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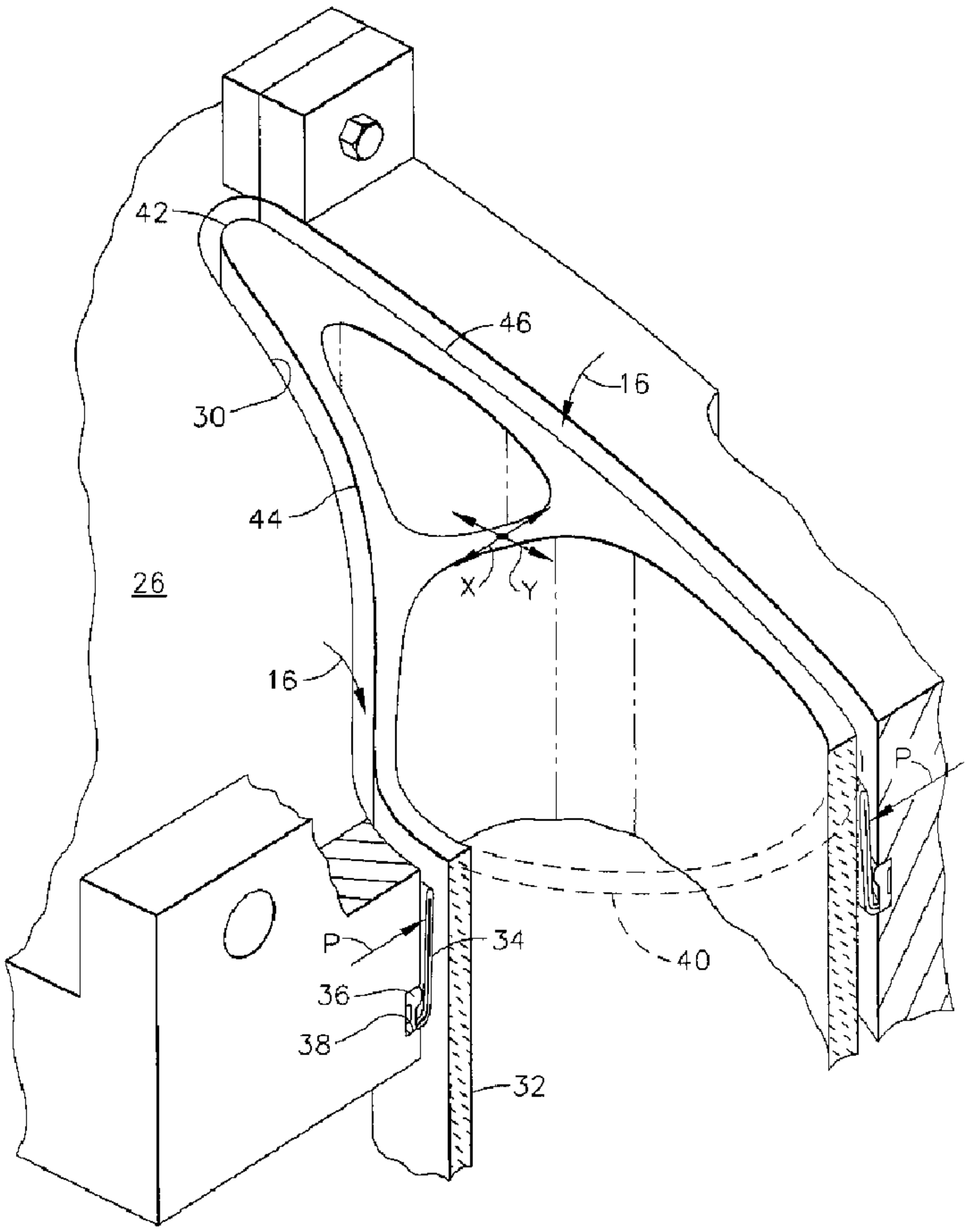
(54) **Titre :** JOINT DE BRIDE DE VANNE A REGISTRE DE TURBINE
(54) **Title:** TURBINE VANE COLLAR SEAL



(57) **Abrégé/Abstract:**

A collar seal (34) is configured for a turbine nozzle vane (32). The seal (34) includes a retainer (36) having a circumferential airfoil contour conforming with the airfoil contour of the vane (32). A flexible leaf (48) is surrounded by the retainer (36) and fixedly joined

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(57) Abrégé(suite)/Abstract(continued):
thereto. A woven sheath (50) encases the leaf (48) and is fixedly joined to the retainer (36). In an exemplary embodiment, the collar seal (34) surrounds one end of a ceramic turbine vane (32) mounted in a metal supporting band (26),(28).

TURBINE VANE COLLAR SEAL

ABSTRACT OF THE DISCLOSURE

A collar seal (34) is configured for a turbine nozzle vane (32). The seal (34) includes a retainer (36) having a circumferential airfoil contour conforming with the airfoil contour of the vane (32). A flexible leaf (48) is surrounded by the retainer (36) and fixedly joined thereto. A woven sheath (50) encases the leaf (48) and is fixedly joined to the retainer (36). In an exemplary embodiment, the collar seal (34) surrounds one end of a ceramic turbine vane (32) mounted in a metal supporting band (26),(28).

TURBINE VANE COLLAR SEAL

BACKGROUND OF THE INVENTION

The present invention relates generally to gas turbine engines, and, more specifically, to turbine nozzles therein.

In a gas turbine engine air is pressurized in a compressor and mixed with fuel in a combustor for generating hot combustion gases. A high pressure turbine (HPT) extracts energy from the hot gases to power the compressor. And, a low pressure turbine (LPT) extracts additional energy from the gases to power an upstream fan in an aircraft turbofan engine application, or to provide external power through a drive shaft for marine and industrial applications.

The HPT includes a first stage turbine nozzle disposed at the outlet of the combustor that first receives therefrom the hot combustion gases which are then directed by the nozzle vanes into a row of first stage turbine rotor blades extending outwardly from the perimeter of a rotor disk. The blades extract energy from the gases to rotate the disk, which in turn rotates the rotor blades of the compressor.

In order to withstand the hot combustion gases, the various components of the HPT are typically formed of superalloys which maintain their strength at elevated temperatures. Furthermore, the nozzle vanes and rotor blades are typically hollow and provided with cooling circuits therein through which is circulated a portion of the air pressurized by the compressor for cooling the vanes and blades during operation.

The prior art includes a myriad of cooling circuits and features specifically configured for the stator vanes of the nozzle and the rotor blades disposed downstream therefrom.

However, any air bled from the compressor for cooling the turbine components is not used during the combustion process and correspondingly reduces the efficiency of the engine. Engine efficiency is directly related to the temperature of the combustion gases generated during operation, with higher combustion gases being used for increasing efficiency of the engine.

Modern gas turbine engines exploit the strength of the superalloy metal vanes and blades and the internal cooling thereof for maximizing engine efficiency, while also obtaining a long useful life of the engine. However, further gains in engine efficiency are limited by the available superalloys and by the amount of cooling air which may be practically bled from the compressor.

Accordingly, current developments in further advancing the efficiency of gas turbine engines include the selective use of ceramic components which can withstand substantially greater temperatures of combustion gases than presently experienced by modern superalloy metals. One type of ceramic material for a gas turbine engine is ceramic matrix composite (CMC) in which silicon carbide fibers are embedded in a silicon carbide matrix for strength and durability.

