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(54) COOLABLE OUTER AIR SEAL ASSEMBLY FOR A TURBINE

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ENSEMBLE D'ETANCHEITE D'AIR EXTERNE A REFROIDISSEMENT POUR TURBINE

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Description

This invention relates to an outer air seal assembly for a turbomachine according to the pre-characterizing part of claim 1. Such assembly is known from GB-A-2 169 037.

A typical turbomachine such as an axial flow gas turbine engine has an annular flowpath for conducting working fluid sequentially through a compressor section, a combustion section, and a turbine section. The compressor section includes a plurality of rotating blades which add energy to the working fluid. The working fluid exits the compressor section and enters the combustion section. Fuel is mixed with the compressed working fluid and the mixture is ignited to add more energy to the working fluid. The resulting products of combustion are then expanded through the turbine section. The turbine section includes another plurality of rotating blades which extract energy from the expanding fluid. A portion of this extracted energy is transferred back to the compressor section via a rotor shaft interconnecting the compressor section and turbine section. The remainder of the energy extracted may be used for other functions.

The work output of the gas turbine engine is dependant upon many factors. Among these factors is the heat generated during the combustion process. The amount of heat generation is controlled by the fuels used and the fuel/air ratio but is limited by the allowable temperature within the turbine section. In modern gas turbine engines, working fluid temperatures beyond the melting temperature of the turbine materials are achieved by directing cooling fluid to the turbine section. Typically this cooling fluid is comprised of a portion of working fluid that exits the compressor section and bypasses the combustion process.

Another factor related to the work output is the efficiency of the energy transfer between the products of combustion and the turbine rotor blades. The turbine section includes arrays of aerodynamically shaped vanes upstream of each array of rotor blades to optimize the orientation of the working fluid prior to engagement with the rotor blades. The turbine rotor blades have airfoil portions aerodynamically shaped to efficiently engage the working fluid. The rotor blade includes a platform to provide a radially inner flow surface and the turbine section includes an outer air seal assembly to provide a radially outer flow surface. The combination of these two flow surfaces confine the flow of working fluid to the airfoil portion of the rotor blade.

The outer air seal assembly typically includes a plurality of arcuate segments arranged to form an annular structure extending about the longitudinal axis of the gas turbine engine. An array of rotor blades rotates within the confines of one of the outer air seal assemblies. Each rotor blade includes a radially outer tip which, during rotation of the rotor assembly, passes within close radial proximity to or in contact with the outer air seal assembly.

Contact between the tips of the blades and the flow surface of the outer air seal assembly may occur due to the proximity required to confine the flow of working fluid to the airfoil portion. To prevent damage to the rotor blades during contact, the tips of the rotor blades are coated with an abrasive material and the outer air seal assembly has a layer of abradable material over its flow surface. Therefore, as the tip passes over the flow surface any contact will result in particles of the abradable material being dislodged rather than the blade being worn or damaged.

The segments of the outer air seal assembly are exposed to the hot working fluid. Typically, segments are cooled to prevent overheating of the substrate material. Cooling fluid is flowed radially inward through the stator assembly and over the radially outer surfaces of the substrate. This cooling fluid then flows radially inward between adjacent segments and exits out into the flowpath.

One type of abradable coating used in outer air seal assemblies is formed from ceramic materials. Ceramic materials are useful because of their ability to withstand high temperatures such as those found in turbines. Unfortunately, there have been difficulties associated with bonding the ceramic coating to the metal substrates because of thermal stresses caused by having two materials with different rates of thermal expansion exposed to a very hot environment. This is especially true for the first stages of the turbine, which are exposed to the highest temperature working fluid, and has lead to cracking and debonding of the ceramic coating from the substrate.

The above art notwithstanding, scientists and engineers under direction of Applicant's Assignee are working to develop an outer air seal assembly with minimal cracking and/or debonding of an abradable layer from a seal segment.

The prior art outer air seal assembly according to GB-A-2 169 037 comprises a substrate and an abradable layer not including any cooling holes permitting fluid communication between the first cavity and the flow path.

US-A-3 365 172 discloses an air seal assembly in which a substrate comprises a cover disposed radially outward of the substrate, a cavity defined between the cover and the substrate, and a layer disposed radially inward of the substrate and including a plurality of cooling holes permitting fluid communication between the cavity and the flow path of the working fluid of the turbomachine.

According to the present invention, an outer air seal assembly includes the features of claim 1.

Preferred embodiments are defined in the dependent claims.

Where, for structural reasons, the air seal segment includes an enlarged end portion, such as the upstream end portion, the cavity adjacent thereto may include a

longitudinally extending chamber disposed in the enlarged end portion. The chamber passes cooling fluid to the end portion for improved cooling thereof and has the additional benefit of providing stress relief in that end portion.

A principle feature of the present invention is the combination of impingement cooling means and film cooling means in an outer air seal segement. Another feature is the alignment of the cooling holes with the blade passing direction. A feature of a particular embodiment is the pair of cavities defined by the impingement cover and the substrate. Another feature of the particular embodiment is the means to generate a pressure differential between the cavities. A further feature is the angle and shape of the cooling holes. A still further feature is the intersegment holes disposed along the lateral edge of the segment.

An advantage of the present invention is the level of thermal stress within the segment as a result of the impingement cooling and film cooling. The impingement cooling maintains the substrate within an acceptable temperature range for the substrate material. The film cooling generates a buffer of cooling fluid between the abradable layer and the working fluid to cool the abradable layer. The two cooling means in conjunction minimize the temperature gradients between the layer of abradable material and the substrate to minimize thermal stresses between the two materials. Another advantage is the expected useful life of the segment as a result of angling the holes relative to the radial axis and aligning the cooling holes with the blade passing direction. Angling the cooling holes enlarges the opening in the abradable layer to reduce the likelihood of plugging the cooling hole with particles disclosed as a result of abrasive contact between the blade tip and segment. Aligning the cooling holes with the blade passing direction further minimizes the likelihood of plugging the cooling hole with dislodged particles. An advantage of the particular embodiment is the availability of high pressure film cooling at the upstream, high pressure end of the segment as a result of the multiple cavities and pressure differential means. Another advantage of the particular embodiment is the level of thermal stress near the lateral edges of the segment as a result of the intersegment cooling. The intersegment cooling holes provide convective cooling and impingement cooling to the lateral edges of the segments. In addition, the cooling fluid flowing into the intersegment region purges this region to block the ingestion of hot working fluid between adjacent segments.

The foregoing and other objects, features and advantages of the present invention become more apparent in light of the following detailed description of the exemplary embodiments thereof, as illustrated in the accompanying drawings.

