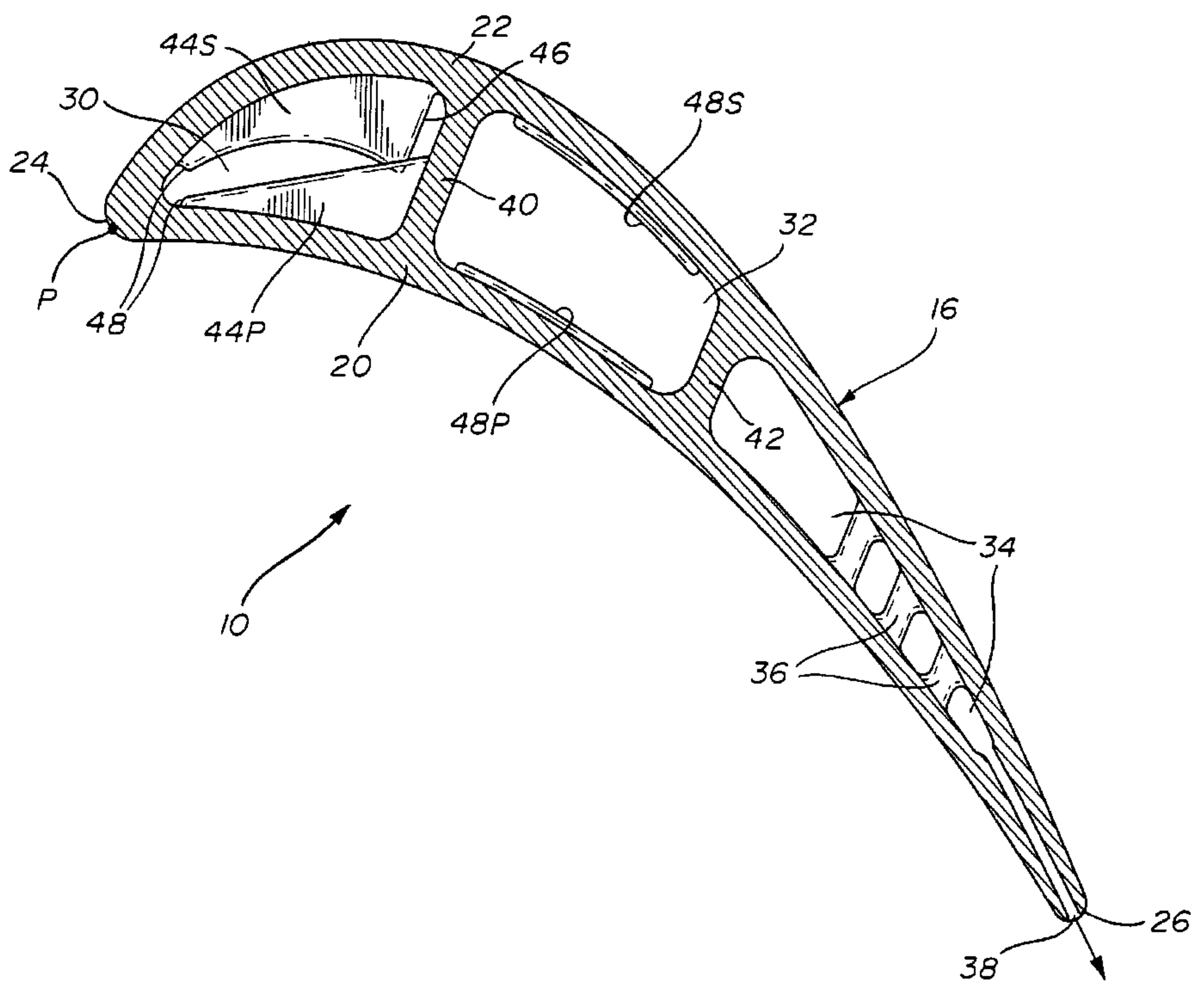

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A cooled airfoil has an internal cooling passage in which a plurality of trip strips are arranged to effect variable coolant flow and heat transfer coefficient distribution so as to advantageously minimize the amount of coolant flow required to adequately cool the airfoil structure. In one embodiment, this is accomplished by varying the dimensions of the trip strips along a transversal axis relative to the cooling passage.