However, ceramic materials lack ductility and require special mounting to prevent excessive stress therein which could lead to their brittle failure and correspondingly short useful life.

For example, ceramic materials in a gas turbine engine would necessarily be used in conjunction with conventional metal components of the same engine. The ceramic components may be preferentially utilized in the direct flowpath of the hot combustion gases and supported in metal components which do not experience the high heat loads from the combustion gases.

This presents a significant design problem since the ceramic materials have a relatively low coefficient of thermal expansion compared with metal components which expand and contract as temperatures increase and decrease during the various portions of the engine cycle.

In view of the substantial difference in coefficients of thermal expansion between the ceramic material and supporting metal components, substantial thermal stress can be generated in the ceramic material leading to the short life thereof.

Furthermore, the first stage turbine nozzle vanes are also subject to the aerodynamic or pressure loading from the hot combustion gases which must also be carried from the vanes into their supporting components.

Accordingly, it is desired to provide a turbine nozzle with ceramic vanes mounted in metal components which accommodate the different coefficients of thermal expansion therebetween.

BRIEF DESCRIPTION OF THE INVENTION

A collar seal is configured for a turbine nozzle vane. The seal includes a retainer having a circumferential airfoil contour conforming with the airfoil contour of the vane. A flexible leaf is surrounded by the retainer and fixedly joined thereto. A woven sheath encases the leaf and is fixedly joined to the retainer.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, in accordance with preferred and exemplary embodiments, together with further objects and advantages thereof, is more particularly described in the following detailed description taken in conjunction with the accompanying drawings in which:

Figure 1 is a partly sectional and schematic view of a exemplary first stage turbine nozzle in the core engine of a gas turbine engine.

Figure 2 is a planiform view of a portion of the turbine nozzle illustrated in Figure 1 and taken along line 2-2.

Figure 3 is a partly sectional isometric view of an exemplary one of the ceramic vanes illustrated in Figures 1 and 2 mounted in an outer metal band using a surrounding collar seal.

Figure 4 is an enlarged, partly sectional isometric view of a portion of the collar seal illustrated in Figure 3 mounted in a corresponding slot in the metal band.

Figure 5 is a partly sectional isometric view of the collar seal illustrated in Figures 2 and 3 in isolation from the corresponding end of the ceramic vanes mounted in the metal bands.

Figure 6 is a flowchart representation of the assembly of the various components of the collar seal illustrated in Figures 3-5, and their mounting into the corresponding metal band in an exemplary embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Illustrated schematically in Figure 1 is a portion of a gas turbine engine (10) which is axisymmetrical about a longitudinal or axial centerline axis (12). The engine includes a multistage axial compressor (14) configured for pressurizing ambient air (16).

An annular combustor (18) is disposed downstream from the compressor for receiving therefrom pressurized air which is mixed with fuel and ignited for generating hot combustion gases (20).

A high pressure turbine (HPT) follows the combustor and includes an annular first stage turbine nozzle (22) shown schematically in its position in the engine axisymmetrically around the centerline axis (12), as well as shown in part in isometric view. The HPT also includes a turbine rotor (24) having a row of turbine rotor blades extending radially outwardly from a supporting rotor disk, which in turn is joined by a shaft to the several stages of rotor blades of the compressor (14).

But for the turbine nozzle (22), the engine illustrated in Figure 1 may have any conventional configuration and operation in which energy is extracted from the hot combustion gases in the turbine rotor (24) for powering the compressor (14). This core engine may be used in various applications, including, for example, turbofan aircraft engines which would also include a low pressure turbine (LPT) downstream of the core engine for extracting additional energy from the combustion gases to power an upstream turbine fan (not shown). In marine and industrial applications, the LPT may be used to drive an external shaft for powering the drive system of a ship or an electrical generator, for example.

The turbine nozzle (22) illustrated in Figure 1 includes radially outer and inner bands (26),(28) each having a plurality of circumferentially spaced apart apertures (30) extending radially therethrough. The two bands have similar configurations for supporting the opposite radial ends of a corresponding row of hollow nozzle vanes (32).

Each of the vanes (32) is a discrete component and is preferably ceramic as compared to the supporting bands (26),(28) which are preferably metal. The ceramic vanes may be formed of the typical CMC material described above, whereas the bands may be formed of typical superalloys, such as cobalt-based metal alloys.

By utilizing ceramic vanes (32) in the first stage turbine nozzle (22), the temperature of the combustion gases (20) may be further increased in the engine for further increasing the overall efficiency of the engine. The ceramic vanes (32) have sufficient strength at such elevated temperatures for ensuring a suitable useful life during operation.

The vanes are preferably hollow with two simple radial flow channels extending between the opposite ends thereof through which a portion of pressurized compressor air (16) may be channeled during operation for internal cooling thereof. The compressor bleed air (16) may also be used for cooling the outer and inner bands (26),(28) in any convenient manner.

As indicated above, the coefficient of thermal expansion for the ceramic vanes (32) is significantly lower than the coefficient of thermal expansion for the metal bands (26),(28). Accordingly, in order to effectively mount the vanes (32) in the supporting bands (26),(28), the mounting apertures (30) have airfoil configurations matching those of the opposite ends of the vanes (32), and the ends of the vanes are mounted in those apertures using corresponding collar seals (34) which mount the vanes to the bands, as well as seal the vanes to the bands.

More specifically, the plurality of nozzle vanes (32) are initially formed as individual or discrete ceramic vanes. The outer and inner bands are configured as full annular rings when mounted in the engine, and are preferably formed in individual segments, such as one segment corresponding with each of the vanes. The band segments may be fixedly joined together using suitable mounting flanges and bolt fasteners extending therethrough in the exemplary manner illustrated in Figures 1 and 2.

As initially illustrated in Figure 3, each of the collar seals (34) is fixedly joined at a proximal end to each of the bands in respective ones of the apertures (30). The opposite tip or distal ends of the seals surround corresponding vane ends in both sealing engagement therewith, as well as a structural mount therefor. In this way, the individual vanes are not fixedly or integrally joined to the outer and inner bands in the conventional manner of all-metal turbine nozzles, but instead, the individual vanes are loosely trapped in the two collar seals at the opposite radial ends thereof in the mounting apertures (30).

As shown in Figures 1 and 2, the individual vanes are fully trapped around the circumference of the opposite radial ends thereof in the corresponding bands. The individual vanes may also be radially trapped in the bands using stop members located outboard of the outer band and inboard of the inner band, such as integral small tabs or flanges (not shown) which overlap in part the apertures (30) over the corresponding ends of the vanes.

A portion of an exemplary configuration of the collar seal (34) is illustrated in more detail in Figure 4. Each collar seal includes an annular backing bar or retainer (36) having a circumferential airfoil contour which conforms with the airfoil contour of the mounted end of the vane (32) as illustrated in Figures 2 and 3.

The retainer (36) illustrated in Figures 3 and 4 is mounted in a corresponding recess or slot 38 formed around the inner surface of each of the apertures (30). As shown in Figure 3 each vane (32) has a leading edge (40) which first receives the combustion gases from the combustor, and an axially opposite trailing edge (42).

The vane has an aerodynamic or airfoil profile in radial section which decreases in thickness from the wide leading edge portion of the vane to the thin trailing edge portion of the vane along circumferentially opposite pressure and suction sides (44),(46). The pressure side (44) of the vane is generally concave, with the opposite suction side (46) being generally convex in the typical profile of turbine nozzle vanes.