Brief Description of the Drawings

FIG. 1 is a cross sectional side view of a gas turbine engine.

FIG. 2 is a sectional side view of an outer air seal assembly, a turbine rotor assembly, and an upstream and downstream vane assembly.

FIG. 3 is a radially outward view of a single outer air seal segment.

FIG. 4 is a radially inward view of a single outer air seal segment.

FIG. 5 is a partially sectioned side view taken along line 5-5 of FIG. 3.

FIG. 6 is an axially upstream view of the outer air seal segment with arrows showing the direction of flow of the film cooling.

FIG. 7a is a sectional view of a film cooling hole taken along line 7-7 of FIG. 5. FIG. 7b is an illustration of the film cooling hole after a build-up of dislodged abradable particles.

FIG. 8 is a partially sectioned side view similar to Fig. 5, but illustrating an alternate embodiment of the invention.

Best Mode for Carrying Out the Invention

Illustrated in Fig. 1 is an axial flow gas turbine engine 12 shown as an example of a typical turbomachine. The gas turbine engine includes an axially directed flowpath 14, a compressor 16, a combustor 18, and a turbine 22. The compressor includes a plurality of compressor blades 24 which extend through the flowpath and engage working fluid in the flowpath. The engagement between the working fluid and the compressor rotor blades transfers energy to the working fluid. Working fluid exits the compressor and enters the combustor where it is mixed with a supply of fuel. The mixture is ignited in the combustor to add more energy to the working fluid. The products of the combustion are then expanded through the turbine. The turbine includes a plurality of axially alternating stages of turbine vanes 26 and turbine rotor blades 28. The turbine rotor blades extend through the flowpath and engage the working fluid to transfer energy from the working fluid to the turbine rotor blades. A portion of this energy transferred to the turbine rotor blades is transferred to the compressor section via a pair of rotor shafts 32 interconnecting the turbine and compressor.

As shown in Fig. 2, each stage of turbine rotor blades 28 is axially downstream of a stage of turbine vanes 26. Each turbine rotor blade includes an airfoil portion 34 having a radial tip 36 and a platform 38 disposed radially inward of the airfoil portion. The platform includes a flow surface 42 which faces radially outward towards the flowpath. The platform flow surface discourages working fluid within the flowpath from flowing radially inward.

Radially outward of the airfoil tip is an outer air seal

assembly 44. The outer air seal assembly includes a plurality of segments 46 spaced circumferentially about the turbine rotor blades. The plurality of segments define an annulus having a flow surface 52 which faces radially inward towards the flowpath. The outer air seal flow surface is in radial proximity to the airfoil tip and discourages working fluid from flowing radially outward.

The segment is illustrated in more detail in Figs. 3-6. Each segment includes a substrate 54, an impingement cover 56, and a layer of abradable ceramic material 58. The substrate includes a plurality of hooks 62 which engage stator structure 64 within the turbine to retain each of the segments. Ceramic material is suggested for the abradable layer because of its insulating characteristics, although non-ceramic materials may also be applicable.

The impingement cover is disposed on the outward side of the substrate. The impingement cover and substrate define a first cavity 66 and a second cavity 68 disposed axially downstream of the first cavity. The impingement cover, as shown more clearly in Figs. 4 and 5, includes a first plurality of impingement holes 72 and a second plurality of impingement holes 74. The first plurality of impingement holes provide fluid communication between the first cavity and the source of cooling fluid. The second plurality of impingement holes provide fluid communication between the second cavity and the source of cooling fluid.

The segment includes means to generate a pressure differential between the two cavities, with higher pressure in the first cavity than in the second cavity. As shown in FIG. 4, the means is defined by having different diameter impingement holes. Each of the first plurality of cooling holes has a diameter D_1. Each of the second plurality of cooling holes has a diameter D_2, wherein D_2 is less than D_1. The larger diameter cooling holes permit a greater flow of cooling fluid into the first cavity. Since the cavities have approximately the same number of film cooling holes, and they are approximately the same size, the difference in impingement hole diameter generates a higher pressure in the first cavity. Although described and shown at thus, other means to generate a pressure differential may be used, such as a greater quality of impingement holes in the first cavity.

A plurality of film cooling holes 76 extend through the substrate and abradable layer as shown in Figs. 3 and 5. A first plurality of film cooling holes 78 extends between the first cavity and the flowpath. A second plurality of film cooling holes 82 extends between the second cavity and flowpath. The film cooling holes are closely spaced over the entire surface of the abradable layer to provide optimal coverage taking into account the engine efficiency costs of the cooling fluid. The broad extent of the coverage of film cooling holes results in a uniform film of cooling fluid over most of the abradable layer flow surface.

Each of the film cooling holes is shaped and oriented as shown in Fig. 7a. Each film cooling hole includes a constant diameter portion 84 and a flared portion 86. The flared portion opens into the flow surface and provides diffusion of the cooling fluid flowing through the film cooling hole. By diffusing the cooling fluid before ejecting it over the flow surface, the area of the cooling fluid is increased and the velocity exiting the film cooling hole is reduced. Increasing the area of the ejected fluid correspondingly increases the coverage each film cooling hole provides over the flow surface. Reducing the velocity of the cooling fluid ejected from the film cooling hole encourages the ejected fluid to remain attached to the flow surface.

Each of the film cooling holes is canted at an angle α relative to a radial axis 88 of the gas turbine engine. Angling the holes results in an elliptical opening in the flow surface of the abradable layer. The elliptical opening is less likely to become closed due to particles deposited in the opening by flow over the flow surface. In addition, angling the cooling holes relative to the radial axis ejects cooling fluid tangentially over the flow surface as shown by arrows 90 to further encourage the development of a film of cooling fluid.

The majority of the film cooling holes are oriented such that the direction of cooling fluid ejection is laterally aligned with the blade passing direction is shown by arrow 92. Aligning the cooling holes as such results in film cooling holes which are less likely to become blocked by dislodged particles of the abradable layer.

Each segment includes a plurality of intersegment cooling holes 94. The intersegment cooling holes provide fluid communication between the cavities and the lateral space 96 between adjacent segments. The cooling fluid flows through the intersegment holes to provide convective cooling of the substrate in the region of the intersegment cooling holes. Cooling fluid exiting the intersegment cooling holes (shown by arrows 96) is impinged upon the lateral edge 102 of the adjacent segment to provide cooling of the adjacent segments lateral edges. After the impingement occurs, the cooling fluid then flows radially inward between the adjacent segments and out into the flowpath. Flowing cooling fluid into the intersegment space provides means to purge the space and prevents the ingestion of working fluid into the intersegment space.

