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(54) **GAS TURBINE NOZZLE VANE INSERT AND METHODS OF INSTALLATION**

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(76) **Inventors: William John Miller, Simpsonville, SC (US); Daniel Ross Predmore, Clifton Park, NY (US); James Michael Placko, West Chester, OH (US)**

(57) **ABSTRACT**

Correspondence Address:  
**Richard G. Besh**  
**Nixon & Vanderhye P.C.**  
**1100 North Glebe Road, 8th Floor**  
**Arlington, VA 22201-4714 (US)**

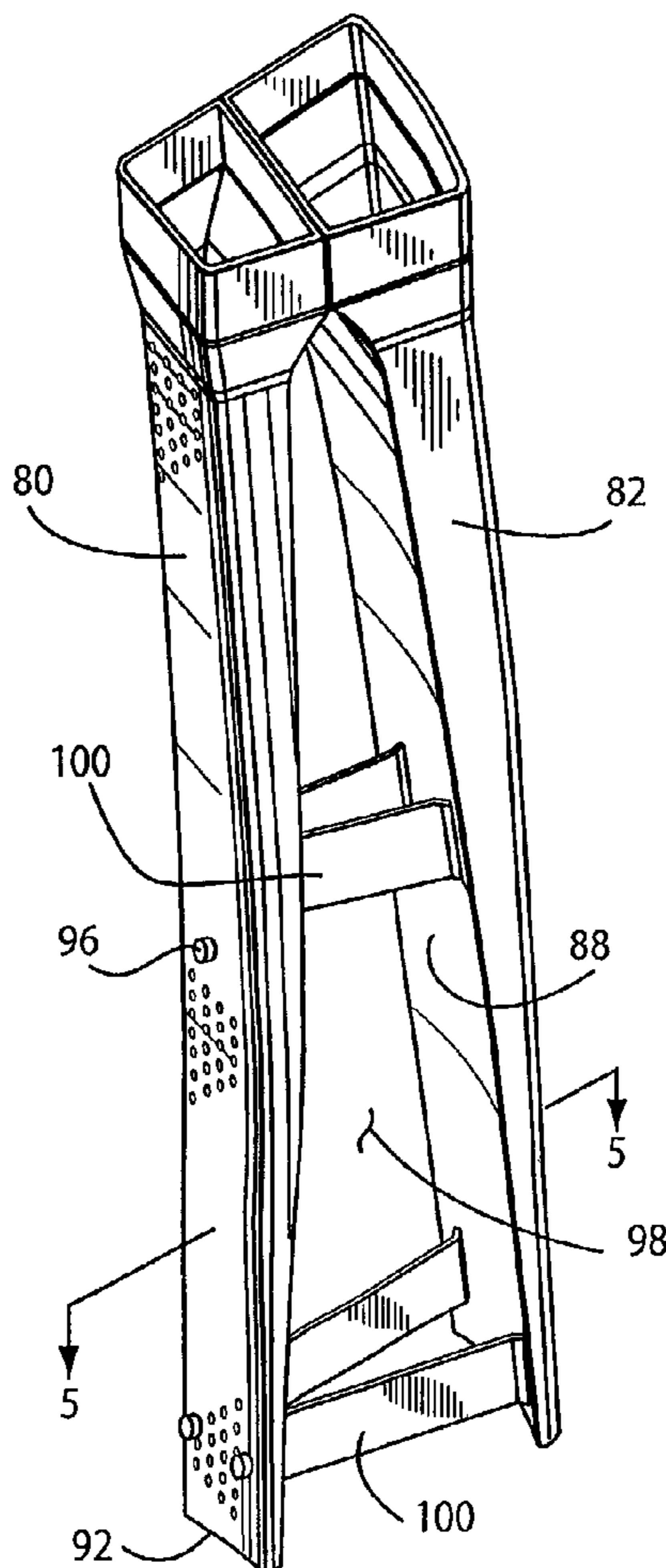
A pair of hollow elongated insert bodies are disposed in one or more of the nozzle vane cavities of a nozzle stage of a gas turbine. Each insert body has an outer wall portion with apertures for impingement-cooling of nozzle wall portions in registration with the outer wall portion. The insert bodies are installed into the cavity separately and spreaders flex the bodies toward and to engage standoffs against wall portions of the nozzle whereby the designed impingement gap between the outer wall portions of the insert bodies and the nozzle wall portions is achieved. The spreaders are secured to the inner wall portions of the insert bodies and the bodies are secured to one another and to the nozzle vane by welding or brazing.