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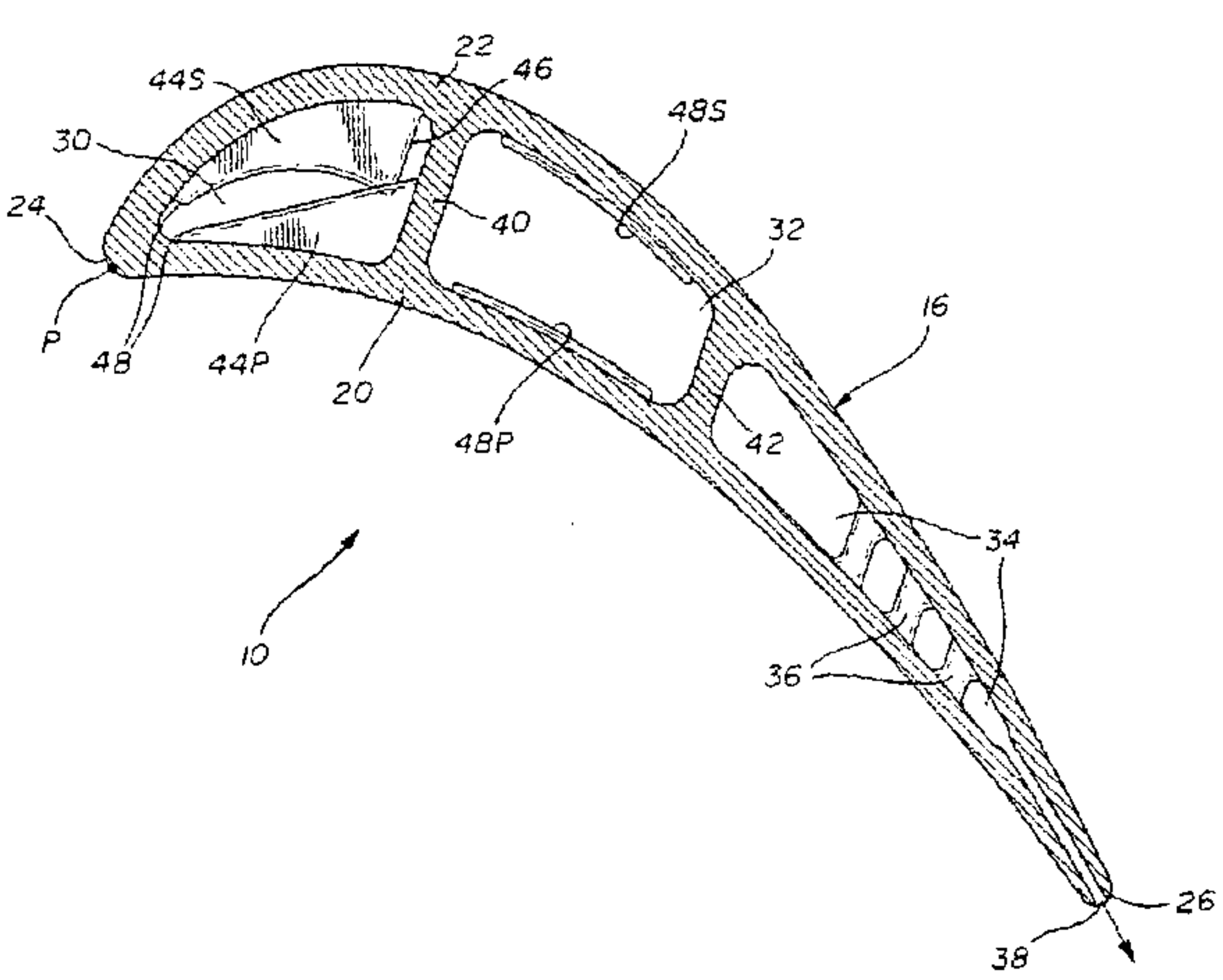
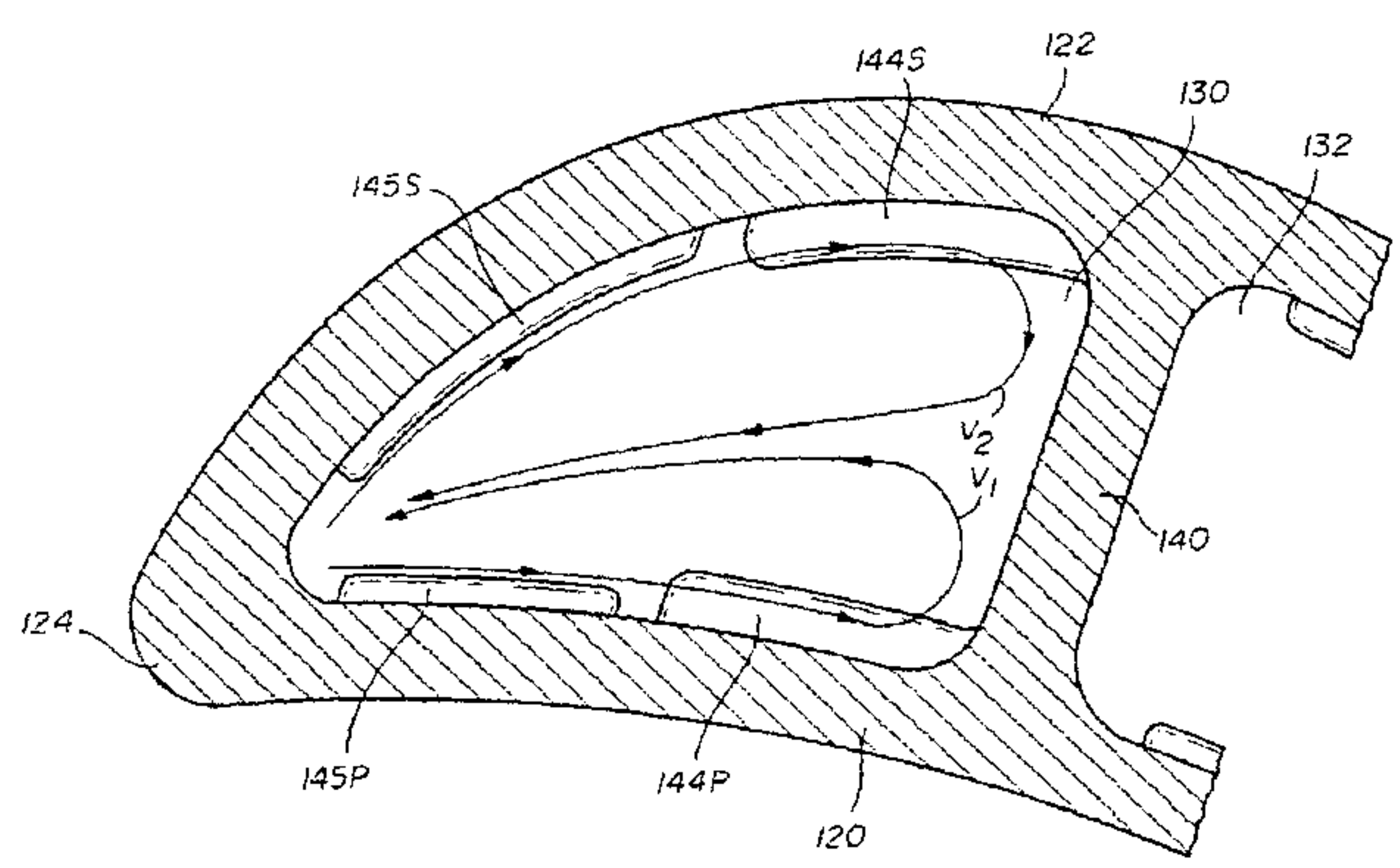




WO 01/31170 A1

HEAT TRANSFER PROMOTION STRUCTURE FOR INTERNALLY CONVECTIVELY COOLED AIRFOILS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the cooling of components exposed to hot gas atmosphere and, more particularly, pertains to internally convectively cooled airfoil structures.

2. Description of the Prior Art

It is well known to cool airfoil structures, such as gas turbine blades or vanes, exposed to a hot gas atmosphere by circulating a cooling fluid through internal cooling passages defined within the airfoil structures in order to reduce the level of thermal stresses and reduce the peak airfoil temperatures in the airfoil structures and, thus, preserve the structural integrity and the service life thereof.

In gas turbine applications, the airfoil structures are typically air cooled by a portion of the pressurized air emanating from a compressor of the gas turbine engine. In order to preserve the overall gas turbine engine efficiency, it is desirable to use as little of pressurized air as possible to cool the airfoil structures. Accordingly, efforts have been made to efficiently use the cooling air. For instance, GB laid-open Patent Application No. 2,112,467 filed on December 3, 1981 in the names of Schwarzmann et al. discloses a coolable airfoil having a leading edge cooling passage in which a plurality of identical and uniform sized trip strips are oriented at an angle to a longitudinal axis of the cooling passage in order to increase turbulence in the leading edge region of the blade, which is typically the most thermally solicited portion of the airfoil.

United States Patent No. 4,416,585 issued on November 22, 1983 to Abdel-Messeh and United States Patent No. 4,514,144 issued on April 30, 1985 to Lee both disclose a cooled blade having an internal cooling passage in which pairs of uniform sized ribs are angularly disposed to form a channel therebetween for channeling the cooling fluid along a selected flow path in order to increase heat transfer coefficient while at the same time minimizing the cooling fluid pressure drop in the internal cooling passage.

European Patent Application EP 0 939 196 A2 published on September 1, 1999 discloses a gas turbine blade defining a leading edge internal cooling passage provided with a plurality of spaced-apart trip strips arranged in two rows equidistant from the leading edge of the blade. The trip strips of both rows have the same height and width. The rows have the same linear density of trip strips.

German Patent Application DE 195 26 917 A1 published on January 23, 1997 discloses a gas turbine blade defining an internal cooling passage provided with side-by-side rows of trip strips of similar height and width. The rows of trip strips have the same linear density.

Although the heat transfer promotion structures described in the above-mentioned references are effective, it has been found that there is a need for a new and improved heat transfer promotion structure which allows for variable coolant flow and heat transfer coefficient distribution which can be set in accordance with a non-uniform external heat load.

SUMMARY OF THE INVENTION

It is therefore an aim of the present invention to provide a new and improved heat transfer promotion structure which is adapted to efficiently use cooling fluid to convectively cool a gas turbine airfoil structure.

It is also an aim of the present invention to provide such a heat transfer promotion structure which allows for variable cooling flow and heat transfer coefficient distributions.

Therefore, in accordance with the present invention there is provided a coolable gas turbine airfoil structure having a leading edge, a leading edge internal cooling passage through which a cooling fluid is circulated to convectively cool the airfoil structure, and a heat transfer promotion structure provided within the leading edge internal cooling passage. The heat transfer promotion structure comprises a plurality of trip strips arranged to cause the cooling fluid to flow towards the leading edge in a pair of counter-rotating vortices, thereby promoting heat transfer at the leading edge.

In accordance with a further general aspect of the present invention, there is provided a cooled airfoil structure for a gas turbine engine, comprising first and second opposed side walls joined together at longitudinally extending leading and trailing edges, at least one longitudinally extending internal cooling passage for passing a cooling fluid therethrough to convectively cool the airfoil structure, and a heat transfer promotion structure provided within the internal cooling passage. The heat transfer promotion structure includes a plurality of trip strips arranged inside the internal cooling passage to effect a variable heat transfer coefficient distribution. Each of the trip strips has a height (h) and a width (w) defining a w/h ratio. Within the plurality of trip strips, at least one of the height (h), the width (w) and the w/h ratio is varied along a transversal axis relative to the internal cooling passage. This advantageously provides variable flow and heat transfer coefficient distribution, thereby allowing to reduce cooling flow requirements.