During operation, hot working fluid passes over the flow surface of the outer air seal and heats the outer air seal assembly. Cooling fluid flows radially inward into the space radially outward of the impingement cover. This cooling fluid flows through the impingement cooling holes and into the cavities. The internal pressure of the first cavity is greater than the internal pressure of the second cavity. As a result of the larger impingement cooling holes. Cooling fluid within the cavities then flows through the film cooling holes and exits the film cooling holes to form a film or buffer of cooling fluid over the flow surface of the segment. The pressure on the abradable layer caused by the working fluid is greatest at the upstream end of the abradable layer and decreases towards the downstream end of the abradable layer. Hav-

ing separated cavities that are axially spaced within the segment provides means to have high pressure cooling fluid flowing through the upstream film cooling holes where it is needed and lower pressure cooling fluid flowing through the downstream holes. This ensures that an adequate supply of film cooling fluid is provided over the axial extent of the flow surface. A portion of the cooling fluid within the cavities flows to the intersegment cooling holes to provide convective cooling to the segment, impingement cooling to an adjacent segment, and to purge the intersegment space of hot working fluid.

Abrasive contact between the airfoil tip and the abradable layer may result in (dislodged particles of the abradable layer). These particles 104 may be deposited within the film cooling holes and result in a reduction in the flow area of the film cooling hole. As shown in Figs. 7a and 7b, however, the angle, orientation, and shape of the film cooling holes make this event less likely than a radially oriented, constant diameter cooling hole. Since the cooling holes are aligned with the blade passing direction, and since the cooling holes are angled relative to a radial axis, the effective diameter of the cooling is maximized. This effect minimizes the likelihood of dislodged particles closing the film cooling holes. In addition, the larger opening resulting from the flared portion and the angle of the film cooling hole relative to the radial axis also reduces the likelihood of the film cooling hole becoming completely blocked or plugged. Reducing the likelihood of blocked film cooling holes increases the life expectancy of the segment by ensuring that, even after some degradation of the abradable layer, cooling fluid will continue to flow through the film cooling holes to provide cooling of the segment.

Referring to Fig. 8, an alternate embodiment of seal segment 46 is shown. For various structural reasons which need not be set forth for purposes hereof, this seal segment includes an enlarged upstream end portion 108 provided with hook 110 similar to hook 62 disposed at the downstream end of the segment and described hereinabove. Like hook 62, hook 110 is captured within a slot in stator structure 64, for mechanical retention of the seal segment. For purposes of cooling enlarged end portion 108, first cavity 66 is provided with a chamber 112 extending longitudinally into end portion 108. Chamber 112 functions as a passage for channeling cooling air from cavity 66 to end portion 108. It will be appreciated that such provision of cooling air within the interior of end portion 108 will reduce thermally induced stresses therewithin and enhance the thermal isolation of hook 110 (and the contiguous stator structure) from the extremely hot working fluid flowing past abradable ceramic material 58. Such a reduction in thermal stress in end portion 108 enhances the reliability and performance of the seal and is accompanied by increased flexibility of end portion 108 due to the void therein defined by chamber 112. This increased flexibility and thermal stress reduction results in a minimization of seal distortion (maximization of seal concentricity) for improved performance of the gas turbine engine. The cooling scheme illustrated and described with respect to the seal segments illustrated in Figs. 2-7 is equally well suited for the seal segment illustrated in Fig. 8.

Claims

1. An outer air seal assembly (44) for a turbomachine (12), the turbomachine (12) including a flowpath (14), a rotor blade assembly being rotatable about a longitudinal axis of the turbomachine (12), and a source of cooling fluid, the rotor blade assembly including a plurality of blades (28), each of the blades (28) including a radially outward tip (36), the outer air seal assembly (44) disposed radially outward of the rotor blade assembly, wherein the outer air seal assembly (44) further includes:
a plurality of circumferentially spaced arcuate segments (46) forming an annulus axially aligned with the rotor blade assembly and defining a radially outer flow surface (52) for the flowpath (14), the flow surface (52) in radial proximity to the radial tips (36), wherein each segment (46) includes a substrate (54) including means to retain the segment, an impingement cover (56) disposed radially outward of the substrate (54) and including a plurality of apertures (72) extending radially through the impingement cover (56), a first cavity (66) defined by a separation between the impingement cover (56) and the substrate (54), a layer of abradable material (58) radially inward of the substrate (54) to form the radially outer flow surface (52), and wherein the apertures (72) provide fluid communication between the cavity (66) and the source of cooling fluid such that cooling fluid passing through the apertures (72) impinges upon the substrate (54),
characterized in that
the substrate (54) and abradable layer (58) include a plurality of cooling holes (76) permitting fluid communication between the first cavity (66) and the flow path (14), the cooling holes (76) having an exit in the abradable layer (58), that the cooling holes (76) are angled relative to a radial axis of the turbomachine (12) such that the cooling fluid exiting the cooling hole (76) is urged to form a film of cooling fluid over the flow surface (52), that a plurality of intersegment cooling holes (94) is disposed along a lateral edge of the segment (46), the intersegment cooling holes (94) providing fluid communication between the cavity (66) and the lateral space (96) between adjacent segments (46), wherein the intersegment cooling holes (94) provide convective cooling to the lateral edge of the segment (46), wherein the intersegment cooling holes (94) direct cooling fluid towards the adjacent segment (101) provide impingement cooling of a lateral edge (102) of the adjacent segment (101), and wherein the

cooling fluid exiting the intersegment cooling holes (94) flows between the segments (46, 101) such that the lateral space (96) between the adjacent segments (46, 101) is purged.

2. The outer air seal assembly (44) according to claim 1, wherein the cooling holes (76) are aligned with the direction of movement of the rotor blade (28) relative to the segment (46).

3. The outer air seal assembly (44) according to claim 1 or 2, wherein each cooling hole (76) has a downstream end and includes a flared portion (86) at the downstream end, the flared portion (86) diffusing the cooling fluid passing through the cooling hole (76).

4. The outer air seal assembly (44) according to claim 1, 2 or 3, further including a second cavity (68) extending between the cover (56) and the substrate (54), the second cavity (68) being downstream of the first cavity (66), a second plurality of apertures (74) extending through the cover (56) and providing fluid communication between the second cavity (68) and the source of cooling fluid, and means to generate a pressure differential between the first cavity (66) and the second cavity (68).