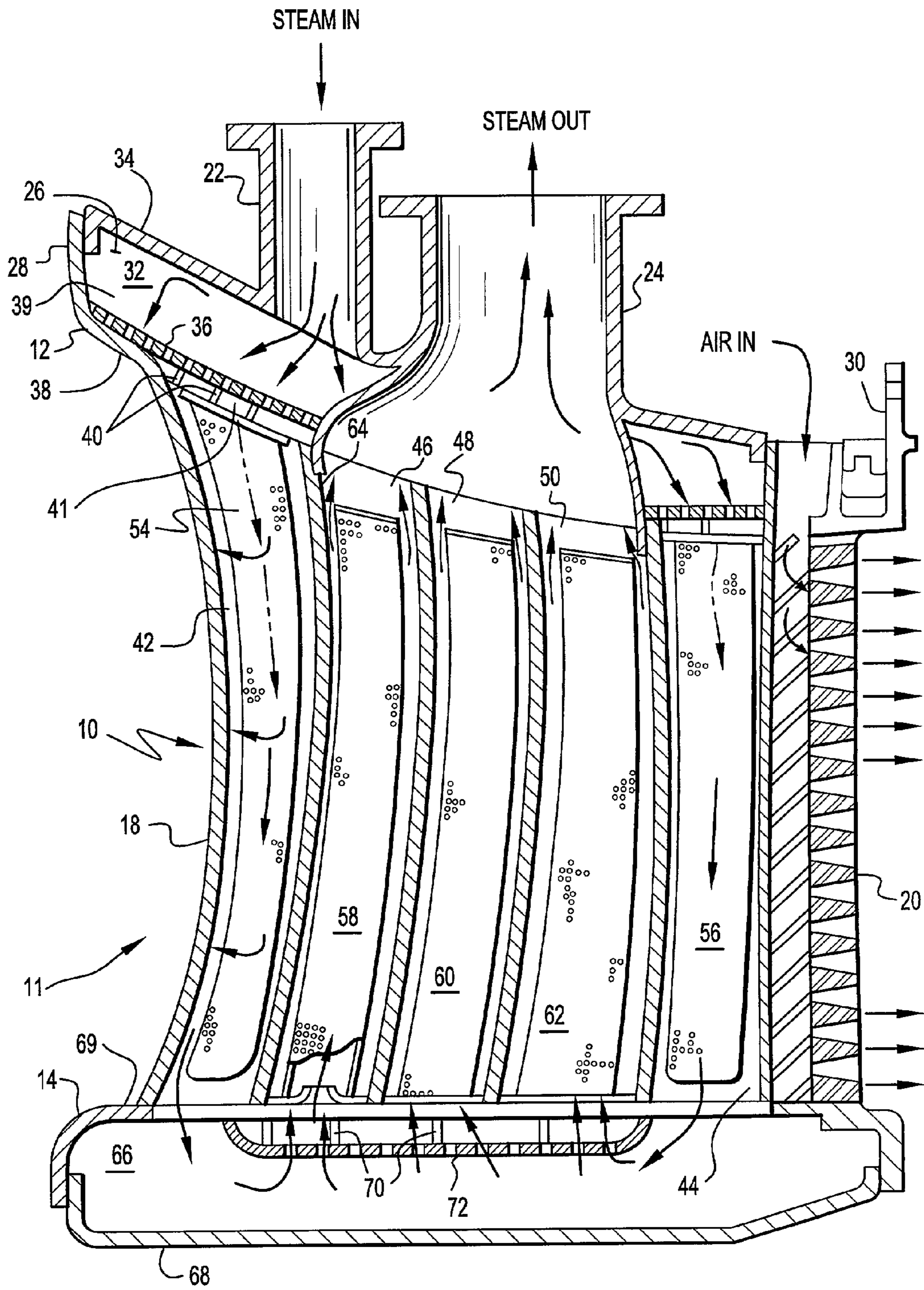
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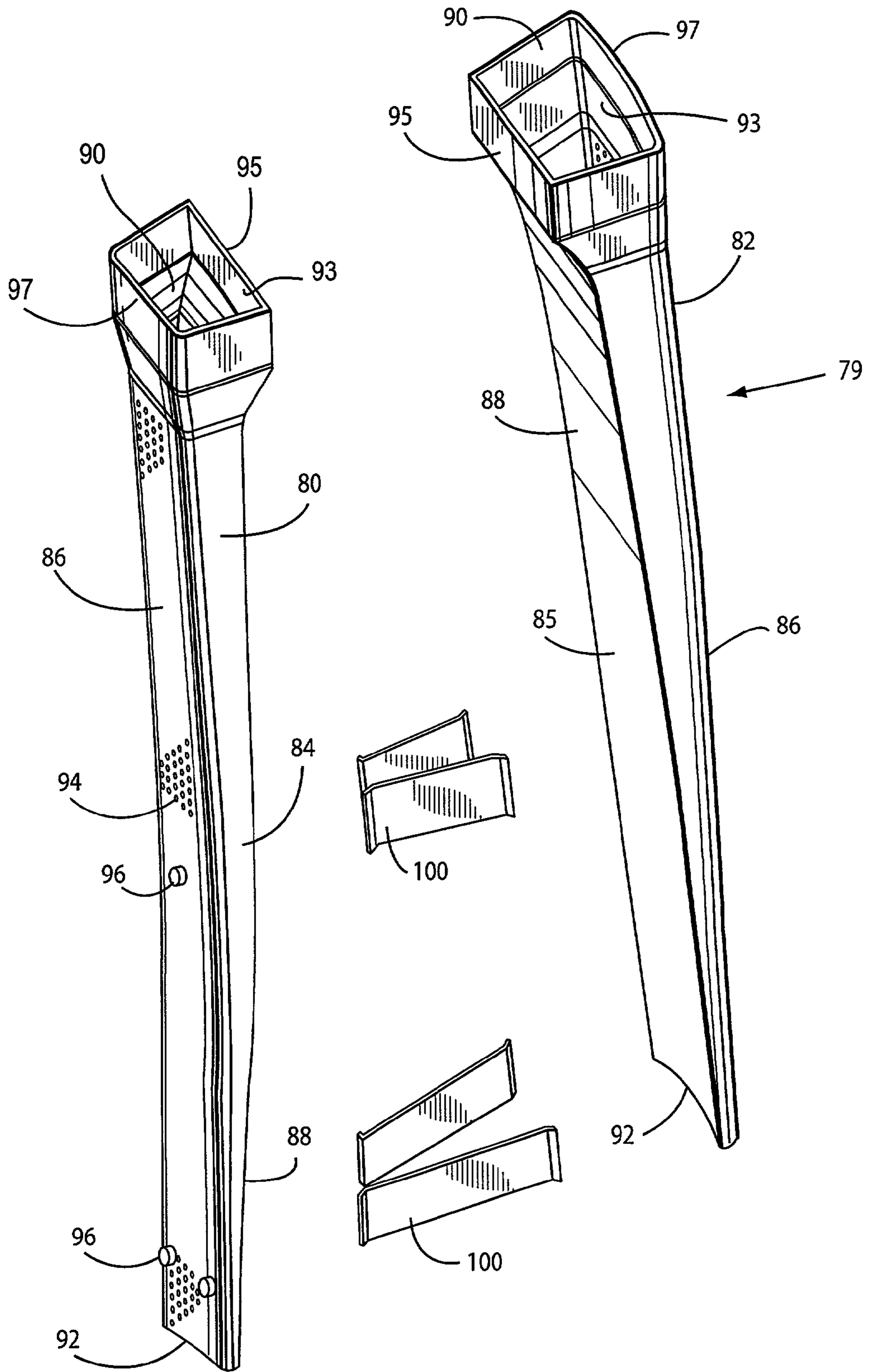
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**Fig. 1** (PRIOR ART)