In accordance with a further general aspect of the present invention, there is provided a method of cooling a leading edge of a gas turbine engine airfoil having a leading edge internal cooling passage extending between first and second side walls, comprising the steps of: providing a heat transfer promotion structure within the leading edge internal cooling passage, directing a cooling fluid into the leading edge internal cooling passage, and causing said cooling fluid to flow towards the leading edge in a pair of counter-rotating vortices, thereby promoting heat transfer at the leading edge.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus generally described the nature of the invention, reference will now be made to the accompanying drawings, showing by way of illustration a preferred embodiment thereof, and in which:

Fig. 1 is a partly broken away longitudinal sectional view of an internally convectively cooled blade in accordance with a first embodiment of the present invention;

Fig. 2a is a cross-sectional view taken along line 2a-2a of Fig.1;

Fig. 2b is a cross-sectional view taken along line 2b-2b of Fig. 1;

Fig. 3 is a partly broken away longitudinal sectional view of an internally convectively cooled blade in accordance with a second embodiment of the present invention;

Fig. 4 is an enlarged cross-sectional view taken along line 4-4 of Fig. 3; and

Fig. 5 is a partly broken away longitudinal sectional view of an internally convectively cooled blade in accordance with a third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now referring to Figs. 1, 2a and 2b, there is shown an internally convectively cooled blade 10 suited for used as a turbine blade of a conventional gas turbine engine (not shown).

The cooled blade 10 comprises a root section 12, a platform section 14 and a hollow airfoil section 16 over which flows hot combustion gases emanating from a combustor (not shown) forming part of the gas turbine engine. The root section 12, the platform section 14 and the airfoil section 16 are typically integrally cast as a unitary structure.

According to one application of the present invention, the cooled blade 10 extends radially from a rotor (not shown) and is connected thereto via the root section 12. The root section 12 defines a fluid passage 18 which is in fluid communication with a source of pressurized cooling fluid, typically pressurized air emanating from a compressor (not shown) of the gas turbine engine.

The hollow airfoil section 16 includes a pressure side wall 20 and a suction side wall 22 joined together at longitudinally extending leading and trailing edges 24 and 26. The airfoil section 16 further includes a tip wall 28 at a distal end thereof. As seen in Figs. 1, 2a and 2b, the airfoil section 16 defines an internal cooling passageway 29 arranged in a serpentine fashion and through which the cooling air is passed to convectively cool the blade 10, as depicted by arrows 27 in Fig.1.

The cooling passageway 29 includes a leading edge cooling passage 30 extending in the spanwise or longitudinal direction of the blade 10 adjacent the leading edge wall 24 thereof. The leading edge cooling passage 30 is in flow communication with passage 18 and extends to the tip wall 28 of the blade 10 where the coolant air is deviated 180^0 degrees into a central cooling passage 32, as seen in Fig. 1. The cooling air then flows longitudinally into the central cooling passage 32 towards the root section 12 of the blade 10 before being deviated 180^0 degrees longitudinally into a trailing edge cooling passage 34 which extends to the tip wall 28 and in which a plurality of spaced-apart pedestals 36 are provided between the pressure and suction side walls 20 and 22 of the cooled blade 10. The cooling air is typically discharged from the trailing edge cooling passage 34 via a plurality of exhaust ports 38 defined at selected locations through the trailing edge 26, as seen in Figs. 2a and 2b.

The leading edge cooling passage 30 is delimited by the pressure and suction side walls 20 and 22, the leading edge wall 24 and a partition wall 40 extending in the longitudinal direction of the blade 10 between the pressure and suction side walls 20 and 22. As seen in Fig. 1, the partition wall 40 forms a gap with the tip wall 28 for allowing the cooling air to flow from the leading edge cooling passage 30 into the central or midchord cooling passage 32. Similarly, a second partition wall 42 (see Figs. 2a and 2b) extends longitudinally from the tip wall 28 of the cooled blade 10 towards the root section 12 between the pressure and suction side walls 20 and 22 for separating the central cooling passage 32 from the trailing edge cooling passage 34 and, thus, cause the cooling air to flow in a serpentine fashion towards the exhaust ports 38 defined through the trailing edge 26 of the cooled blade 10.

The external heat load is usually more important at the leading edge 24 and, more particularly, at a stagnation point P located thereon. Furthermore, the external surface of the leading edge region of the airfoil section 16 which is exposed to the hot gas is large compared to that exposed to the cooling air. Therefore, it is desirable to promote heat transfer to the cooling air in the leading edge region of the blade 10 in order to keep the cooling flow requirements to a minimum.

It has been found that by causing the cooling air to flow towards the leading edge 24 in a pair of counter-rotating vortices V_1 and V_2 (see Fig. 4), an efficient cooling of this region of the blade 10 can be achieved.

According to one embodiment of the present invention, this is accomplished by providing a heat transfer promotion structure comprising a plurality of trip-strips or ribs having variable dimensions in a lengthwise direction thereof, the dimensions of the trip strips being set to produce the desired flow pattern and augmentation in local heat transfer coefficient in accordance with the non-uniform external heat load exerted on the blade 10.

More specifically, as seen in Figs. 1, 2a and 2b, a first array of parallel trip strips or ribs 44s of variable dimensions extend from an inner surface of the suction side wall 22 at angle θ with respect to a longitudinal axis of the leading edge cooling passage 30 or to the direction of the cooling flow. The value of θ may be comprised in a range of about 20^0 degrees to about 60^0 degrees. However, the preferred range of angle θ is between 40^0 degrees to 50^0 degrees. As seen in Figs 2a and 2b, a second array of parallel trip strips or ribs 44p of variable dimensions extend from an inner surface of the pressure side wall 20. The trip strips 44p are parallel and staggered with respect to the trip strips 44s such that the trip strips 44p and 44s extend alternately in succession across the leading edge cooling passage 30.

The trip strips 44p and 44s may or may not extend to the partition wall 40 and are spaced from the leading edge wall 24.

The leading edge cooling passage 30 has a generally triangular cross-section and has a height (H) at any point along a line which is perpendicular to a meanline of the leading edge cooling passage 30, as seen in Fig. 2a. The trip strips 44p and 44s have a height (h) (see Fig. 2a) and a width (w)(see Fig. 1) defining a w/h ratio. The preferred value of the ratio w/h is comprised in a range of 0.05 to 20 inclusively. The preferred value of the strip-to-passage height ratio h/H is comprised in a range of 0.05 to 1.0 inclusively.

The dimensions of each trip strips 44s and 44p generally gradually decrease from a first end 46 to a second end 48 thereof, the second end being disposed upstream of the first end 46 and closer to the leading edge 24. The width (w), the height (h) and/or the w/h ratio may be varied along the length of each trip strips 44s and 44p to induce the desired flow pattern which will promote heat transfer in the leading edge region of the blade 10.

The trip strips 44p and 44s are typically integrally cast with the associated side wall 20 and 22.

Conventional trip strips 48p and 48s of uniform sizes can be provided in the central cooling passage 32 to promote heat transfer therein. The orientation of trip strips 44p, 44s, 48p and 48s can generally be the same. It is understood that the swirling movement of the air may be carried over from one passage to the next. However, this is not necessarily the case, as it may be eradicated by a 180° turn and then re-started by the next set of trip strips.

According to a second embodiment of the present invention which is illustrated in Figs. 3 and 4, the cooling air may be caused to flow in a pair counter-rotating vortices V_1 and V_2 within a triangular or trapezoidal passage by providing a plurality of trip strips 144s and 144p of uniform but different dimensions within the passage.