5. The outer air seal assembly (44) according to claim 4, wherein the pressure differential means is defined by each of the first plurality of apertures (72) having a diameter D_1, each of the second plurality of apertures (74) having a diameter D_2, and wherein $D_1 > D_2$ such that the internal pressure of the first cavity (66) is greater than the internal pressure of the second cavity (68).

6. An outer air seal assembly (44) according to any of claims 1 to 5, wherein said substrate has at least one enlarged end portion (108), said first cavity (66) has a longitudinally extending chamber (112) disposed in said enlarged end portion (108), said chamber (112) providing a passage for channeling cooling air to said enlarged end portion (108) as well as reducing internal stresses therewithin.

7. A segment for an outer air seal assembly (44) of a turbomachine (12), characterized by comprising the segment-related features of any of claims 1 to 6.

Patentansprüche

1. Äußere Luftdichtungsanordnung (44) für eine Turbomaschine (12), wobei die Turbomaschine (12) einen Strömungsweg (14), eine um eine Längsachse der Turbomaschine (12) drehbare Rotor-Laufschaufelanordnung und eine Kühlfluidquelle aufweist, wobei die Rotor-Laufschaufelanordnung mehrere Laufschaufeln (28) aufweist, von denen jede eine radial äußere Spitze (36) aufweist, wobei die äußere Luftdichtungsanordnung (44) radial außerhalb der Rotor-Laufschaufelanordnung angeordnet ist und sie ferner aufweist: mehrere umfangsmäßig beabstandete, gekrümmte Segmente (46), die einen axial mit der Rotor-Laufschaufelanordnung ausgerichteten Ring bilden und eine radial äußere Strömungsfläche (52) für den Strömungsweg (14) definieren, die sich in radialer Nähe zu den radialen Spitzen (36) befindet, wobei jedes Segment (46) ein Substrat (54) mit Mitteln zum Festhalten des Segments, eine Auftreffabdeckung (56), die radial außen von dem Substrat (54) angeordnet ist, und mehrere sich radial durch die Auftreffabdekkung (56) erstreckende Öffnungen (72), einen durch einen Abstand zwischen der Auftreffabdekkung (56) und dem Substrat (54) definierten ersten Hohlraum (66) und eine Schicht aus abnutzbarem Material (58) radial innen von dem Substrat (54) aufweist, um die radial äußere Strömungsfläche (52) zu bilden, und wobei die Öffnungen (72) eine Fluidverbindung zwischen dem Hohlraum (66) und der Kühlfluidquelle so bilden, daß durch die Öffnungen (72) strömendes Kühlfluid auf das Substrat (54) auftrifft,
dadurch gekennzeichnet,
daß das Substrat (54) und die abnutzbare Schicht (58) mehrere Kühlöffnungen (76) aufweisen, die eine Fluidverbindung zwischen dem ersten Hohlraum (66) und dem Strömungsweg (14) zulassen, wobei die Kühlöffnungen (76) einen Ausgang in der abnutzbaren Schicht (58) besitzen, daß die Kühlöffnungen (76) relativ zu einer radialen Linie der Turbomaschine (12) so im Winkel angeordnet sind, daß das aus der Kühlöffnung (76) austretende Kühlfluid gezwungen ist, einen Film aus Kühlfluid über der Strömungsfläche (52) zu bilden, daß mehrere Zwischensegmentkühlungs-Öffnungen (94) entlang eines Seitenrandes des Segments (46) angeordnet sind, wobei die Zwischensegmentkühlungs-Öffnungen (94) zwischen dem Hohlraum (66) und dem seitlichen Raum (96) zwischen benachbarten Segmenten (46) eine Fluidverbindung schaffen, wobei die Zwischensegmentkühlungs-Öffnungen (94) dem Seitenrand des Segments (46) eine konvektive Kühlung bereitstellen und Kühlfluid in Richtung auf das benachbarte Segment (101) lenken, um für den benachbarten Rand (102) des benachbarten Segments (101) eine Auftreffkühlung bereitzustellen, und wobei das aus den Zwischensegmentkühlungs-Öffnungen (94) austretende Kühlfluid zwischen den Segmenten (46, 101) so strömt, daß der seitliche Raum (96) zwischen den benachbarten Segmenten (46, 101) gespült wird.

2. Äußere Luftdichtungsanordnung (44) nach An-

spruch 1, bei der die Kühlöffnungen (76) mit der Bewegungsrichtung der Rotor-Laufschaufeln (28) relativ zu dem Segment (46) ausgerichtet sind.

3. Äußere Luftdichtungsanordnung (44) nach Anspruch 1 oder 2, bei der jede Kühlöffnung (76) ein stromabwärtiges Ende besitzt und einen sich nach außen erweiternden Bereich (86) an dem stromabwärtigen Ende aufweist, der für das durch die Kühlöffnung (76) tretende Kühlfluid als Diffusor wirkt.

4. Äußere Luftdichtungsanordnung (44) nach Anspruch 1, 2 oder 3, ferner aufweisend einen zweiten Hohlraum (68), der sich zwischen der Abdeckung (56) und dem Substrat (54) erstreckt und sich stromabwärts des ersten Hohlraums (66) befindet, eine zweite Mehrzahl von Öffnungen (74), die sich durch die Abdeckung (56) erstrecken und zwischen dem zweiten Hohlraum (68) und der Kühlfluidquelle eine Fluidverbindung bereitstellen, und eine Einrichtung zum Erzeugen einer Druckdifferenz zwischen dem ersten Hohlraum (66) und dem zweiten Hohlraum (68).

5. Äußere Luftdichtungsanordnung (44) nach Anspruch 4, bei der die Druckdifferenzeinrichtung dadurch definiert ist, daß jede Öffnung von der erste Mehrzahl von Öffnungen (72) einen Durchmesser D_1 aufweist, daß jede der Öffnungen der zweiten Mehrzahl von Öffnungen (74) einen Durchmesser D_2 aufweist und wobei $D_1 > D_2$, so daß der Innendruck des ersten Hohlraums (66) größer ist als der Innendruck des zweiten Hohlraums (68).

6. Äußere Luftdichtungsanordnung (44) nach einem der Ansprüche 1 bis 5, bei der das Substrat mindestens einen vergrößerten Endbereich (108) aufweist, wobei der erste Hohlraum (66) eine sich in Längsrichtung erstreckende Kammer (112) aufweist, die in dem vergrößerten Endbereich (108) angeordnet ist, wobei die Kammer (112) eine Durchgang zum Kanalisieren von Kühlluft zu dem vergrößerten Endbereich (108) sowie zum Reduzieren von inneren Spannungen darin schafft.