**Fig. 2**



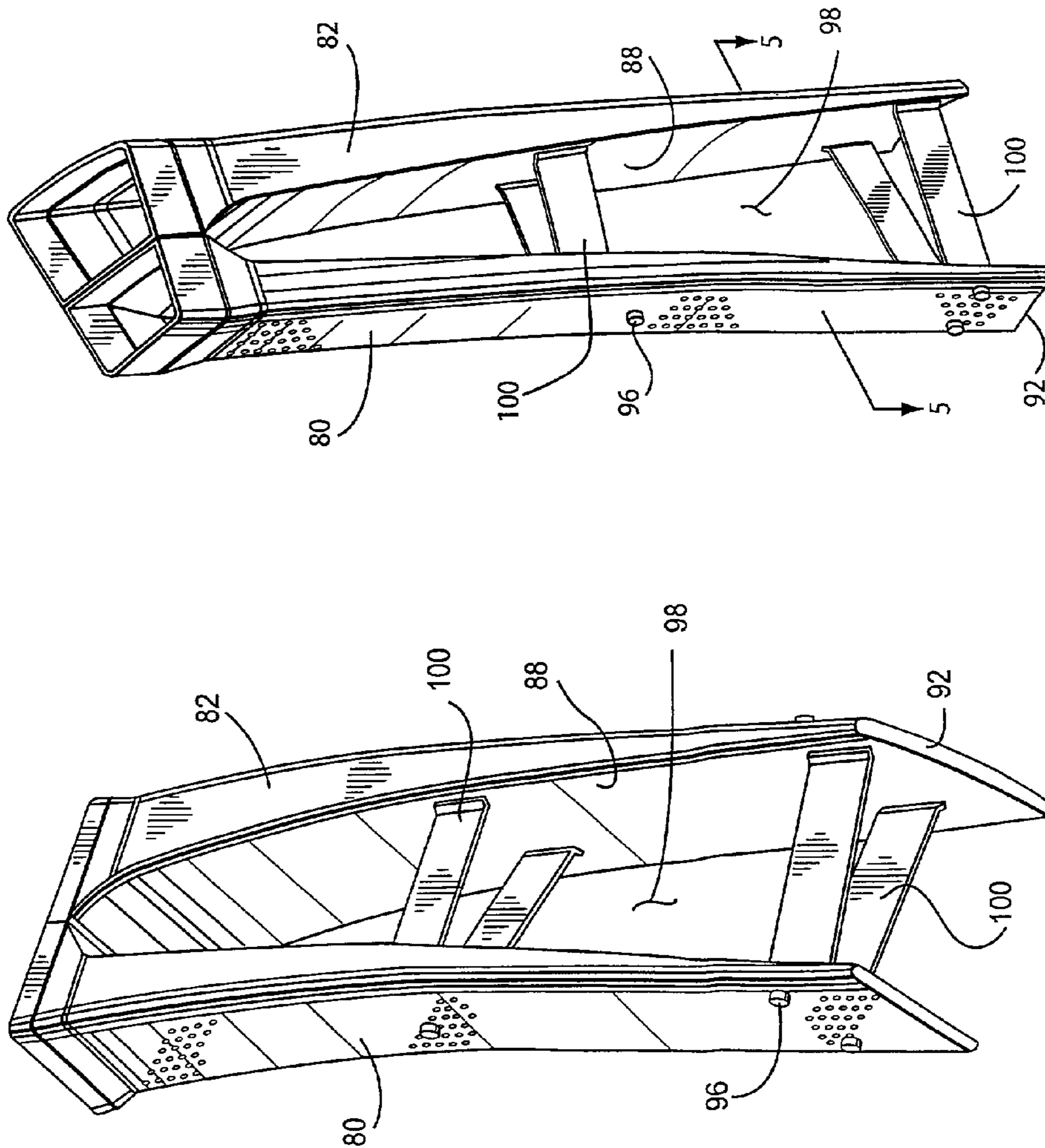
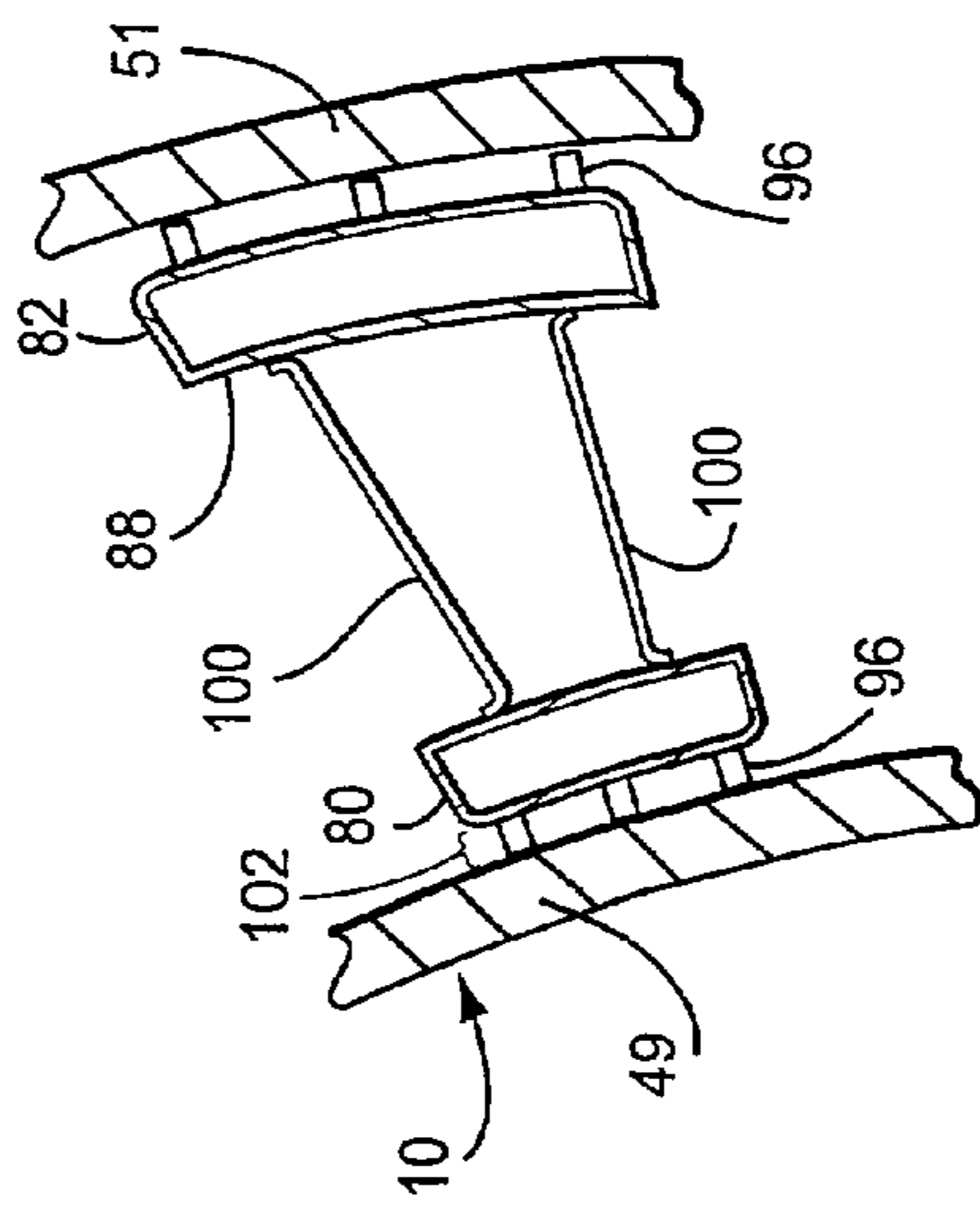


Fig. 4

Fig. 3

Fig. 5



## GAS TURBINE NOZZLE VANE INSERT AND METHODS OF INSTALLATION

[0001] This invention was made with Government support under Contract No. DE-FC21-95MC31176 awarded by the Department of Energy. The Government has certain rights in this invention.