More specifically, as seen in Fig. 3, a first array of parallel trip strips 144s extend from the suction side wall 122 and the partition wall 140 in a crosswise direction with respect to the flow direction and the longitudinal axis of the leading edge cooling passage 130. However, it is understood that the trip strips 144s do not necessarily have to extend to the partition wall 140. Each trip strips 144s is of uniform dimensions. The trip strips 144s are uniformly distributed along the longitudinal axis of the leading edge cooling passage 130. A second array of parallel trip strips 145s, which are spaced from the distal end of the first trip strips 144s, extend from the suction side wall 122. The trip strips 145s are disposed closer to the leading edge 124 than the first array of trip strips 144s. Each trip strips 145s is of uniform dimensions. The second trip strips 145s are generally smaller than the first trip strips 144s. The height (h) and the width (w) of the trip strips 145s are less than the height (h) and the width (w) of the trip strips 144s. The dimensions of the trip strips 144s and 145s are set to provide the desired variable heat transfer coefficient distribution across the leading edge cooling passage 130.

As seen in Fig. 3, the second trip strips 145s are uniformly longitudinally distributed within the leading edge cooling passage 130. The spacing between adjacent trip strips 145s is less than the spacing between adjacent trip strips 144s.

As seen in Fig. 4, third and fourth corresponding arrays of trip strips 144p and 145p of uniform but different dimensions extend from the pressure side wall 120 inwardly into the leading edge cooling passage 130. The third and fourth arrays of trip strips 144p and 145p are respectively longitudinally staggered with respect to corresponding first and second arrays of trip strips 144s and 145s.

In the leading edge cooling passage 130, the provision of the trip strips 144s, 144p, 145s and 145p causes the cooling air to flow in a pair of counter-rotating vortices V_1 and V_2. The first vortex V_1 defines a vortex line extending from the leading edge area generally in parallel with an inner surface of the pressure side wall 120 and then back towards the leading edge area. Likewise, the second vortex V_2 defines a vortex line which extends from the leading edge area generally in parallel to an inner surface of the suction side wall 122 and then back towards the leading edge area.

In addition to the benefits of the first embodiment, the second embodiment has the advantages of being easier to manufacture and to allow for different spacing for different sized trip strips.

In an alternate embodiment illustrated in Fig. 5, a first array of trip strips 244 of variable dimensions and a second array of uniformed sized trip strips 245 extend from the pressure side wall 220 as well as from the suction side wall 222 of the cooled blade 200. It is understood that any permutation of the first two embodiments of the present invention may be used in a same passage to produce the desired results.

It is understood that the present invention could apply to a variety of cooling schemes, including leading edge cooling passages that only extend half way up the leading edge. Also, the leading edge passage may end in a 90° turn, instead of a 180° turn, as described hereinbefore. It is also understood that the remainder of the cooling scheme, i.e. past the leading cooling passage, is immaterial to the functioning of the present invention. Finally, it is understood that the present invention is not restricted to large trip strips near the root of the airfoil and smaller ones near the tip thereof.

CLAIMS:

1. A coolable gas turbine engine airfoil structure (116, 216) having a leading edge (124, 224), a leading edge internal cooling passage (130, 230) through which a cooling fluid is circulated to convectively cool the airfoil structure (116, 216), the passage (116, 216) having a leading edge side disposed closer to the leading edge (124, 224) than a second side thereof, and a heat transfer promotion structure provided within said leading edge internal cooling passage (130, 230), said heat transfer promotion structure comprising a plurality of spaced-apart trip strips (144S, 144P, 145S, 145P; 244, 245) arranged to cause said cooling fluid to flow towards said leading edge (130, 230) in a pair of counter-rotating vortices, thereby promoting heat transfer at said leading edge (130, 230), characterized in that the plurality of trip strips (144S, 144P, 145S, 145P; 244, 245) includes a first array of trip strips (144S, 144P, 244)and a second array of trip strips (145S, 145P, 245), the fist array being disposed generally farther from said leading edge (130, 230) than the second array, the trip strips (144S, 144P, 244) of said first array having at least one of a height (h) and a width (w) generally greater than one of a height (h) and a width (w) of the trip strips (145S, 145P, 245) of said second array, and wherein the trip strips (144S, 144P, 145S, 145P; 244, 245)are spaced closer to one another in said leading edge side of the passage (130, 230) than in said second side thereof.

2. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 1, wherein the height (h) and the width (w) of each trip strips (144S, 144P, 145S, 145P; 244, 245) defines a w/h ratio, and wherein within said plurality of trip strips (144S, 144P, 145S, 145P;

244, 245) at least one of said height (h), said width (w) and said w/h ratio is varied along a transversal axis relative to said leading edge internal cooling passage (130, 230).

3. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 2, wherein within said plurality of trip strips (144S, 144P, 145S, 145P; 244, 245) at least one of said height (h) and said width (w) is varied from a maximum value to a minimum value along said transversal axis towards said leading edge (124, 224), said minimum value being in proximity of said leading edge (124, 224).

4. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 3, wherein said w/h ratio is comprised within a range of 0.05 to 20 inclusively.

5. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 4, wherein said leading edge internal cooling passage (130, 230) has a height (H) and wherein:

$$0.05 \leq h/H \leq 1.0.$$

6. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 2, wherein each of said trip strips (144S, 144P, 145S, 145P; 244, 245) has first and second opposed ends, said second end being disposed closer to said leading edge (130, 230) than said first end and upstream with respect to said first end.

7. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 6, wherein each of said trip strips (144S, 144P, 145S, 145P; 244, 245) is oriented at an acute angle θ with respect to a

longitudinal axis of said leading edge internal cooling passage (130, 230), and wherein θ is comprised in a range of about 20° to about 60°.

8. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 2, wherein the trip strips (144S, 144P, 145S, 145P; 244, 245) extend transversally of a longitudinal axis of the passage (130, 230), and wherein the first array of trip strips (144S, 144P; 244, 245) is longitudinally distributed within said leading edge internal cooling passage (130, 230), each said trip strip (144S, 144P, 244) of said first array having variable dimensions from a first end to a second opposed end thereof, said variable dimensions resulting from a variation of at least one of said height (h), said width (w) and said w/h ratio.

9. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 8, wherein said variable dimensions of each said trip strip (144S, 144P, 145S, 145P; 244, 245) decrease from a maximum value at said first end thereof to a minimum value at said second end thereof, said second end being disposed closer to said leading edge (124, 224) than said first end.

10. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 9, wherein said airfoil structure (116, 216) has a pressure side wall (120, 220) and a suction side wall (122, 222), said first array of trip strips (144P, 244) being disposed on said pressure side wall (120, 220), whereas the second array of trip strips (145S, 245) is disposed on said suction side wall (122) in a staggered manner with respect to said first array of trip strips (144P, 244).

11. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 2, wherein said first and second arrays of trip strips (144S, 144P, 145S, 145P; 244, 245) are staggered with respect to one another such that said trip strips (144S, 144P, 145S, 145P; 244, 245) of said first and second arrays are disposed in alternating succession along a longitudinal axis of said leading edge internal cooling passage (130, 230).

12. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 2, wherein said trip strips (144S, 144P, 145S, 145P; 244, 245) of said first and second arrays are of uniform but different dimensions, said trip strips (145S, 145P, 245) of said second array being smaller than said trip strips (144S, 144P, 244) of said first array.

13. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 11, wherein each of said trip strips (144S, 144P, 244) of said first array is of variable dimensions from a first end to a second opposed end thereof, whereas said trip strips (145S, 145P, 245) of said second array are of uniform dimensions.

14. A coolable gas turbine engine airfoil structure (116, 216) as defined in claim 2, wherein third and fourth arrays of trip strips (144P, 145P, 244, 245) corresponding respectively to said first and second arrays of trip strips (144S, 145S, 244, 245) are disposed on an inner surface of one of a pressure side wall (120, 220) and a suction side wall (122) opposed to said first and second arrays of trip strips (144S, 145S, 244, 245).