7. Segment für eine äußere Luftdichtungsanordnung (44) einer Turbomaschine (12), dadurch gekennzeichnet, daß es die auf das Segment bezogenen Merkmale eines der Ansprüche 1 bis 6 aufweist.

Revendications

1. Un ensemble d'étanchéité d'air externe (44) destiné à une turbomachine (12), la turbomachine (12) comprenant un chemin d'écoulement (14), un ensemble d'aubes de rotor pouvant tourner autour d'un axe longitudinal de la turbomachine (12) et une source de fluide de refroidissement, l'ensemble d'aubes de rotor comprenant une pluralité d'aubes (28), chacune des aubes (28) comprenant un bout radialement extérieur (36), l'ensemble d'étanchéité d'air externe (44) étant disposé radialement à l'extérieur de l'ensemble d'aubes de rotor, dans lequel l'ensemble d'étanchéité d'air externe (44) comprend en outre :
une pluralité de segments arqués (46) espacés circonférentiellement, formant un anneau aligné axialement vis-à-vis de l'ensemble d'aubes de rotor et définissant une surface d'écoulement radialement (52) pour le chemin d'écoulement (14), la surface d'écoulement (52) étant à proximité radiale des bouts radiaux (36), dans lequel chaque segment (46) comprend un substrat (54) comprenant des moyens pour retenir le segment, un couvercle d'impact (56) disposé radialement à l'extérieur du substrat (54) et comprenant une pluralité d'ouvertures (72) s'étendant radialement dans le couvercle d'impact (56), une première cavité (66) définie par une séparation constitiuée entre le couvercle d'impact (56) et le substrat (54), une couche de matériau abrasible (58) placée radialement à l'intérieur du substrat (54) afin de former la surface d'écoulement radialement extérieure (52), et dans lequel les ouvertures (72) établissent des communications hydrauliques entre la cavité (66) et la source de fluide de refroidissement, de manière que le fluide de refroidissement passant par les ouvertures les ouvertures (72) heurtent le substrat (54),
caractérisé en ce que le substrat (54) et la couche abrasible (58) comprennent une pluralité de trous de refroidissement (76) permettant d'établir une communication de fluide entre la première cavité (70) et le chemin d'écoulement (14), les trous de refroidissement (76) ayant une sortie ménagée dans la couche abrasible (58), de manière que les trous de refroidissement (76) soient orientés suivant un angle par rapport à un axe radial de la turbomachine (12), de manière que le fluide de refroidissement sortant du trou de refroidissement (76) soit véhiculé pour constituer un film de fluide de refroidissement sur les surfaces d'écoulement (52), en ce qu'une pluralité de trous de refroidissement (76) intersegments (94) sont disposés sur un bord latéral du segment (46), les trous de refroidissement intersegments (94) établissant une communication hydraulique entre la cavité (66) et l'espace latéral (96) existant entre des segments (46) adjacents, dans lequel les trous de refroidissement intersegments (94) assurent un refroidissement par convection sur le bord latéral du segment (46) dans lequel les trous de refroidissement intersegments (94) dirigent du fluide de refroidissement vers le segment adjacent (101) en produisant un refroidissement par impact d'un bord latéral (102) du segment (101) adjacent et dans lequel le fluide de re-

froidissement sortant des trous de refroidissement intersegments (94) s'écoule entre les segments (46, 101), de manière que l'espace latéral (96) existant entre les segments adjacents (46, 101) soit purgé.

2. L'ensemble d'étanchéité d'air externe (44) selon la revendication 1, dans lequel des trous de refroidissement (76) sont alignés vis-à-vis de la direction de déplacement de l'aube rotor (28) par rapport au segment (46).

3. L'ensemble d'étanchéité d'air externe (44) selon la revendication 1 ou 2, dans lequel chaque trou de refroidissement (76) a une extrémité aval et comprend une partie (86) évasée à l'extrémité aval, la partie évasée (86) diffusant le fluide de refroidissement passant par le trou de refroidissement (76).

4. L'ensemble d'étanchéité d'air externe (44) selon la revendication 1, 2 ou 3, comprenant en outre une deuxième cavité (68) s'étendant entre le couvercle (56) et le substrat (54), la deuxième cavité (68) étant en aval de la première cavité (66), une deuxième pluralité d'ouvertures (74) s'étendant par le couvercle (56) et fournissant une communication hydraulique entre la deuxième cavité (68) et la source de fluide de refroidissement, et des moyens pour générer une différence de pression entre la première cavité (66) et la deuxième cavité (68).

5. L'ensemble d'étanchéité d'air externe (44) selon la revendication 4, dans lequel les moyens de constitution d'une différence de pression sont définis par chacune parmi la première pluralité d'ouvertures (72) ayant un diamètre D_1, chacune de ladite deuxième pluralité d'ouvertures (74) ayant un diamètre D_2 et dans lequel $D_1 > D_2$, de manière que la pression interne de la première cavité (66) soit supérieure à la pression interne de la deuxième cavité (68).

6. Un ensemble d'étanchéité d'air externe (44) selon l'une quelconque des revendications 1 à 5, dans lequel chaque substrat a au moins une partie extrémité (108) agrandie, ladite première cavité (66) ayant une chambre (112) s'étendant longitudinalement disposée dans ladite partie extrémité (108) agrandie, ladite chambre (112) fournissant un passage pour canaliser de l'air de refroidissement vers ladite partie extrémité (108) élargie, ainsi que pour y réduire les contraintes internes.

7. Un segment d'un ensemble d'étanchéité d'air externe (44) d'une turbomachine (12), caractérisé par le fait de comprendre les caractéristiques du segment telles qu'indiquées dans l'une quelconque des revendications 1 à 6.