Accordingly, the retainer (36) of the collar seal has a matching or conforming airfoil contour to closely surround the perimeter of the mounting ends of the vanes. Each seal additionally includes a thin, flexible shim or leaf (48) as shown in Figure 4 which is surrounded by the retainer (36) and fixedly joined thereto. Correspondingly, a woven cloth or fabric sheath (50) covers or encases the leaf (48) and is also fixedly joined to the common retainer (36).

The various components of the collar seal (34) are preferably made of metal such as the various superalloy metals commonly found in turbine designs. For example, the annular retainer (36) may be formed of Inconel 625, the flexible leaf (48) may also be formed of Inconel 625, and the woven sheath (50) may be formed of Haynes 188, which is a cobalt-based superalloy.

The thin leaf (48) and woven sheath (50) are commonly joined to the supporting retainer and are relatively flexible whereas the retainer is rigid. The sheath and leaf provide a resilient support for the corresponding end of the ceramic vane, and a suitable line of contact seal therewith.

The woven sheath provides wear resistance and heat protection from the heat loads emitted from the hot combustion gases which flow over the exposed surfaces of the ceramic vanes during operation when mounted between the opposite outer and inner bands in which the collar seals are mounted and protected.

The collar seal (34) is illustrated installed in the aperture (30) of the outer band (26) in Figure 4, and in isolation in Figure 5. The embedded leaf (48) is preferably laminated in multiple layers or plies, such as two-plies which extend around or along the airfoil contour of the rigid retainer (36) which provides corresponding shape definition to the flexible leaf and sheath. The exemplary two-plies of the leaf (48) have generally flat surfaces which laterally abut each other radially or vertically outwardly from the common retainer (36).

The woven sheath (50) is preferably a single ply metallic cloth having metal fibers or strands woven in any suitable manner such as with diagonal orientation relative to the common retainer (36). The woven sheath (50) wraps around the common distal ends of the two-ply leaf (48) and conforms with the flat configuration of the leaf around the entire airfoil contour of the retainer (36).

As best shown in Figure 4, the proximal ends of the two leaf plies (48) and the encasing sheath (50) are commonly joined to the retainer (36) by welding for example which results in a weld bead (52) extending along the circumference of the retainer (36). The rigid retainer (36) is in turn suitably fixedly joined to the supporting band by brazing for example which results in a continuous braze joint (54) along the circumference of the retainer.

In this way, the individual collar seals (34) are fixedly joined by their rigid retainers (36) in the corresponding slots (38) around the perimeter of the mounting apertures (30). The proximal ends of the leaf (48) and sheath (50) are rigidly joined to the retainer, and the opposite distal or tip ends thereof extend vertically or radially inside the apertures (30) for providing flexible support and sealing with the corresponding ends of the ceramic vanes around the full circumference thereof.

Figure 2 illustrates the full circumference mounting of the opposite ends of the ceramic vanes (32) using the surrounding collar seals (34) mounted in the bands. During operation, the hot combustion gases (20) flow axially through the converging nozzle passages defined circumferentially between the adjacent vanes for being properly directed to the downstream rotor blades (not shown). The individual vanes are therefore subject to both the elevated temperature and pressure of the hot combustion gases during operation.

As indicated above, the temperature of the combustion gases causes the ceramic vanes and the metal bands to expand and contract at different rates corresponding with their different coefficients of thermal expansion. Furthermore, the substantial pressure drop of the combustion gases across the nozzle vanes creates aerodynamic loads thereon which must be carried through the collar seals (34) into the outer and inner bands.

Since the individual vanes are loosely and not integrally mounted into the respective bands, they are subject to various rocking, rolling, and slipping movement within the small surrounding clearance provided between the vanes and mounting apertures (30). Furthermore, manufacturing tolerances for the vanes themselves, the mounting apertures (30), and the collar seals (34) correspondingly affect the specific location of the vane ends in the corresponding surrounding mounting apertures.

Accordingly, the airfoil configuration of the collar seal (34) and flexibility of the leaf (48) and sheath (50) thereof may be used to advantage to accommodate the various local movement of the vane ends in the mounting apertures (30), see movement axes X,Y in figure 3, which vary during operation along both the pressure and suction sides of the collar seal itself as well as between the corresponding leading and trailing edges thereof.

As shown in Figures 4 and 5, the leaf plies (48) are preferably slit along their local axial axis which corresponds with the radial axis of the vanes mounted in the engine. Each ply includes a plurality of transverse slits (56) which extend from the proximal ends thereof at the retainer (36) to their distal ends for increasing flexibility thereof. In this way, the leaf plies may be formed of individual cantilevered fingers which better conform with the airfoil configuration of the supported vane around the full circumference thereof including the opposite leading and trailing edges and pressure and suction sides.

In the preferred embodiment, the slits (56) in each of the two plies of the leaf (48) are preferably longitudinally or circumferentially offset around the perimeter of the collar seal between the two plies thereof to improve sealing by reducing any leakage introduced by the slits themselves.

Figures 3 and 4 illustrate the collar seal (34) mounted in the corresponding supporting band. During operation, the pressurized air (16) is suitably channeled from the compressor through the outboard end of the apertures (30) in the outer band, and correspondingly through the inboard end of the apertures in the inner band with the corresponding collar seals being mounted upside down compared to the configuration illustrated in Figure 4.

The pressurized air (16) acts over the entire outer surface area of the individual collar seals as shown in Figures 3 and 4 to exert an inwardly directed pressure force P on the sheath and leaf thereof which drives the collar seal in further sealing engagement with the respective vanes being mounted therein. The leaf and sheath of each seal may therefore deflect as required from the supporting retainer (36) to maintain line of contact sealing with the vane, notwithstanding relative X,Y movement of the vane in the corresponding mounting apertures (30).

In the preferred embodiment illustrated in Figure 5, the retainer (36), leaf plies (48), and sheath (50) are segmented around the circumference of the individual collar seal for advantages in manufacture and for better conforming with the three dimensional configuration and orientation of the collar seal when mounted in the annular bands shown in Figure 1.

For example, the collar seal illustrated in Figure 5 includes three segments along the pressure side of the seal as delineated by the corresponding splitlines (58). And, each collar seal preferably also includes four segments along the suction side thereof which also wraps around the leading edge to the beginning of the pressure side.

The seven segments illustrated in Figure 5 may be separately manufactured for better conforming with the substantial change in contour of the vane between its leading and trailing edges. The seven segments may then be suitably assembled together to conform not only with the perimeter airfoil contour of the individual vane itself, but also the cylindrical contour of the outer and inner bands in which they are mounted, as shown in Figure 1.

The retainer (36) illustrated in Figures 4 and 5 is preferably a rigid rod or bar which conforms with the airfoil contour of the vane ends, and may be suitably machined in conventional multiaxis numerically controlled machines. The leaf plies (48) are preferably thin, flexible sheet metal which may be conventionally formed to shape to additionally include the slits (56) extending in most part therethrough.

The initially flat sheet metal segments of the collar seal are welded along with the encasing sheath (50) to the rigid retainer (36) which then conforms the sheet metal leaf plies and woven sheath to the desired airfoil contour.