### BACKGROUND OF THE INVENTION

[0002] The present invention relates to a gas turbine having a closed-circuit cooling system for one or more nozzle stages and particularly relates to a gas turbine having inserts for impingement-cooling of the nozzle vane walls and which inserts are sectional to facilitate installation into the nozzle vane cavities, with determinant impingement-cooling gaps between the inserts and the nozzle vane walls.

[0003] In advanced gas turbines, nozzle stages are often provided with a closed-circuit cooling system for cooling the nozzle vanes exposed to the hot gas path. For example, each nozzle vane may include a plurality of cavities extending between the outer and inner nozzle bands. Impingement-cooling inserts are provided in one or more cavities and a cooling medium such as steam is passed into the insert for flow through openings or apertures in the side walls of the insert for impingement-cooling the adjacent wall portions of the nozzle vane. An example of a closed-circuit steam-cooled nozzle for a gas turbine is disclosed in U.S. Pat. No. 5,743,708, of common assignee herewith, the disclosure of which is incorporated herein by reference.

[0004] Typically, the nozzle insert is a unitary body provided by an insert supplier and nominally sized for reception within the cavity of the nozzle vane. It will be appreciated that the insert is inserted into the vane cavity and provides an impingement gap between the interior wall of the nozzle and the wall of the insert. However, because of manufacturing tolerances involved, with the nozzle cavity and the insert per se, as well as a need to be able to dispose the insert endwise into the nozzle cavity, variations from the designed impingement gap along the length of the insert and nozzle vane wall frequently occur. A variation in the impingement gap can, in turn, cause a significant change in the heat transfer between the nozzle vane walls and the cooling medium. For example, it has been found that a 0.010 inch variation in the gap from a nominal dimension can result in an approximate 13% reduction in heat transfer coefficient. Also, this percentage increases exponentially with further impingement gap variation. Further, installation of a unitary insert into the nozzle vane cavity is somewhat difficult, oftentimes requiring a custom fit, which requires hand bench standoffs individually formed and hence is increasingly costly. There is also a potential for low-cycle fatigue as a result of the variation in heat transfer coefficient caused by the varying impingement gap.

### BRIEF SUMMARY OF THE INVENTION

[0005] In accordance with a preferred embodiment of the present invention, there is provided apparatus and methods for facilitating the disposition of an insert in a nozzle vane cavity to achieve a designed impingement gap between the internal wall of the nozzle and the wall of the insert, minimize or eliminate potential low-cycle fatigue problems and facilitate installation. To accomplish this, an insert comprised of two elongated hollow insert bodies is provided

for installation separately within the nozzle cavity. Each insert body includes a hollow sleeve open at one end for receiving a cooling medium and closed at its opposite end. Each insert body also includes an outer wall portion having apertures through which an impingement cooling medium flows to impingement-cool registering wall portions of the nozzle, the remaining walls of the insert body being closed and without apertures. The insert bodies are configured for side-by-side disposition within the nozzle vane cavity with the walls containing the apertures in registration with the opposed wall portions of the nozzle vane. Inner wall portions of the bodies, when installed in the vane cavity, are spaced one from the other. The open ends of the bodies are also configured for securement of the bodies to one another in situ, i.e., within the nozzle vane cavity after installation. Standoffs are provided on each of the insert body walls containing the apertures. One or more spreaders are provided between the inner walls of the insert bodies to flex the bodies outwardly to engage the standoffs against the wall surfaces of the nozzle vane.

[0006] To install the insert bodies, the bodies are inserted into the nozzle vane cavity separately, thereby eliminating manufacturing tolerance stackup. After insertion, one or more spreaders are installed and joined to the insert bodies to engage the standoffs against the internal nozzle cavity walls, thus positively determining the designed impingement gap. The open inlet ends of the inserts can then be secured to one another and to the nozzle. By employing this configuration and installation procedure, the designed impingement gap is provided between the side wall portions of the insert bodies and the nozzle vane walls throughout the length of the vane. By installing the insert to the correct impingement gap, heat transfer is significantly improved with corresponding benefit to improved low-cycle fatigue life.

[0007] In a preferred embodiment according to the present invention, there is provided an insert for a cavity of a nozzle vane of a gas turbine for impingement-cooling of the walls of the vane, comprising a pair of elongated hollow insert bodies disposable in side-by-side relation to one another within the cavity, the bodies having a plurality of apertures through oppositely directed outer walls thereof, inner wall portions of the bodies being spaced from one another and at least one spreader disposable between the inner wall portions for maintaining the inner wall portions of the insert bodies spaced from one another.