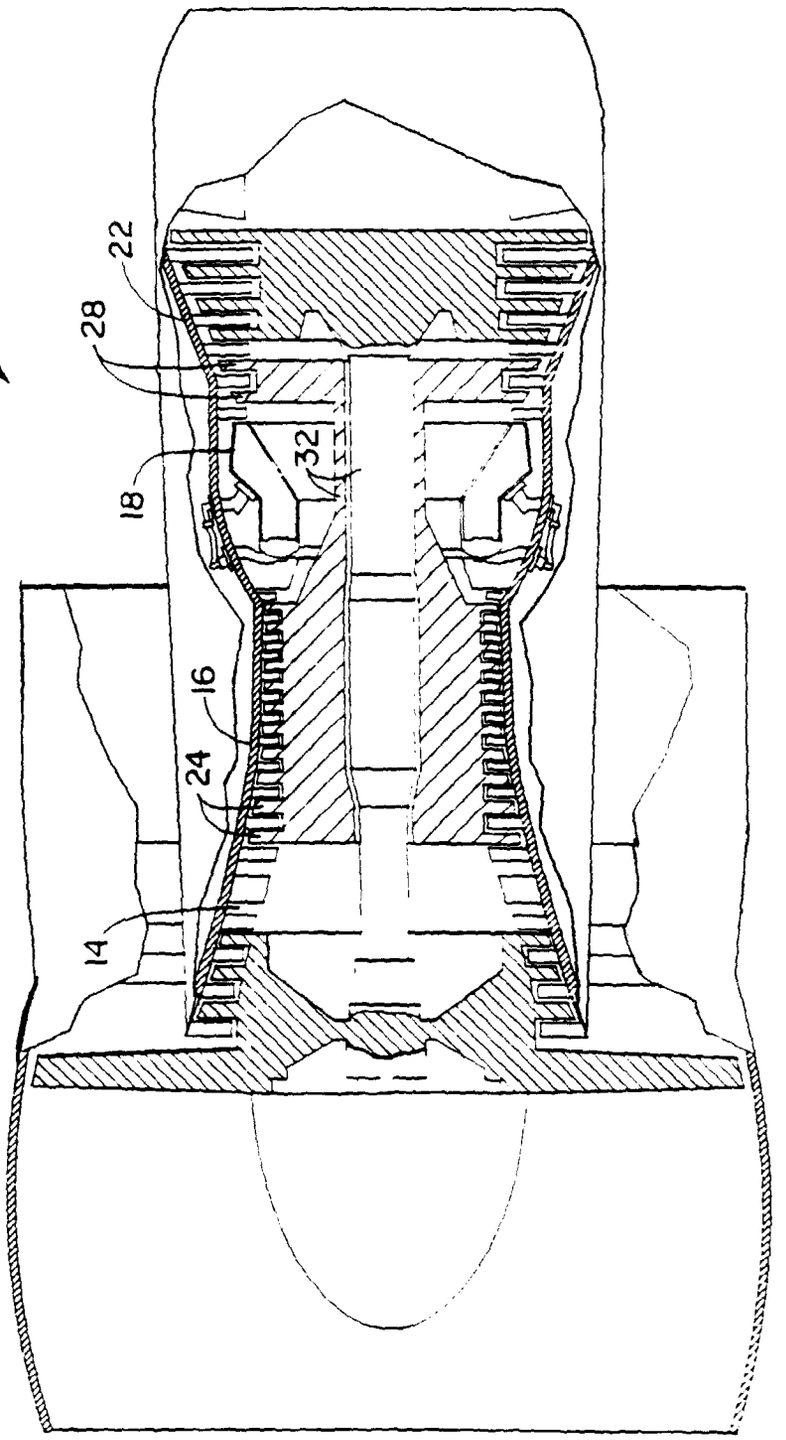
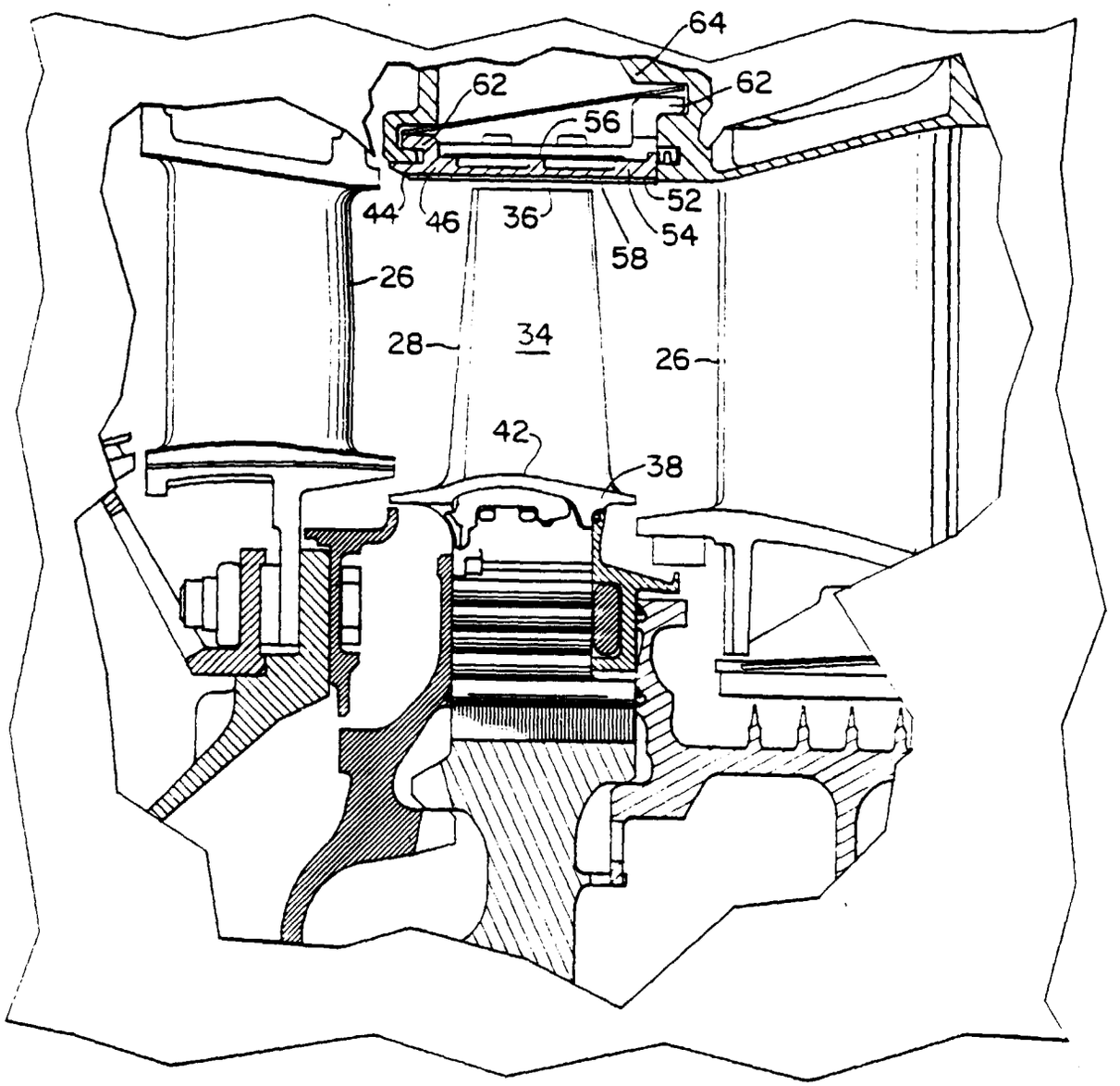