The different segments of the collar seal (34) illustrated in Figure 5 may be specifically configured for locally matching the corresponding portion of the supported vane from its leading edge having a relatively large width with large diameter curvature to the relatively thin trailing edge having a small diameter curvature or radius at the trailing edge thereof. The pressure side of the collar seal is generally concave with the three segments conforming thereto. And, the suction side of the collar seal is generally convex with the three major segments conforming thereto, and the fourth segment being outwardly convex as it wraps around the leading edge portion of the collar seal.

A particular advantage of this configuration is the assembly of the multi-segment collar seal in the corresponding bands, such as the outer band illustrated in Figure 2. The outer band, and similarly the inner band, include axial splitlines (60) which separate the band at the leading and trailing edges of each vane and mounting aperture (30) extending therebetween. Each band segment therefore includes the pressure-side portion of one mounting aperture and the suction-side portion of an adjacent mounting aperture.

Three segments of one collar seal may be conveniently mounted in the supporting slot in the one-half aperture and four segments of the next collar seal may be conveniently mounted in the next half-aperture of the band segment. The entire assembly may then be placed in a vacuum oven for conventional brazing of the seal segments therein.

The so brazed band segments may then be subsequently joined together to complete the annular continuity of the bands and trapping therebetween the corresponding ceramic vanes.

In the preferred embodiment illustrated in Figures 2 and 5, the axial splitlines (60) of the outer band (26) conform with the first segment splitline (58) on the pressure side of the collar seal near the leading edge thereof, and with the last splitline (58) joining the pressure and suction sides of the collar seal at the trailing edge.

In the preferred embodiment illustrated in Figure 5, the segmented retainer (36) includes seven segments having end portions or sections abutting each other around the circumference thereof. Similarly, the woven sheath (50) includes seven segments having end portions or sections abutting each other around the circumference thereof. And, the two leaf plies (48) each includes seven segments having end portions or sections abutting each other around the circumference of the seal.

In this construction of the collar seals, the seven segments may be separately manufactured to locally conform with the corresponding portions of the vanes being supported, and simply abutted together in the mounting slot (38) of the bands as illustrated in Figures 3 and 4. Preferably, the segmented leaf plies (48) overlap each other around the circumference of the collar seal to provide internal seal joints.

This is illustrated in Figure 5 in which one of the leaf plies (48) has a tongue or tab (62) which extends outwardly from the corresponding segments of the other leaf ply, sheath (50), and retainer (36) for mating with a groove in the next adjacent seal segment in which the corresponding leaf ply is offset inside the segment. The tab (62) illustrated in Figure 5 is provided over the full straight portion of the leaf ply, and terminates near the proximal end thereof which is bent as illustrated in Figure 4 for attachment to the retainer (36).

The tongue-and-groove joints of the overlapping leaf plies may be provided at any one or more of the seven collar seal segments illustrated in Figure 5. These joints improve the local sealing of the segments and structurally interconnect the leaf plies and woven sheath. The protruding tabs (62) may be eliminated, if desired, at the two splitlines (58) of the collar seal corresponding with the axial splitline (60) of the bands as illustrated in Figure 2.

The retainer (36) illustrated in Figure 4 preferably includes an outboard surface having a slot in which braze material may be conveniently trapped for furnace brazing the collar seal segments into the band segments during manufacture. The inboard surface of the retainer (36) preferably includes an arcuate or semicircular fulcrum bead (64) extending along the circumference of the collar seal, which is also segmented at the corresponding splitlines (58). The retainer (36) also includes a flat land (66) spaced laterally from the bead (64) which collectively have a generally P-shaped configuration.

The two leaf plies (48) and encasing sheath (50) are welded at their proximal ends to the land (66). The proximal ends of the leaf plies and sheath include a generally 90 degree bend which permits the remainder of the leaf plies and sheath to extend over or overlap the bead (64) in a cantilevered manner. The bead (64) thusly defines a fulcrum for the leaf plies and sheath which extend thereover.

The leaf plies (48) and surrounding sheath (50) have common tip or distal end spaced suitably away from the bead (64), and are sufficiently flexible for accommodating deflection about the bead during operation.

As indicated above, the pressure forces P exerted by the pressurized air (16) during operation drives the tip ends of the leaf plies and surrounding sheath into sealing contact with the vane around the perimeter thereof. The vane is nevertheless subject to differential movement with the outer and inner bands under the temperature and pressure loading which occurs during operation of the turbine nozzle. The vane may rock or roll in space relative to the outer and inner bands, and the corresponding collar seals include sufficient flexibility for accommodating this relative movement of the vanes while still maintaining effective support and seals therefor.

In Figure 4, the pressure force P of the pressurized air 16 tends to rotate the leaf plies and sheath clockwise, whereas differential movement between and bands may tend to rotate the leaf plies and sheath counterclockwise in opposition thereto. In this occurrence, the leaf plies and sheath may then bend about the fulcrum bead (64) when driven therearound during operation. The fulcrum bead (64) minimizes stresses in the leaf plies and sheath and maintains the integrity of the weld joint or bead (52) for ensuring a long useful life of the collar seal.

Figure 6 illustrates schematically the assembly of the various segments of the collar seal in a preferred embodiment. The two leaf plies (48) of each segment may be assembled together and encased in the woven sheath (50) therearound. The proximal ends of the leaf plies and sheath are then placed in abutment with the retainer segments (36) and suitably welded thereto.

The so-preassembled collar segments may then be joined together in abutment, with the tabs (62) of one segment being inserted into the corresponding groove in the adjacent segment, and assembled together in the mounting slots (38) of the bands (26),(28). The retainer segments (36) are then suitably brazed in their mounting slots (38) as indicated above. Final assembly includes trapping the individual vanes between the two halves of each collar seal and joining together the various band segments to form the complete 360 degree nozzle assembly.

The collar seal disclosed above permits mounting of the ceramic vanes (32) illustrated in Figures 1-3 into supporting metal band segments in both the outer and inner bands (26),28. The vanes (32) remain discrete or individual components trapped by the corresponding collar seals (34) in the respective mounting apertures (30) of the two bands in stark contrast with the unitary configuration of typical metal vanes in metal bands found in conventional turbine nozzles.

The collar seals (34) completely encircle the supported ends of the ceramic vanes and provide effective seals therearound to contain the combustion gases in the nozzle passages between the vanes, while minimizing any leakage of the pressurized air past the collar seals.

The collar seals provide resilient supports for the ceramic vanes and accommodate the various differential movement between the vanes and bands due to the pressure loads of the combustion gases and the differential expansion and contraction between the vanes and bands due to the operating temperature of the combustion gases through the various portions of the typical engine cycle.

Segmenting of the collar seal permits the local tailoring of the individual segments to the different local contours of the vane being supported, and permits the use of initially flat, thin, sheet metal leaf plies and woven fabric sheath (50) which conform with the airfoil contour of the vanes when fixedly joined to the airfoil contour of the supporting retainers (36).

The segmented construction of the individual collar seals (34) additionally permits matching of the cylindrical contour of the annular outer and inner bands in which the mounting apertures (30) are found and sealed with the complementary collar seals (34).

While there have been described herein what are considered to be preferred and exemplary embodiments of the present invention, other modifications of the invention shall be apparent to those skilled in the art from the teachings herein, and it is, therefore, desired to be secured in the appended claims all such modifications as fall within the true spirit and scope of the invention.