[0008] In a further preferred embodiment according to the present invention, there is provided a nozzle for a gas turbine, comprising a nozzle vane having a plurality of cavities extending between outer and inner ends of the body and spaced from one another between leading and trailing edges of the vane, an insert in one of the cavities including a pair of elongated, hollow insert bodies in side-by-side relation to one another for receiving a cooling medium, each body having a plurality of apertures through oppositely directed outer walls thereof for flowing the cooling medium to impingement-cool registering side wall portions of the vane, the bodies having respective inner wall portions spaced from one another and at least one spreader disposed between the inner wall portions to maintain the inner wall portions spaced from one another.

[0009] In a still further preferred embodiment according to the present invention, there is provided a method of install-

ing a cooling medium insert into a cavity of a nozzle vane for a gas turbine wherein the insert includes a pair of discrete elongated hollow insert bodies, each having an outer wall portion with a plurality of apertures therethrough, comprising the steps of inserting the discrete insert bodies into the vane cavity for disposition therein in side-by-side relation to one another, with the outer wall portions thereof in registration with side wall portions of the vane and inserting a spreader between spaced inner wall portions of the insert bodies to maintain the outer wall portions of the bodies spaced a predetermined distance from the side wall portions of the vane.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is an enlarged cross-section of a first-stage nozzle vane as in the prior art;

[0011] FIG. 2 is an exploded perspective view of a pair of insert bodies and spreaders constructed in accordance with the present invention and prior to installation into a nozzle vane cavity;

[0012] FIG. 3 is a perspective view of the insert hereof as it would appear within the nozzle vane cavity;

[0013] FIG. 4 is a perspective view similar to FIG. 3; and

[0014] FIG. 5 is a cross-sectional view of the insert bodies and spreader taken generally about on line 5-5 in FIG. 4.

#### DETAILED DESCRIPTION OF THE INVENTION

[0015] As discussed previously, the present invention relates to closed cooling circuits for nozzle stages of a turbine, preferably a first-stage nozzle. Reference is made to the previously identified patent for disclosure of various other aspects of a turbine, its construction and methods of operation. Referring now to FIG. 1, there is schematically illustrated in cross-section a vane 10 comprising one of a plurality of circumferentially spaced vanes, each vane forming part of an arcuate segment 11 of a first-stage nozzle for a gas turbine. It will be appreciated that the segments 11 are connected one to the other to form an annular array of segments defining the hot gas path through the first-stage nozzle of the turbine. Each segment includes radially spaced outer and inner bands 12 and 14, respectively, with one or more of the nozzle vanes 10 extending between the outer and inner bands. The segments are supported about the inner shell of the turbine (not shown) with adjoining segments being sealed one to the other. For purposes of this description, the vane 10 will be described as forming the sole vane of a segment, it being appreciated that each segment 11 may have two or more vanes. As illustrated, the vane 10 has a leading edge 18 and a trailing edge 20.

[0016] The prior art cooling circuit for the illustrated first-stage nozzle vane segment of FIG. 1 has a cooling steam inlet 22 to the outer band 12. A return steam outlet 24 also lies in communication with the outer band of the nozzle segment. The outer band 12 includes an outer side railing 26, a leading railing 28, and a trailing railing 30 defining a plenum 32 with an upper cover 34 and an impingement plate 36 disposed in the outer band 12. (The terms outwardly and inwardly or outer and inner refer to a generally radial direction). Disposed between the impingement plate 36 and the inner wall 38 of outer band 12 are a plurality of structural

ribs 40 extending between the side walls 26, forward wall 28 and trailing wall 30. The impingement plate 36 overlies the ribs 40 throughout the full extent of the plenum 32. Consequently, steam entering through inlet 22 into plenum 32 passes through the openings in the impingement plate 36 for impingement cooling of the outer wall 38 of the outer band 12, the outer band thus having first and second chambers 39 and 41 on opposite sides of the impingement plate.

[0017] The first-stage nozzle vane 10 also has a plurality of cavities, for example, the leading edge cavity 42, an aft cavity 44, three intermediate return cavities 46, 48 and 50, and a trailing edge cavity 52. These cavities are defined by transversely extending ribs extending between opposite side walls 49 and 52 (FIG. 5) of the vane. One or more additional or fewer cavities may be provided.

[0018] Leading edge cavity 42 and aft cavity 44 each have an insert, 54 and 56 respectively, while each of the intermediate cavities 46, 48 and 50 have similar inserts 58, 60 and 62, respectively, all such inserts being in the general form of hollow sleeves. The inserts may be shaped to correspond to the shape of the particular cavity in which the insert is to be provided. The side walls of the sleeves are provided with a plurality of impingement cooling apertures, along portions of the insert which lie in opposition to the walls of the vane to be impingement cooled. For example, in the leading edge cavity 42, the forward edge of the insert 54 is arcuate and the side walls would generally correspond in shape to the side walls of the cavity 42, all such walls of the insert having impingement apertures. The back side of the sleeve or insert 54 in opposition to the rib 64 separating cavity 42 from cavity 46, however, does not have impingement apertures. In the aft cavity 44, on the other hand, the side walls, only, of the insert sleeve 56 have impingement apertures; the forward and aft walls of insert sleeve 56 being of a solid non-perforated material.