15. A cooled airfoil structure (116, 216) for a gas turbine engine, comprising first and second opposed side walls (120, 122, 220) joined together at a leading edge

(124, 224) and a trailing edge (126), a leading edge internal cooling passage (130, 230) for passing a cooling fluid therethrough to convectively cool the airfoil structure (116, 216), and a heat transfer promotion structure provided within said internal cooling passage (130, 230), said heat transfer promotion structure including a plurality of trip strips (144S, 144P, 145S, 145P; 244, 245) arranged inside said internal cooling passage (130, 230) to effect a variable heat transfer coefficient distribution, each of said trip strips (144S, 144P, 145S, 145P; 244, 245) having a height (h) and a width (w) defining a w/h ratio, and wherein within said plurality of trip strips (144S, 144P, 145S, 145P; 244, 245) at least one of said height (h), said width (w) and said w/h ratio is varied along a transversal axis relative to said internal cooling passage (130, 230), characterized in that said plurality of trip strips (144S, 144P, 145S, 145P; 244, 245) are arranged to define first and second arrays of transversally extending trip strips (144S, 144P, 145S, 145P; 244, 245), the first array being disposed generally farther from said leading edge (124, 224) than the second array, the trip strips (145S, 145P, 245) of the second array being spaced closer to one another than the trip strips (144S, 144P, 244) of the first array, the height (h) of the trip strips (144S, 144P, 244) of the first array being generally greater than the height (h) of the trip strips (145S, 145P, 245) of the second array.

16. A cooled airfoil structure (116, 216) as defined in claim 15, wherein within said plurality of trip strips at least one of said height (h) and said width (w) is varied from a maximum value to a minimum value along said transversal axis towards said leading edge (124, 224), said minimum value being provided in proximity of said leading edge.

17. A cooled airfoil structure (116, 216) as defined in claim 16, wherein said w/h ratio is comprised within a range of 0.05 to 20 inclusively.

18. A cooled airfoil structure (116, 216) as defined in claim 17, wherein said internal cooling passage (130, 230) has a height (H) and wherein:

$$0.05 \leq h/H \leq 1.0.$$

19. A cooled airfoil structure (116, 216) as defined in claim 15, wherein the trip strips (144S, 144P, 244) of the first array are longitudinally distributed within said internal cooling passage (130, 230), each said trip strip (144S, 144P, 244) of said first array having variable dimensions from a first end to a second opposed end thereof, said variable dimensions resulting from a variation of at least one of said height (h), said width (w) and said w/h ratio.

20. A cooled airfoil structure (116, 216) as defined in claim 19, wherein said variable dimensions of each said trip strips (144S, 144P, 145S, 145P; 244, 245) decrease from a maximum value at said first end thereof to a minimum value at said second end thereof, said second end being disposed closer to said leading edge (124, 224) than said first end and upstream with respect thereto.

21. A cooled airfoil structure (116, 216) as defined in claim 20, wherein said first array of trip strips (144S, 244) is disposed on an inner surface of said first side wall (120, 220), whereas the second array of trip strips (145P, 245) is disposed on an inner surface of said second side wall (122) in a staggered manner with respect to said first array of trip strips (144S, 244).

22. A cooled airfoil structure (116, 216) as defined in claim 15, wherein said trip strips (144S, 144P, 244) of said first array are different from said trip strips (145S, 145P, 245) of said second array in at least one of said height (h), said width (w) and said w/h ratio.

23. A cooled airfoil structure (116, 216) as defined in claim 22, wherein said trip strips (144S, 144P, 145S, 145P; 244, 245) of said first and second arrays are of uniform but different dimensions, said trip strips (145S, 145P, 245) of said second array being smaller than said trip strips (144S, 144P, 244) of said first array, and wherein said second array of trip strips (145S, 145P, 245) is disposed closer to said leading edge (124, 244) than said first array of trip strips (144S, 144P, 244).

24. A cooled airfoil structure (116, 216) as defined in claim 22, wherein each of said trip strips (144S, 144P, 244) of said first array is of variable dimensions from a first end to a second opposed end thereof, whereas said trip strips (145S, 145P, 245) of said second array are of uniform dimensions.

25. A cooled airfoil structure (116, 216) as defined in claim 24, wherein third and fourth arrays of trip strips (144P, 145P; 244, 245) corresponding respectively to said first and second arrays of trip strips (144S, 145S; 244, 245) are disposed on an inner surface of one of said first and second side walls (120, 122, 220) opposed to said first and second arrays of trip strips (144S, 145S; 244, 245).

26. A cooled airfoil structure (116, 216) as defined in claim 15, wherein each of said trip strips (144S, 144P, 145S, 145P; 244, 245) has first and second opposed ends,

said second end being disposed closer to said leading edge (124, 224) than said first end and upstream of said first end so as to define an acute angle θ with respect to a longitudinal axis of said internal cooling passage (130, 230), and wherein θ is comprised in a range of about 20° to about 60°.