CLAIMS

1. A collar seal (34) for a turbine vane (32) comprising:

a rigid annular retainer (36) having a circumferential airfoil contour conforming with the airfoil contour of said vane (32);

flexible sheet metal leaf plies (48) laminated around said airfoil contour of said retainer (36), and fixedly joined thereto; and

a woven sheath (50) encasing said leaf plies (48) and fixedly joined to said retainer (36).

2. A seal according to claim 1 wherein said retainer (36) includes an arcuate bead (64) extending along said circumference thereof spaced laterally from a land (66), and said leaf plies (48) and sheath (50) are welded to said land (60) and bend to overlap said bead.

3. A seal according to claim 2 wherein said sheath (50) wraps around said leaf plies (48) and conforms therewith around said airfoil contour of said retainer (36), and is commonly joined with proximal ends of said leaf plies to said retainer.

4. A seal according to claim 3 wherein said leaf plies (48) include slits (56) for increasing flexibility thereof, and said slits are offset between said leaf plies.

5. A seal according to claim 4 wherein said retainer (36), leaf plies (48), and sheath (50) are segmented around the circumference thereof, and said segmented leaf plies (48) overlap each other around said circumference.

6. A seal according to claim 5 wherein:

said segmented retainer (36) includes portions abutting each other around said circumference;

said segmented sheath (50) includes portions abutting each other around said circumference; and

said segmented leaf plies (48) include portions abutting each other around said circumference.

7. A turbine nozzle (22) comprising:

radially outer and inner bands (26),(28) having a plurality of circumferentially spaced apart apertures (30) extending radially therethrough;

a plurality of ceramic nozzle vanes (32), each having opposite ends extending through said apertures (30) in said bands;

a plurality of collar seals (34) fixedly joined at one end to said bands ((26),(28) in respective ones of said aperture (30), and having opposite tip ends surrounding said vane ends in sealing engagement therewith; and

each of said collar seals (34) includes:

a rigid annular retainer (36) having a circumferential airfoil contour conforming with the airfoil contour of said vane (32);

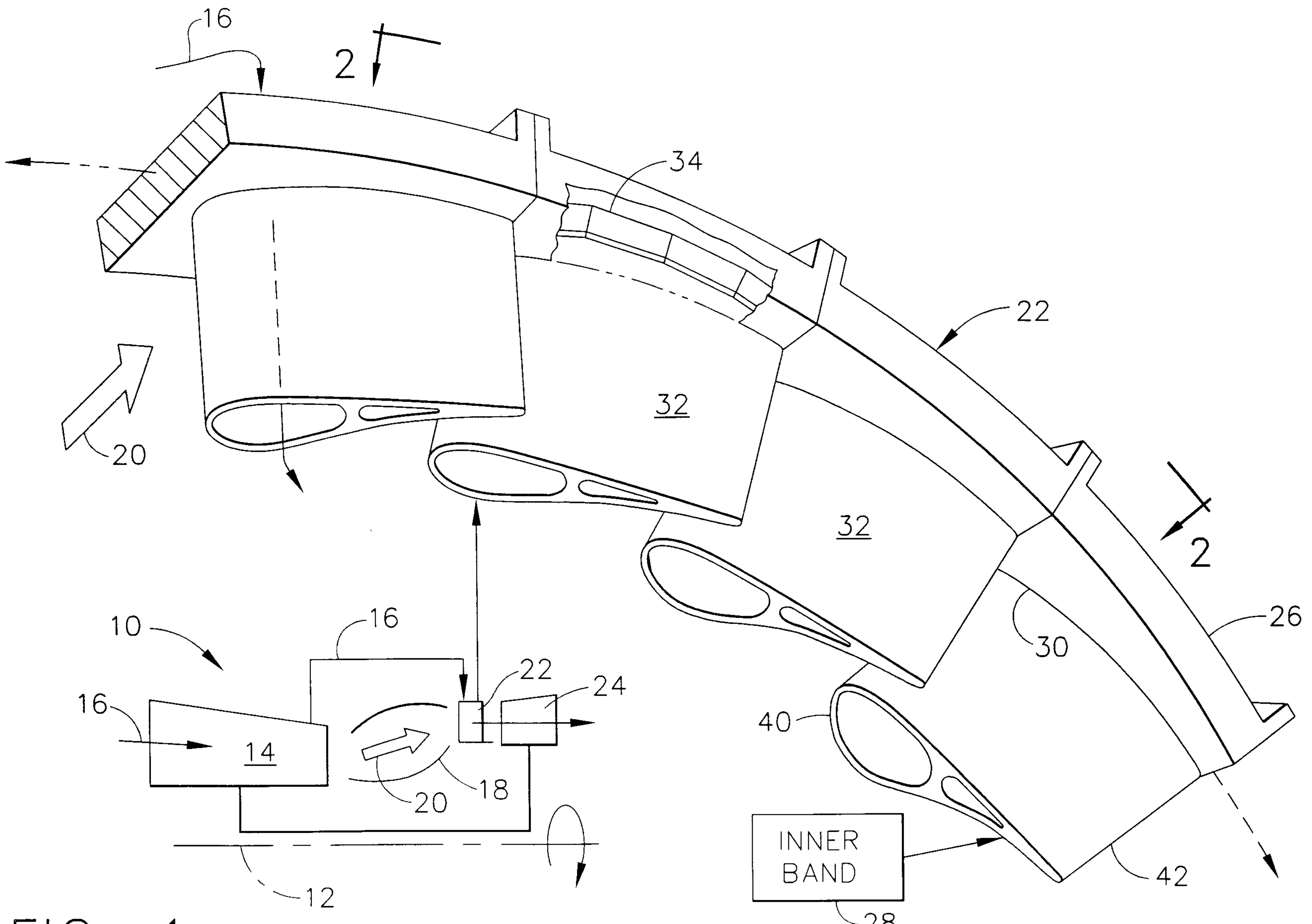
flexible sheet metal leaf plies (48) laminated around said airfoil contour of said retainer (36), and fixedly joined thereto; and

a woven sheath (50) encasing said leaf plies (48) and fixedly joined to said retainer (36).

8. A nozzle according to claim 7 wherein said retainer (36) includes an arcuate bead (64) extending along said circumference thereof spaced laterally from a land (66), and said leaf plies (48) and sheath (50) are welded to said land (60) and bend to overlap said bead.

9. A nozzle according to claim 8 wherein said leaf plies (48) include slits (56) for increasing flexibility thereof, and said slits are offset between said leaf plies.

10. A nozzle according to claim 9 wherein said retainer (36), leaf plies (48), and sheath (50) are segmented around the circumference thereof, and said segmented leaf plies (48) overlap each other around said circumference.