[0019] It will be appreciated that the inserts received in cavities 42, 44, 46, 48, and 50 are spaced from the walls of the cavities to enable a cooling medium, e.g., steam, to flow through the impingement apertures to impact against the interior wall surfaces of the nozzle vane, thus cooling those wall surfaces. As apparent from the ensuing description, inserts 54 and 56 are closed at their radially inner ends and open at their radially outer ends. Conversely, inserts 58, 60 and 62 are closed at their radially outer ends and open at their radially inner ends.

[0020] As illustrated in FIG. 1, the post-impingement cooling medium, e.g., steam cooling the outer wall 38 flows into the open radially outer ends of inserts 54 and 56 for impingement-cooling of the vane walls in registration with the impingement apertures in the inserts along the length of the vane. The spent impingement steam then flows into a plenum 66 in the inner band 14 which is closed by an inner cover plate 68. Structural strengthening ribs 70 are integrally cast with the inner wall 69 of band 14. Radially inwardly of the ribs 70 is an impingement plate 72. As a consequence, it will be appreciated that the spent impingement cooling steam flowing from cavities 42 and 44 flows into the plenum 66 and through the impingement apertures of impingement plate 72 for impingement cooling of the inner wall 69. The spent cooling steam flows by direction of the ribs 70 towards openings in ribs 70 (not shown in detail) for return flow to the steam outlet 24. Particularly, inserts 58, 60 and 62 are

disposed in the cavities **46**, **48**, and **50** in spaced relation from the side walls and ribs defining the respective cavities. The impingement apertures of inserts **58**, **60** and **62** lie along the opposite sides thereof in registration with the vane walls. Thus, the spent cooling steam flows through the open inner ends of the inserts **58**, **60** and **62** and through the impingement apertures for impingement cooling the adjacent side walls of the vane. The spent cooling steam then flows out the outlet **24** for return, e.g., to the steam supply, not shown.

[0021] The air cooling circuit of the trailing edge cavity of the combined steam and air cooling circuits of the vane illustrated in **FIG. 1** generally corresponds to the cooling circuit disclosed in the above-identified patent. Therefore, a detailed discussion thereof is omitted.

[0022] As noted previously, the inserts in the cavities define an impingement gap between the apertured walls of the insert and the adjacent nozzle wall portions which can vary significantly from a designed gap resulting in variations of heat transfer and lower life-cycle fatigue. Those problems are caused by stackup of manufacturing tolerances, difficulty in installation of the inserts and the resulting variation from the designed impingement gap. In accordance with the present invention, there is provided an insert, generally designated **79** and illustrated in **FIG. 2**, comprised of a pair of discrete insert bodies **80** and **82**. Insert bodies **80** and **82** comprise respective hollow elongated sleeves **84** and **85**, each having an outer side wall **86** and an inner wall **88**. Each body **80** and **82** has an open end **90** of generally rectilinear configuration. The outer side wall **86** and inner wall portion **88** of each insert body generally converge toward one another from the open end **90** to the closed opposite end **92**. The outer side wall **86** of each insert body **80** and **82** has a plurality of apertures **94** for passing a cooling medium received within the body through opening **90** toward the registering side wall portions of the nozzle vane when the insert is disposed in the nozzle. Additionally, end portions **93** of bodies **80** and **82** have inner wall portions **95** adjacent the open ends of the insert bodies are configured to abut one another whereby the bodies can be joined one to the other after installation into the nozzle cavity by a welding or brazing operation. The outer edges **97** about the open ends **90** of the bodies are also configured for securement to the nozzle per se after installation, also by a welding or brazing operation. Standoffs **96** are provided at various locations along the outer wall **86** of each body **80** and **82**. The standoffs **96** comprise projections which project from the outer wall surface for engagement with the interior wall surface of the nozzle wall when installed.

[0023] The inner wall portion **88** of each body **80**, **82** is tapered from its open end **90** toward the outer wall **86** and toward the opposite end **92** of each body. Consequently, a gap **98** (**FIG. 3**) is provided between the insert bodies upon installation within the nozzle cavity. Spreaders **100** are provided upon installation for maintaining the standoffs **96** engaged against the inner wall surfaces of the nozzle vane wall. It will be appreciated that one or more spreaders **100** may be provided at longitudinal positions along the length of the insert bodies **80** and **82**. From a review of **FIG. 5**, it will be appreciated that the insert bodies **80** and **82** are not identical to one another. Thus, as illustrated, insert body **80** is narrower in a chordal direction than insert body **82** in accordance with their disposition adjacent the concave and convex sides, respectively, of the vane.