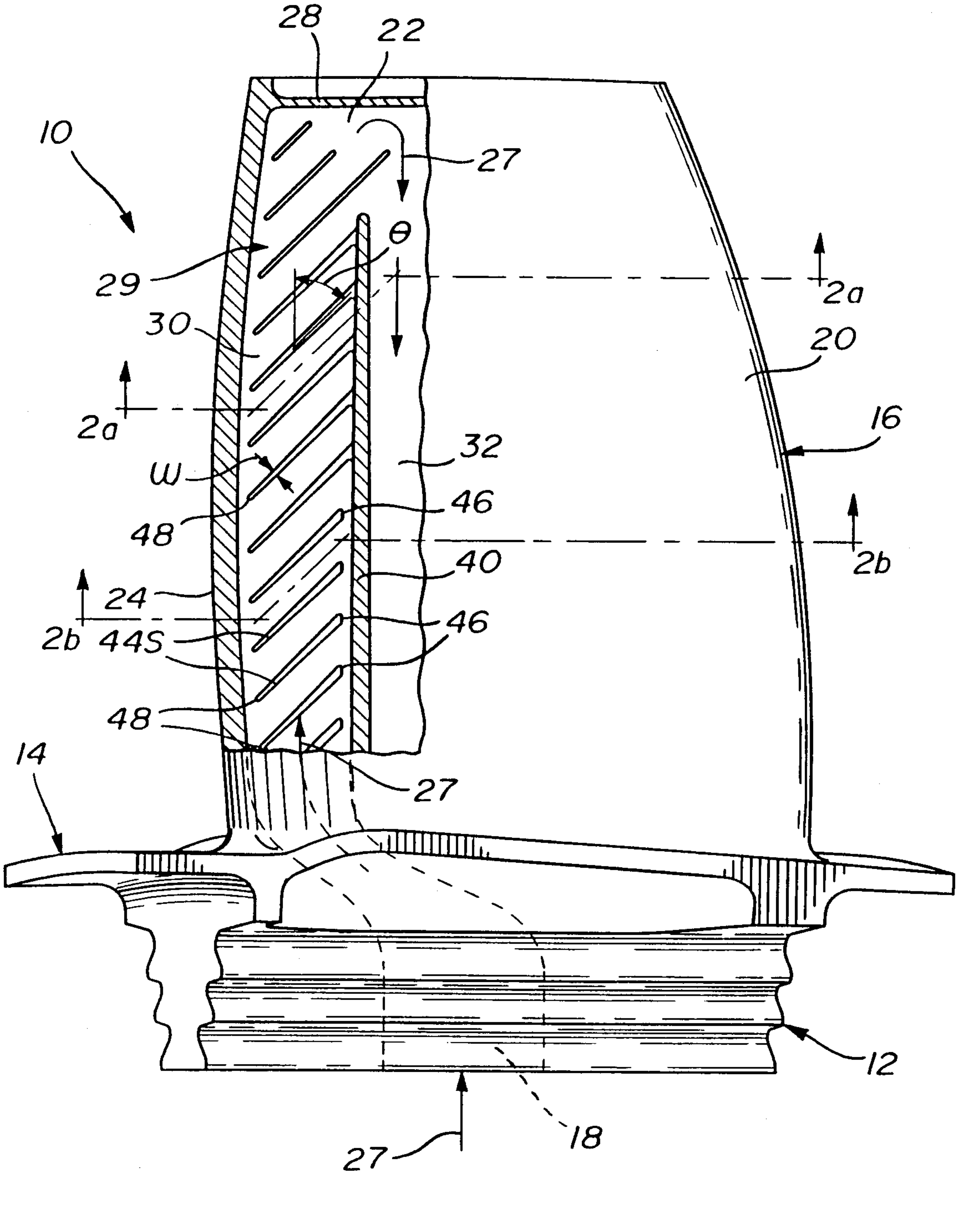

28
22
10
27
θ
29
2a
30
20
2a
16
32
W
46
48
40
2b
24
2b 44S
46
48
14
27
12
27
18

FIG. 1

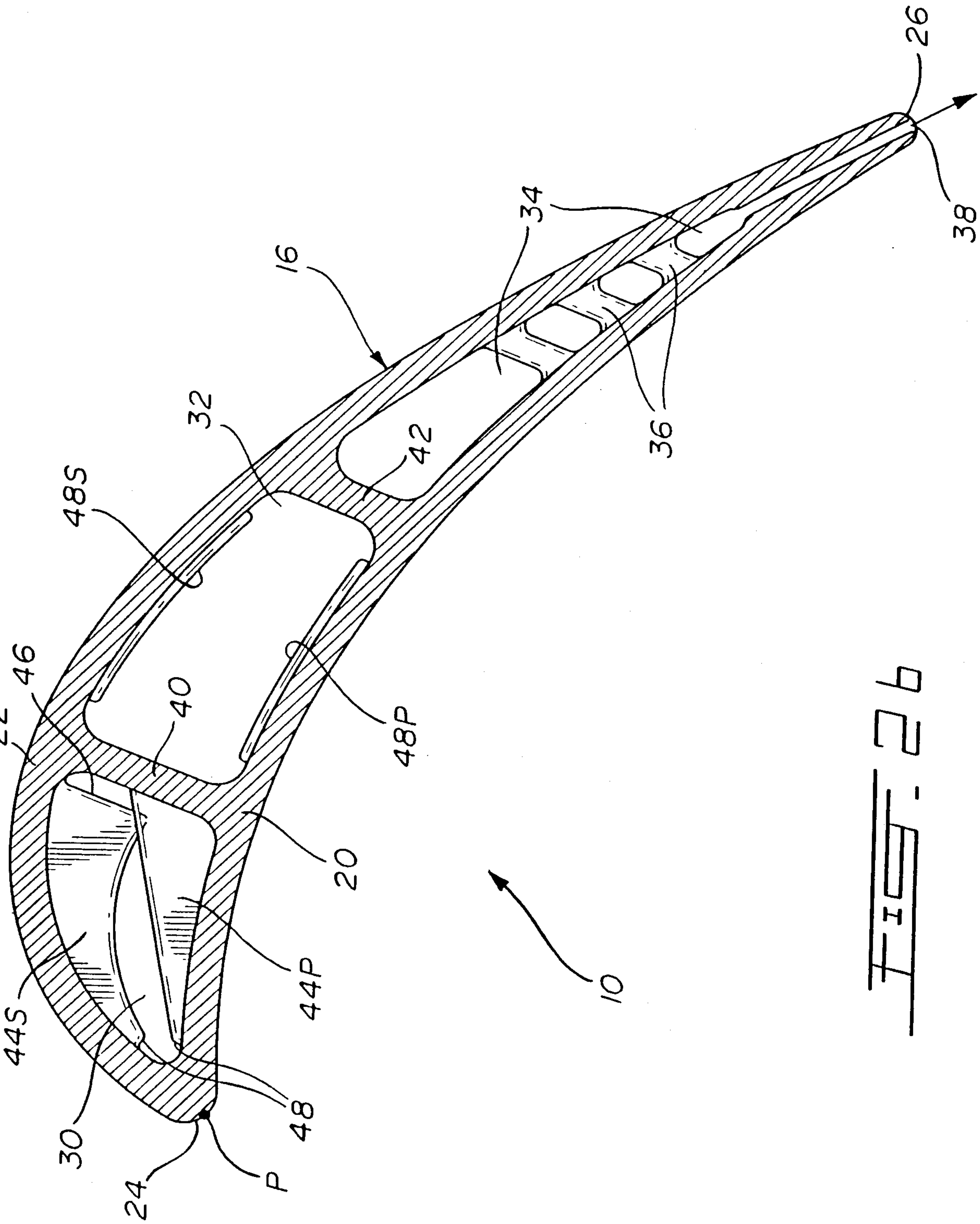


FIG. 2b