16
2
2
34
22
32
32
2
20
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24
16
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18
12
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26
40
INNER BAND
28
42

FIG. 1

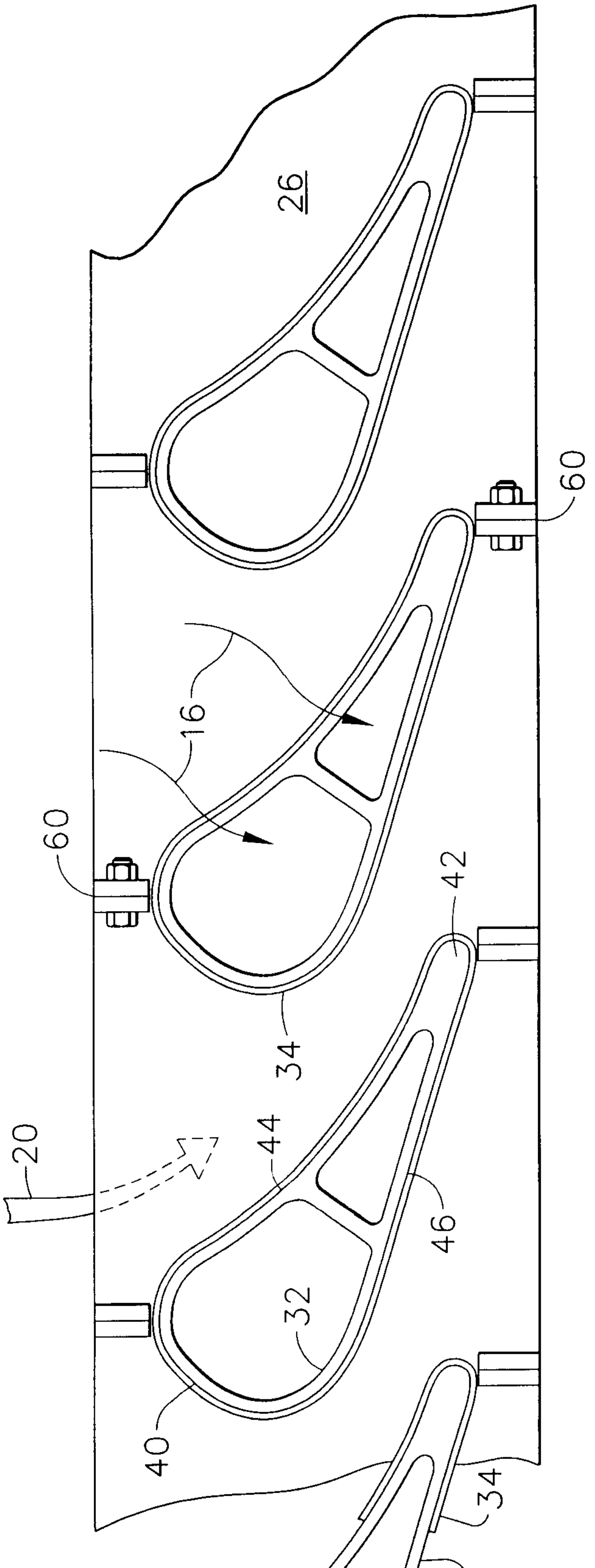


FIG. 2

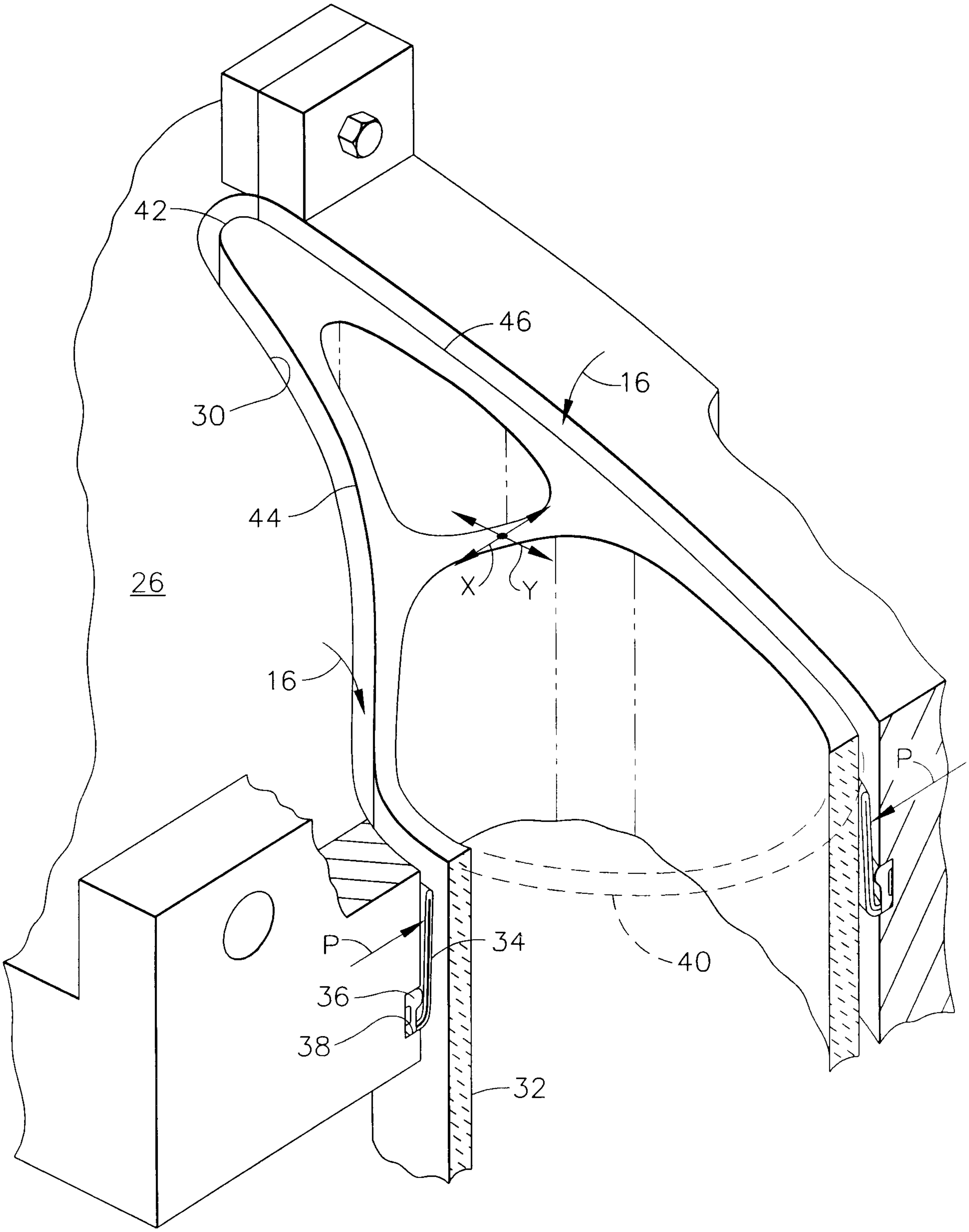


FIG. 3

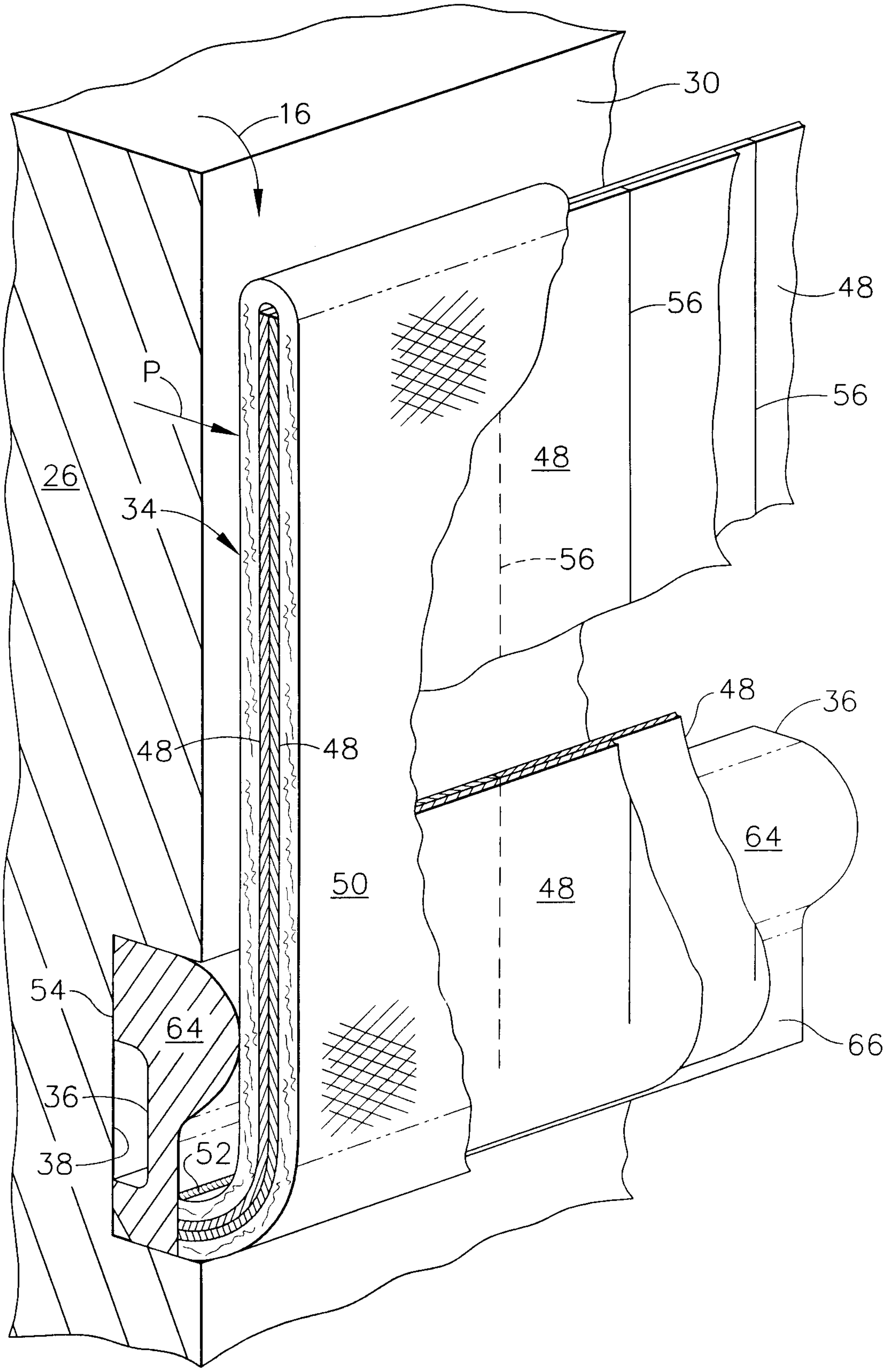


FIG. 4

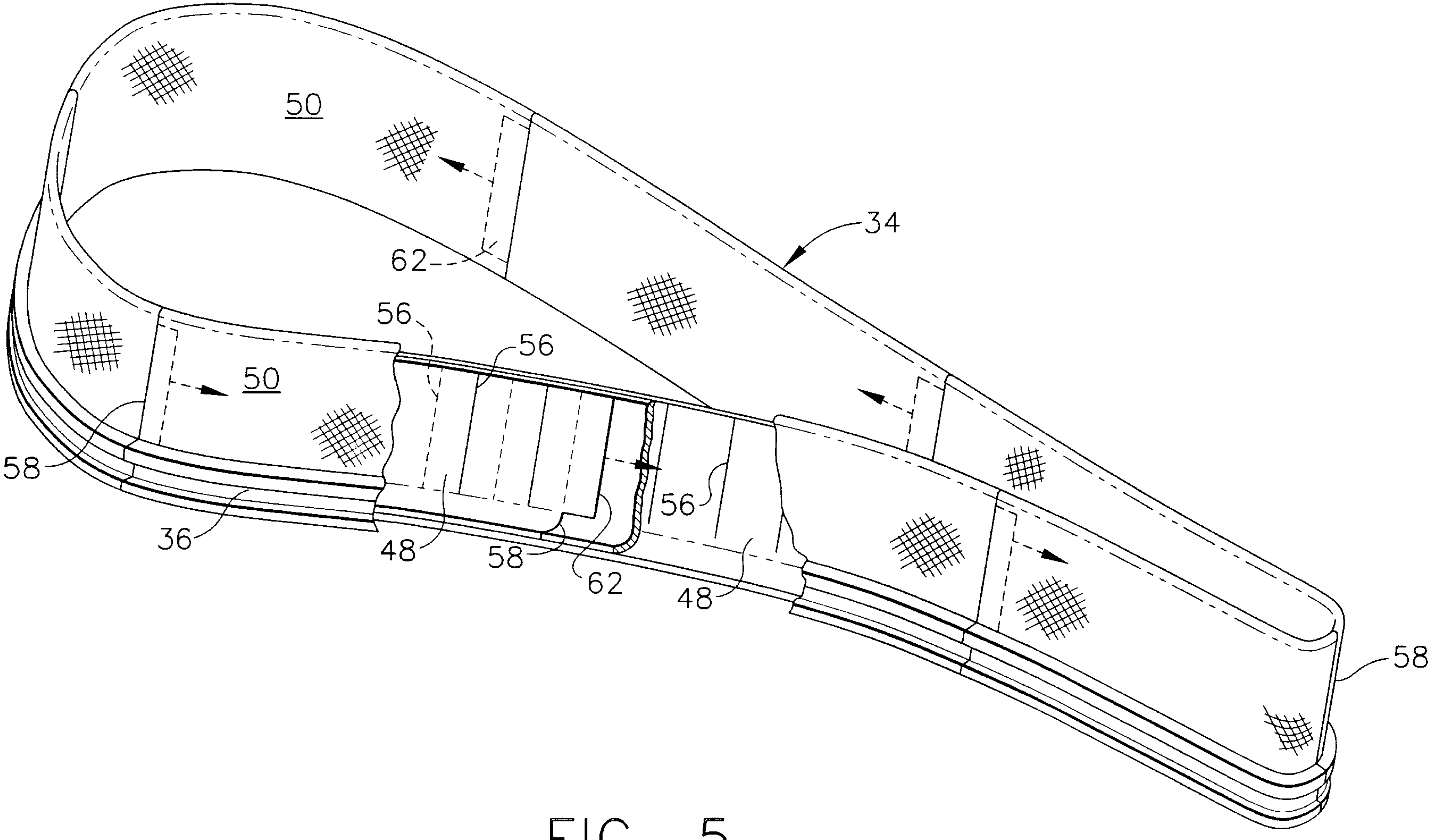
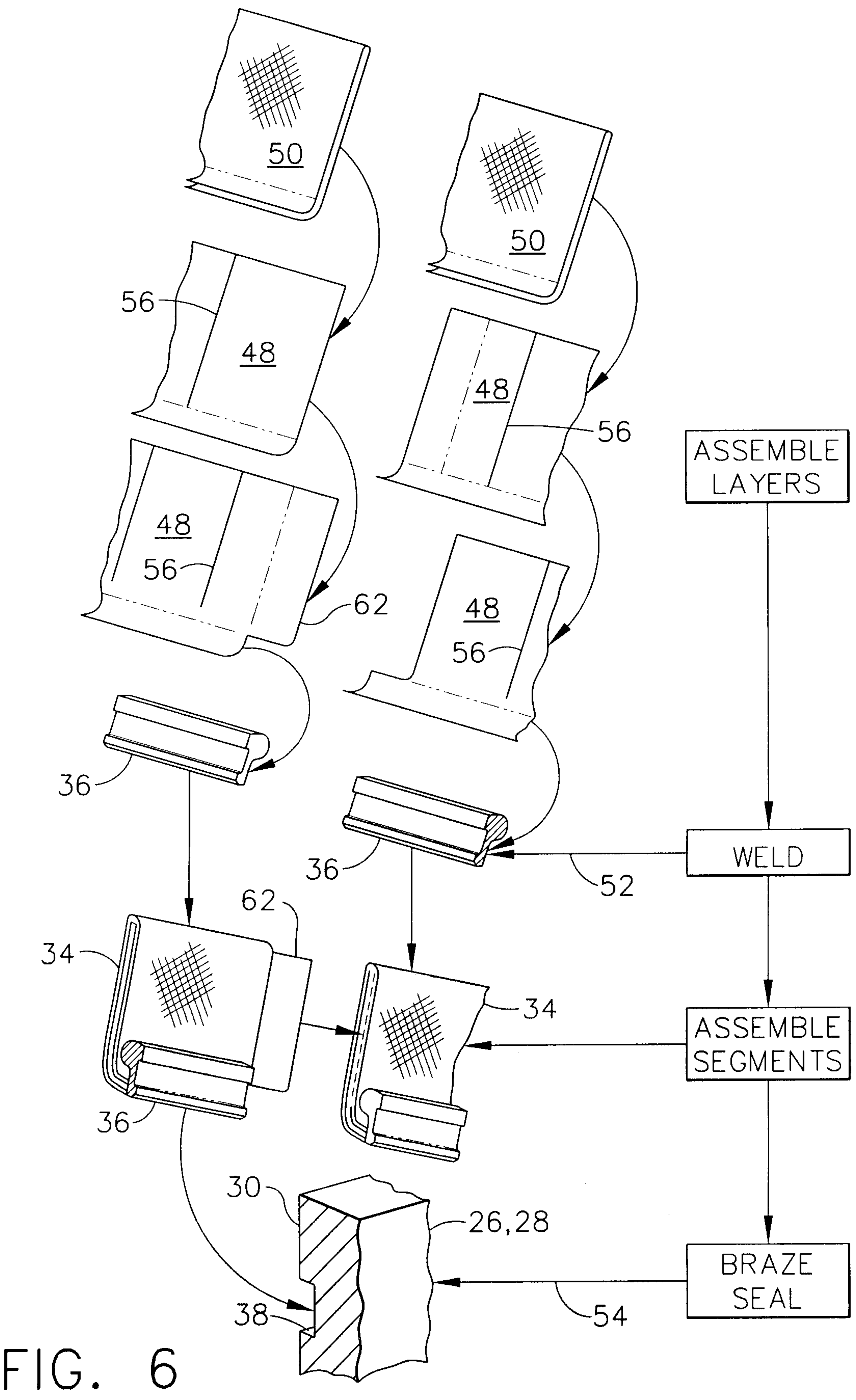