[0024] To install the insert into a cavity, each insert body **80** and **82** is inserted separately into the cavity with the open ends **90** of the bodies aligned with one another and with the nozzle wall to which the bodies will be secured. After insertion of each body, one or more spreaders **100** are disposed between the inner wall portions **88** of the bodies. The bodies are thus flexed outwardly away from one another to engage the standoffs **96** against the inner wall surfaces of the nozzle vane. Once correctly positioned, the spreaders **100** can be secured to the inner walls **88**, for example, by welding or brazing. The open end **90** of each insert body **80** and **82** is then secured to one another and to the surrounding nozzle wall by brazing or welding. As a consequence of this installation procedure, the designed impingement gap **102** (**FIG. 5**) between the outer wall **86** of each insert body and the opposing wall surface of the nozzle vane is obtained. It will be appreciated that the insert bodies are inserted into a vane cavity through openings in the inner or outer band depending upon the direction of the flow of the cooling medium within the cavity, the open end **90** being at the cooling medium inlet end of the cavity.

[0025] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. An insert for a cavity of a nozzle vane of a gas turbine for impingement-cooling of the walls of the vane, comprising:

a pair of elongated hollow insert bodies disposable in side-by-side relation to one another within the cavity, said bodies having a plurality of apertures through oppositely directed outer walls thereof, inner wall portions of the bodies being spaced from one another; and

at least one spreader disposable between said inner wall portions for maintaining said inner wall portions of said insert bodies spaced from one another.

2. An insert according to claim 1 including standoffs spaced from one another along said outer walls of said bodies and extending outwardly from said outer walls for engagement with the walls of said vane.

3. An insert according to claim 1 including a plurality of spreaders extending between inner wall portions of said bodies and at spaced locations along the lengths of said bodies.

4. An insert according to claim 1 wherein end portions of said bodies have inner wall surfaces for engagement with one another to facilitate securement of said bodies to one another.

5. An insert according to claim 1 wherein each of said bodies has an open end for receiving a cooling medium for flow therethrough and through said apertures along said outer walls for impingement-cooling nozzle walls in registration with the apertures.

6. An insert according to claim 5 wherein ends of each of said bodies opposite said open ends thereof are closed.

7. An insert according to claim 1 wherein end portions of said bodies have inner wall surfaces for engagement with one another to facilitate securement of said bodies to one

another, said inner wall surfaces lying adjacent common end portions of said bodies, said bodies extending from said end portions and being cantilevered therefrom.

**8.** A nozzle for a gas turbine, comprising:

a nozzle vane having a plurality of cavities extending between outer and inner ends of said body and spaced from one another between leading and trailing edges of said vane;

an insert in one of said cavities including a pair of elongated, hollow insert bodies in side-by-side relation to one another for receiving a cooling medium, each said body having a plurality of apertures through oppositely directed outer walls thereof for flowing the cooling medium to impingement-cool registering side wall portions of the vane;

said bodies having respective inner wall portions spaced from one another and at least one spreader disposed between said inner wall portions to maintain said inner wall portions spaced from one another.

**9.** A nozzle vane according to claim 8 wherein each insert body includes at least one standoff extending outwardly from said outer wall thereof for engagement with an opposed side wall portion of said vane.

**10.** An insert according to claim 8 including a plurality of spreaders extending between said bodies and at spaced locations along the lengths of said bodies.

**11.** A nozzle vane according to claim 8 wherein said bodies are secured to one another and to said nozzle vane body.

**12.** A nozzle vane according to claim 8 wherein each of said bodies has an open end for receiving a cooling medium for flow therethrough and through said apertures along said outer walls for impingement-cooling said side wall portions of the vane, end portions of each of said bodies opposite said open ends thereof being closed.

**13.** A nozzle vane according to claim 8 wherein each insert body includes at least one standoff extending out-

wardly from said outer wall thereof for engagement with an opposed side wall portion of said vane, and a plurality of spreaders extending between said bodies and at spaced locations along the lengths of said bodies, said spreaders maintaining said standoffs in engagement with the side wall portions of said vane to maintain a predetermined gap between said outer walls of said insert bodies and said side wall portions of said vane.

**14.** A method of installing a cooling medium insert into a cavity of a nozzle vane for a gas turbine wherein the insert includes a pair of discrete elongated hollow insert bodies, each having an outer wall portion with a plurality of apertures therethrough, comprising the steps of:

inserting the discrete insert bodies into the vane cavity for disposition therein in side-by-side relation to one another, with the outer wall portions thereof in registration with side wall portions of said vane; and

inserting a spreader between spaced inner wall portions of said insert bodies to maintain the outer wall portions of said bodies spaced a predetermined distance from said side wall portions of said vane.

**15.** A method according to claim 14 wherein said insert bodies include standoffs, including the step of flexing said bodies in response to insertion of said spreader between said bodies to engage the standoffs with the side wall portions of the vane.

**16.** A method according to claim 14 wherein each of the bodies has an open end for receiving a cooling medium and including the step of securing the bodies to one another adjacent said open ends thereof.

**17.** A method according to claim 14 wherein each of the bodies has an open end for receiving a cooling medium and including the step of securing the bodies to said nozzle vane.

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