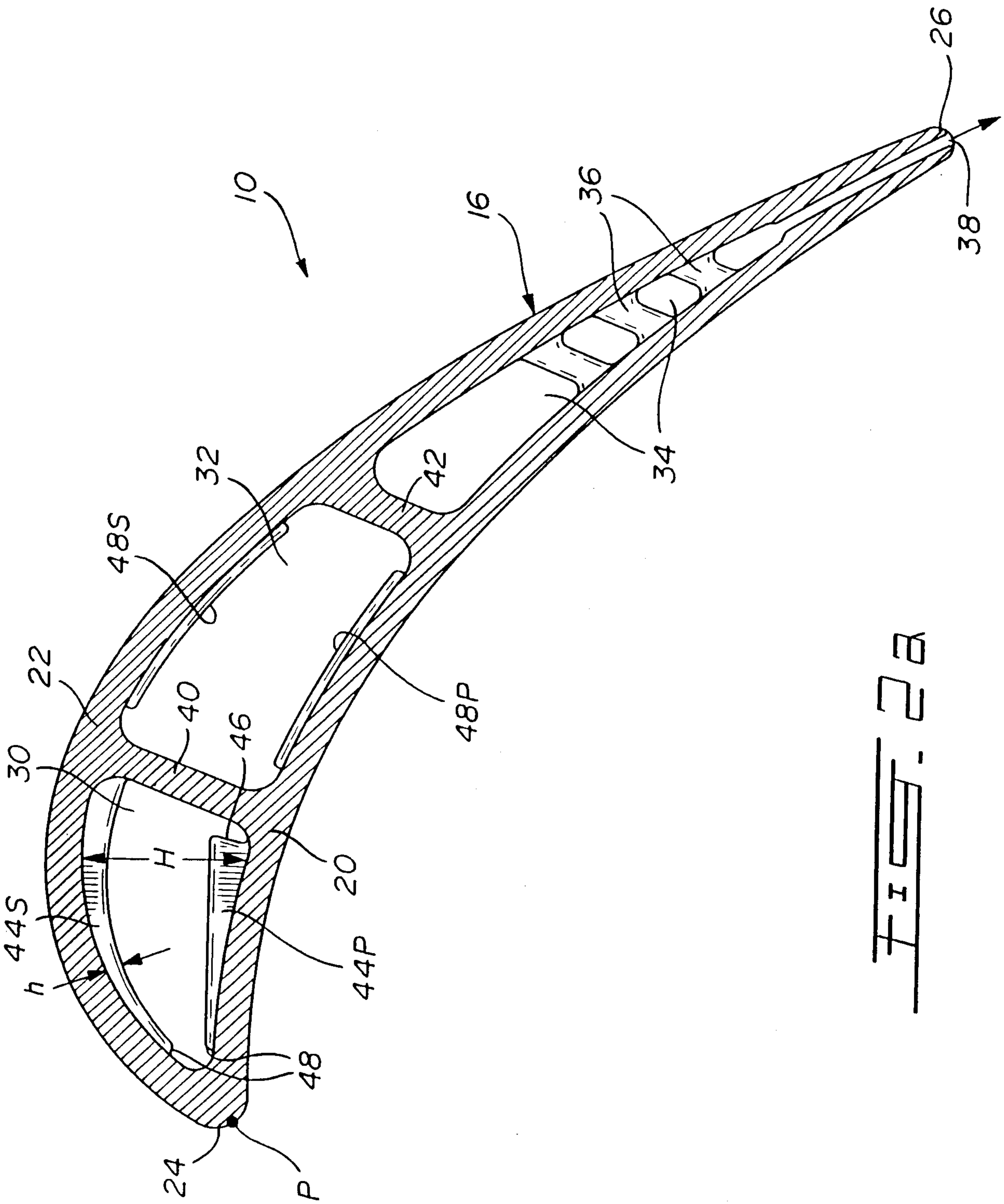


FIG. 2a

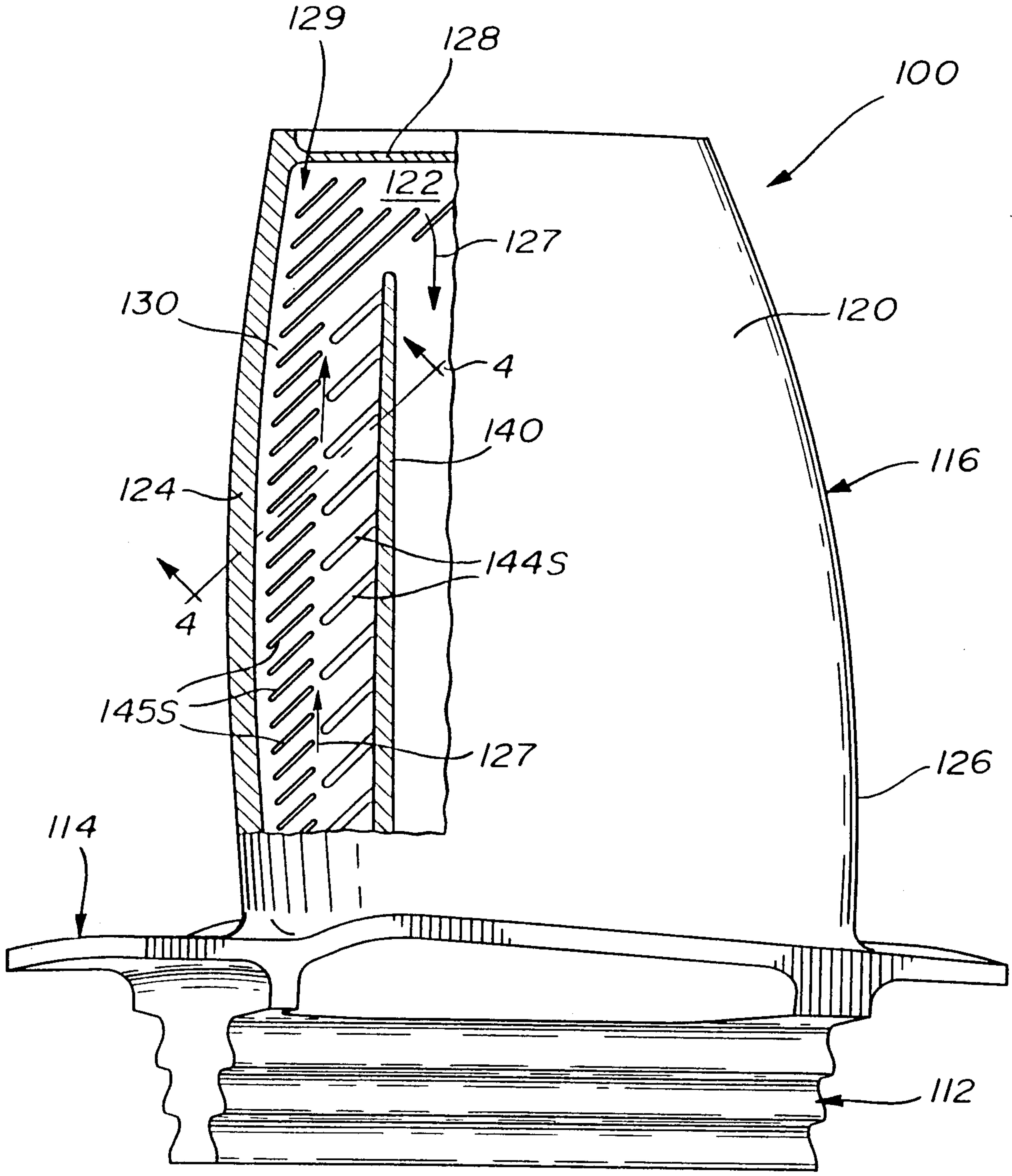

129
128
100
122
127
130
120
4
140
116
124
144S
4
145S
127
126
114
112

FIG. 3