FIG. 5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ASSEMBLE LAYERS
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WELD
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ASSEMBLE SEGMENTS
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26,28
BRAZE SEAL
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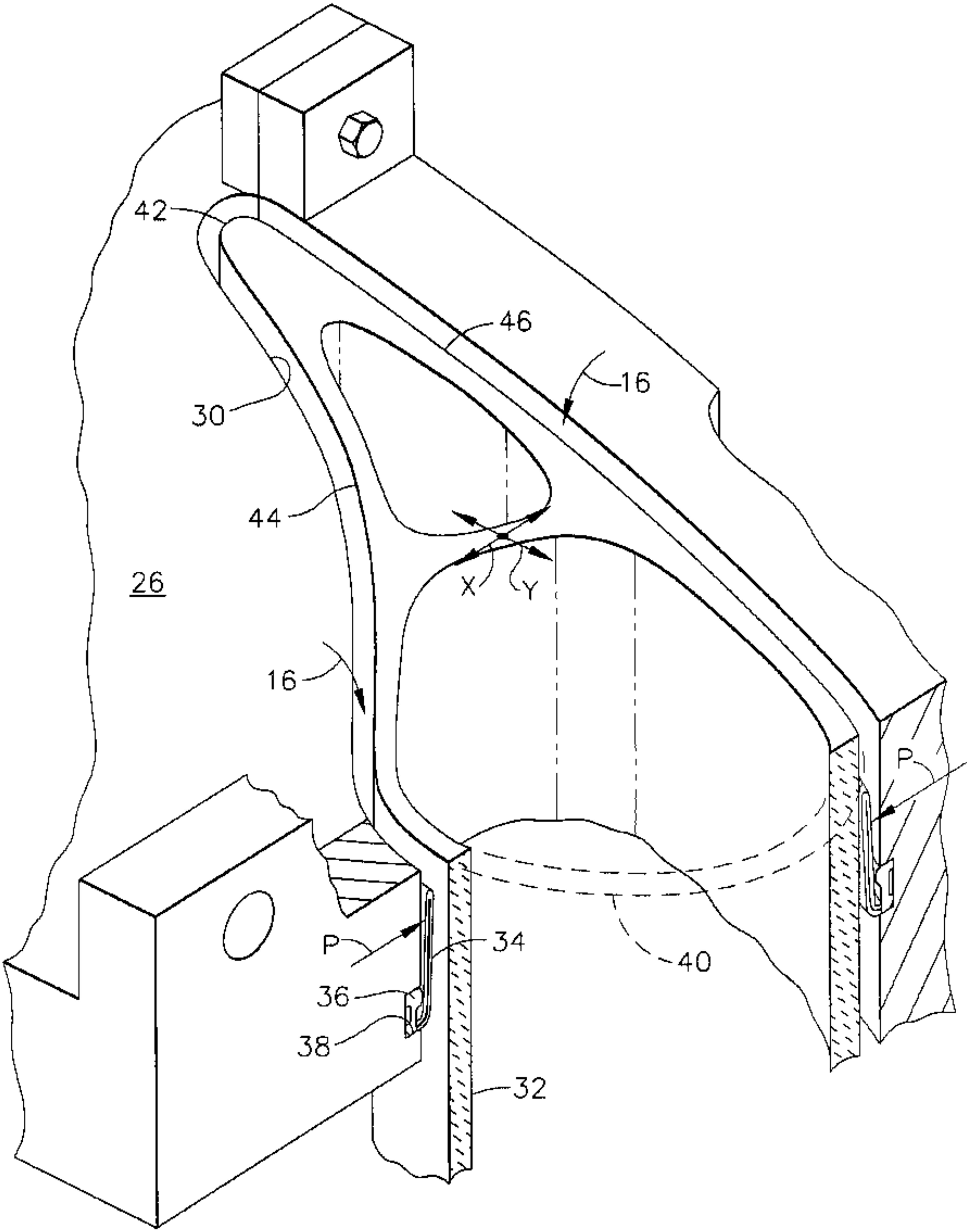
FIG. 6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