FIG. 1

FIG. 2



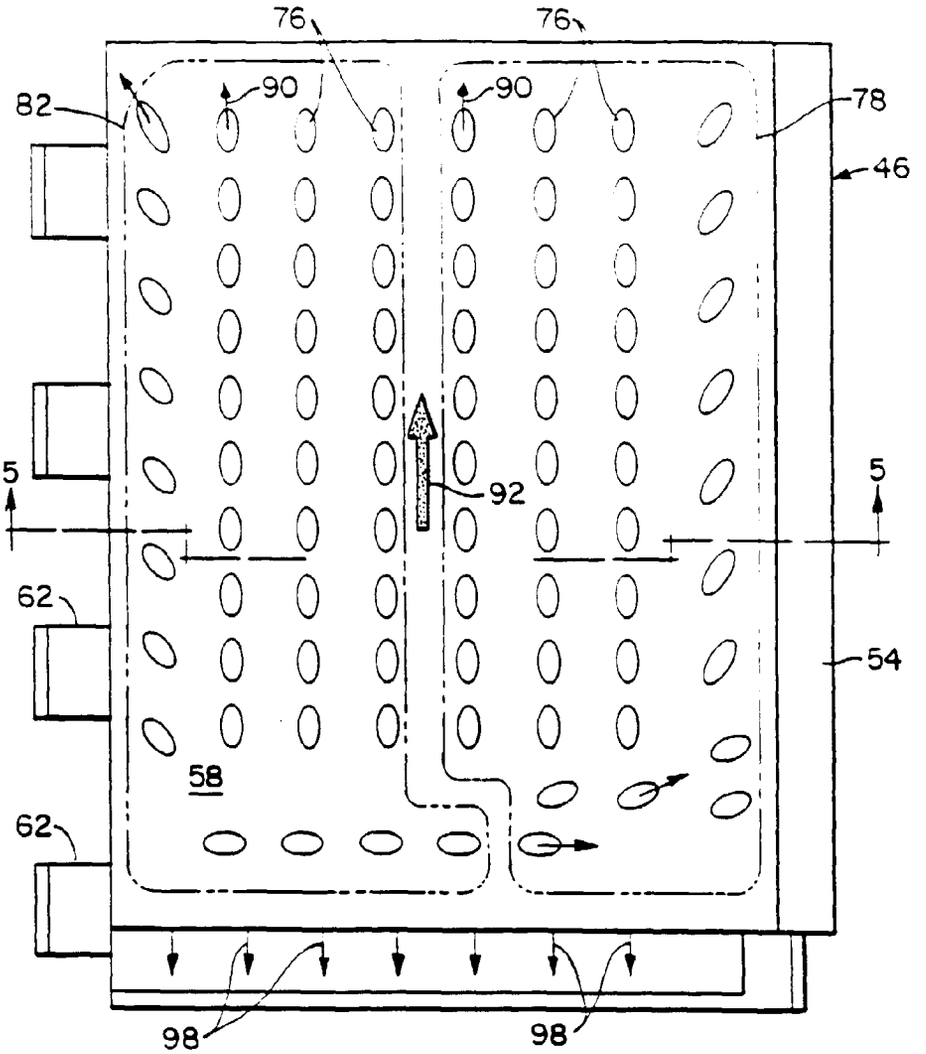

76
76
82
90
90
78
46
5
92
5
62
54
58
62
98
98

FIG. 3

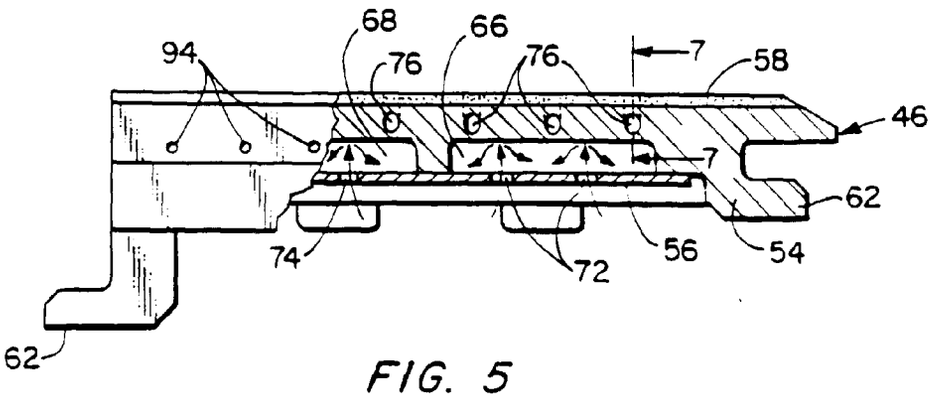

68
66
94
76
76
7
58
46
7
62
74
72
56
54
62

FIG. 5

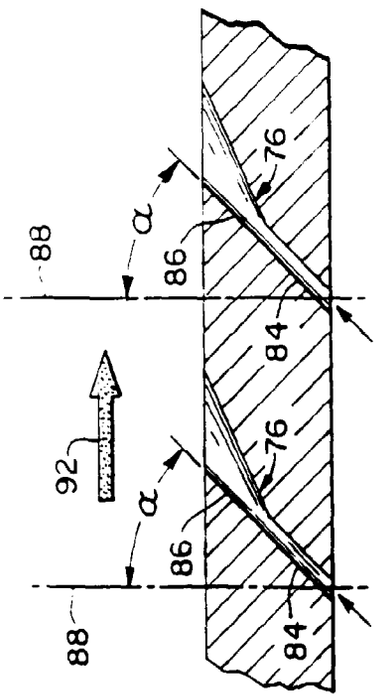


FIG. 7a

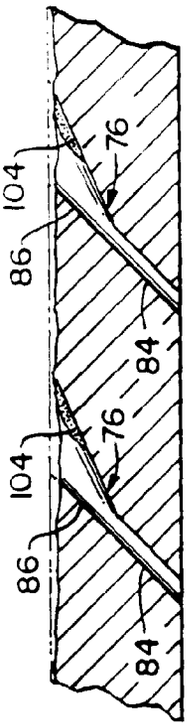