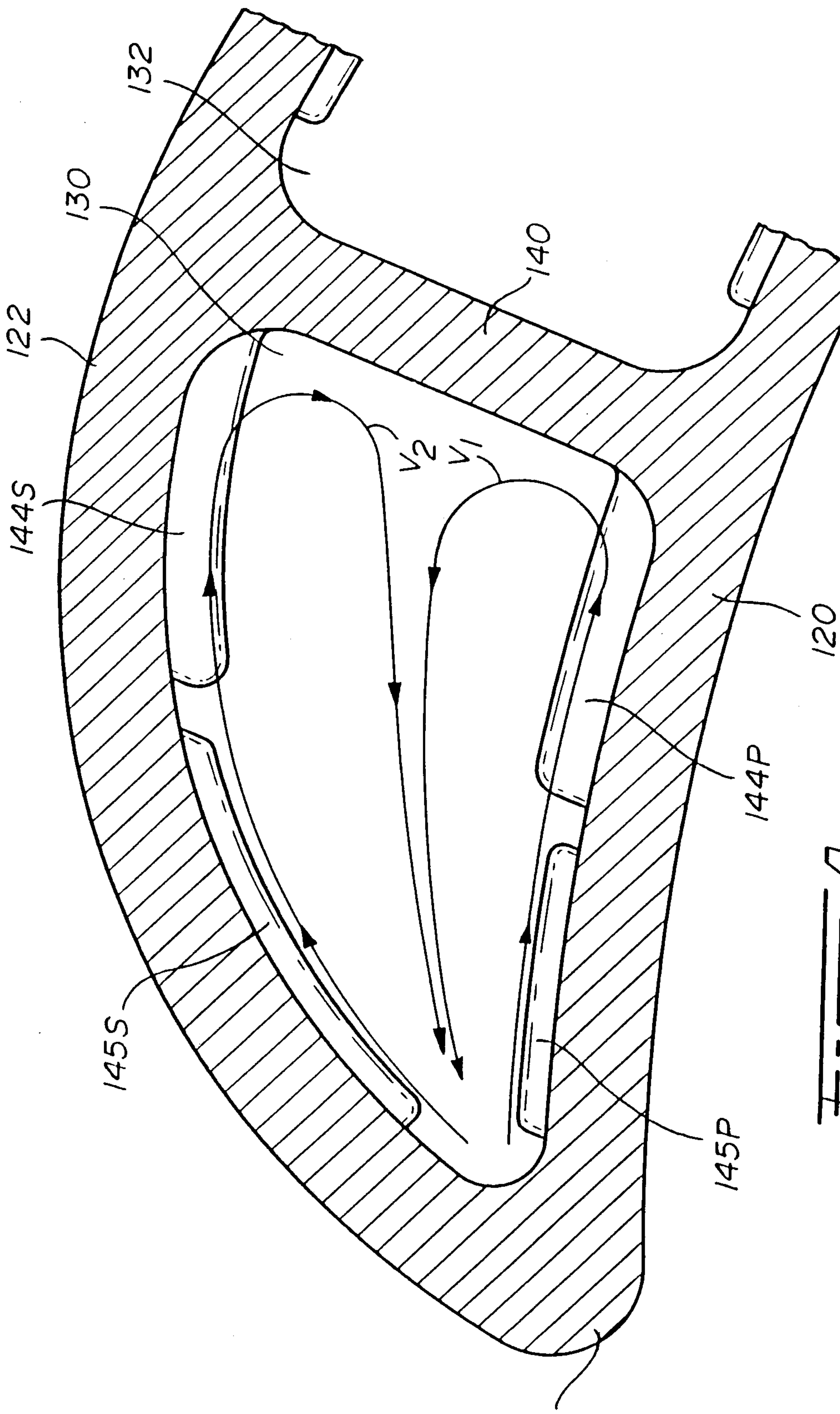


FIG. 4

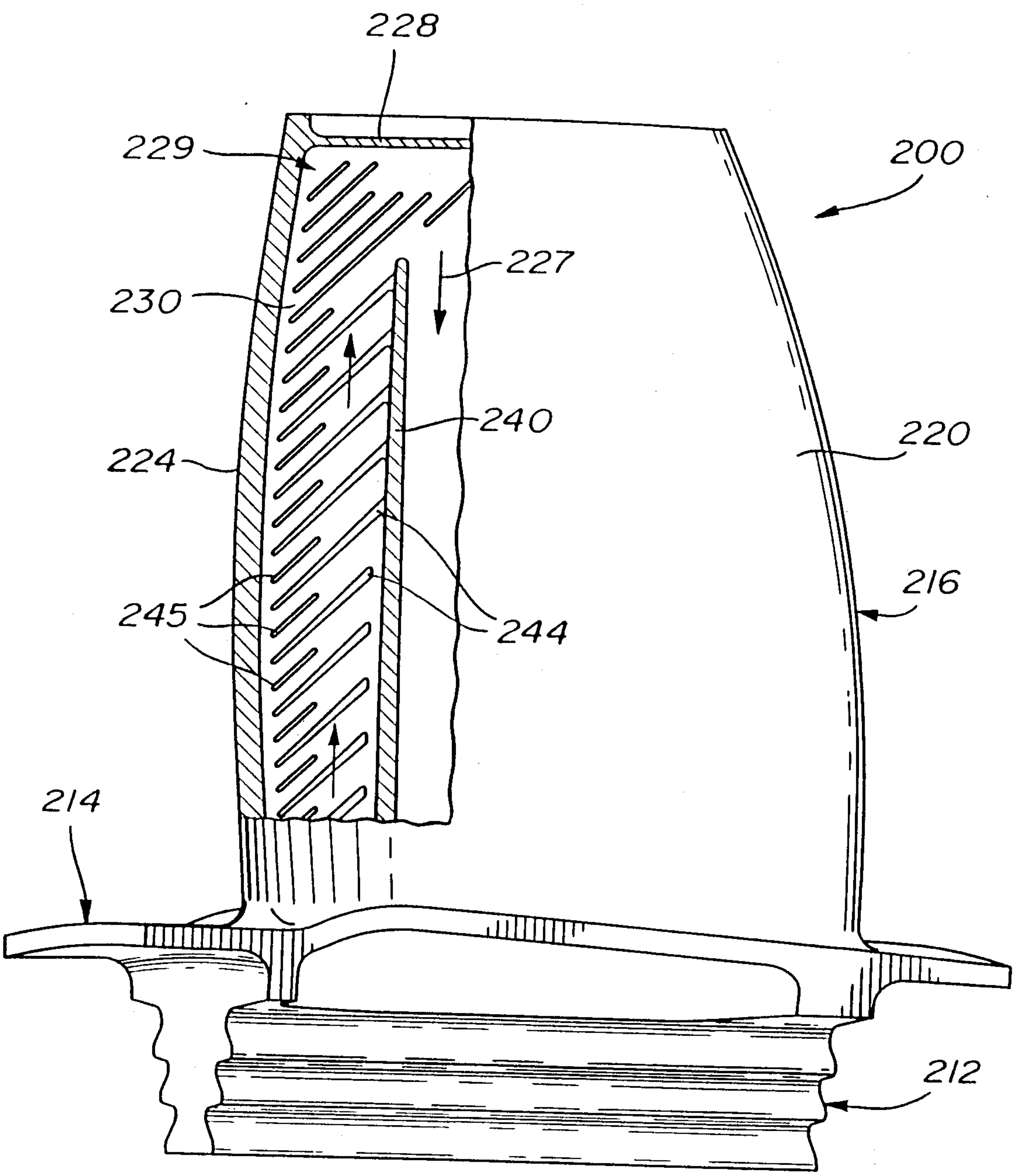
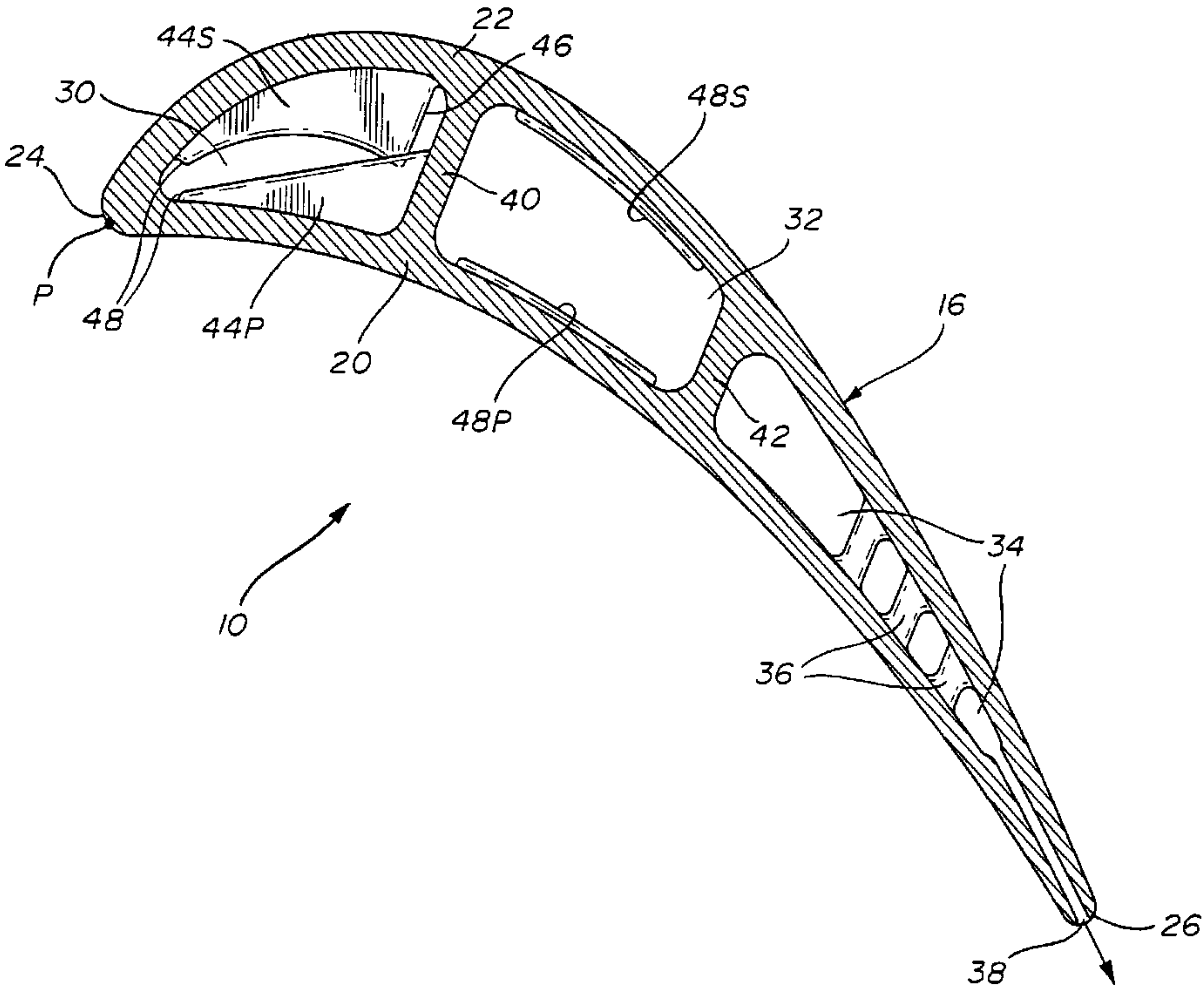


FIG. 5


22
46
44S
30
48S
24
40
32
P
48
44P
20
16
48P
42
34
34
10
36
26
38