FIG. 7b

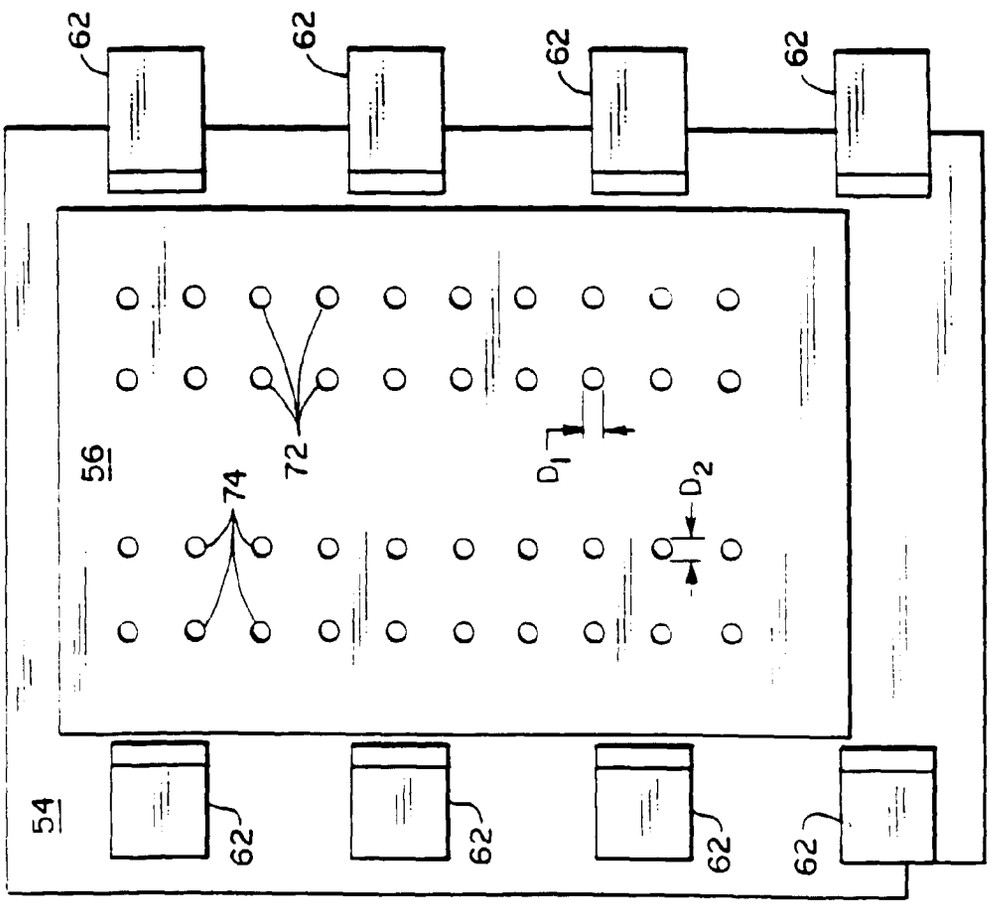


FIG. 4

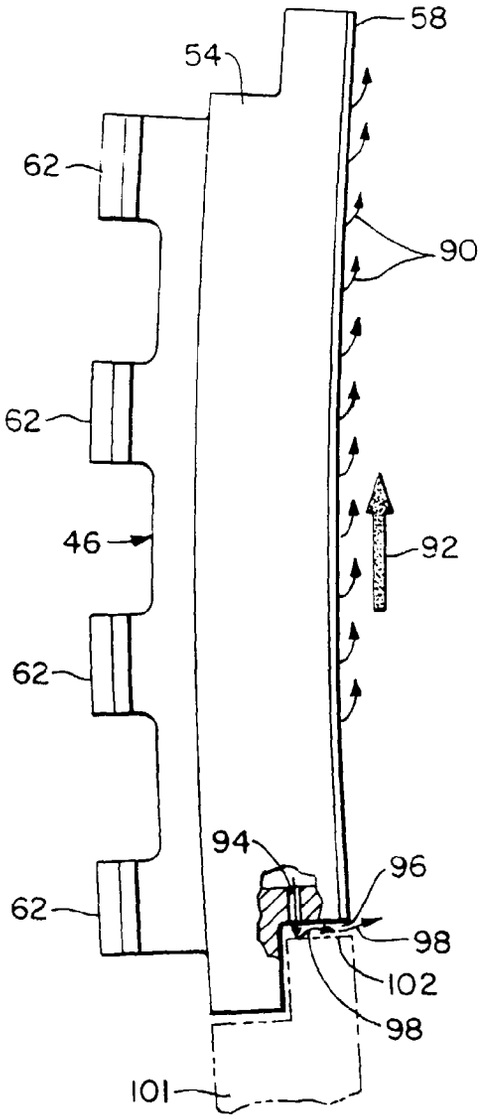

58
54
62
90
62
46
92
62
94
96
62
98
102
98
101

FIG. 6

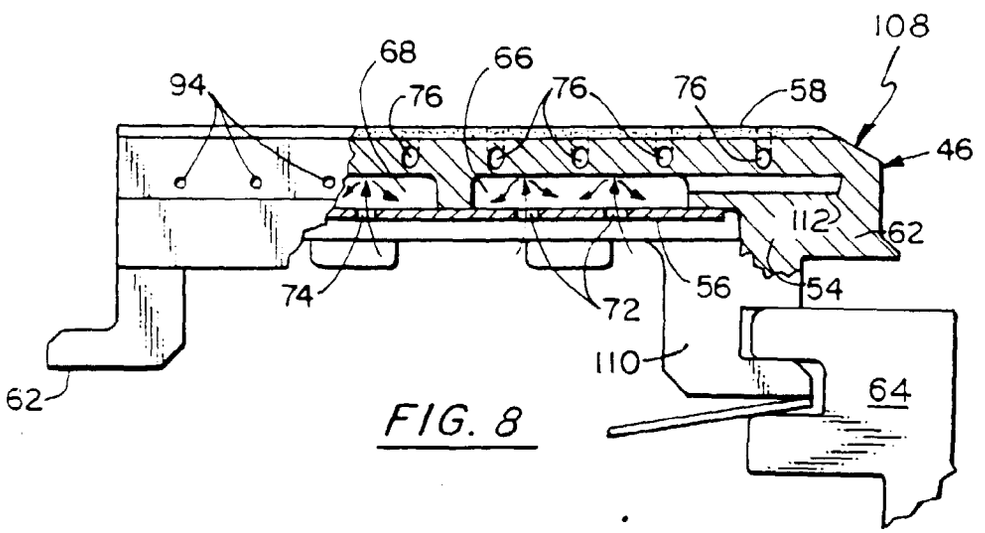

108
68
66
94
76
76
76
58
46
112
62
74
72
56
54
110
64
62

FIG. 8