



(22) Date de dépôt/Filing Date: 1999/12/13

(41) Mise à la disp. pub./Open to Public Insp.: 2000/07/13

(45) Date de délivrance/Issue Date: 2004/08/24

(30) Priorité/Priority: 1999/01/13 (09/229,547) US

(51) Cl.Int.⁷/Int.Cl.⁷ B64D 29/00, B64C 1/40, F02K 1/44

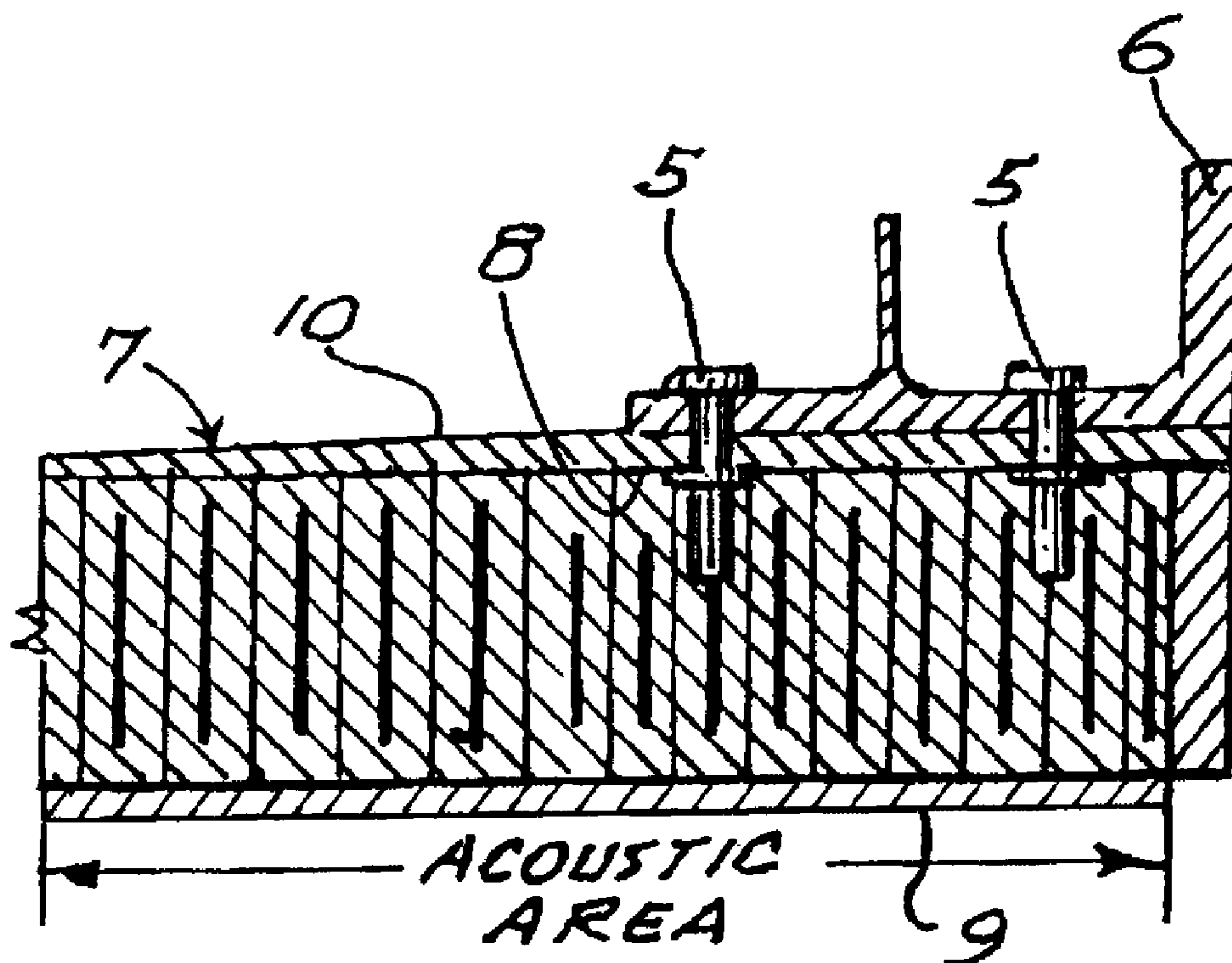
(72) Inventeurs/Inventors:
RIEDEL, BRIAN L., US;
STRUNK, JOHN T., US;
CLARK, RANDALL R., US

(73) Propriétaire/Owner:
THE BOEING COMPANY, US

(74) Agent: SMART & BIGGAR

(54) Titre : FIXATION POUR L'ENVERS DE PANNEAUX INSONORISANTS DU FUSEAU MOTEUR

(54) Title: BACKSIDE FITTING ATTACHMENT FOR NACELLE ACOUSTIC PANELS



(57) Abrégé/Abstract:

A method of attaching acoustic panels to aircraft structures without loss of acoustic area due to the attachment means. The invention comprises the uses of high-shear blind fasteners in combination with acoustic panels having backside laminate and ply build-up area increased in thickness to retain the blind fastener, react the bearing loads and provide adequate stiffness for bending. The present structure and method reduces acoustic panel installation cycle time by an estimated 50% while providing noise reduction.

BACKSIDE FITTING ATTACHMENT FOR NACELLE ACOUSTIC PANELS

5 ABSTRACT OF THE DISCLOSURE

10 A method of attaching acoustic panels to aircraft structures without loss of acoustic area due to the attachment means. The invention comprises the uses of high-shear blind fasteners in combination with acoustic panels having backside laminate and ply build-up area increased in thickness to retain the blind fastener, react the bearing loads and provide adequate stiffness for bending. The present structure and method reduces acoustic panel installation cycle time by an estimated 50% while providing noise reduction.

BACKSIDE FITTING ATTACHMENT FOR NACELLE ACOUSTIC PANELS

5 BACKGROUND OF THE INVENTION

1. Field of the document

The present invention relates to noise reduction and more particularly to noise reduction apparatus and methods for aircraft and for aircraft engine components.

10

2. Description of the related art

U.S. Patent No. 4,235,303 to Dhoore et al. entitled "Combination Bulk Absorber-Honeycomb Acoustic Panels" relates to a combination acoustic panel that provides a high percentage of acoustically effective area. Dhoore et al, describe a sandwich structure comprising a broadband noise-suppressing bulk absorber material mounted between a back sheet and a first side of a perforated septum and a noise suppressing honeycomb material mounted between a second side of the septum and a perforated face sheet. "Thru-bolted" fasteners are used to retain the composite acoustic panel structure.

15

20

U.S. Patent No.'s 4,293,053 and 4,384,634 to Shuttleworth et al. describe a "Sound Absorbing Structure" using a combination of elastomeric and coulombic retention means for acoustic panels in engine nacelles. The coulombic retention means utilizes rubbing contact to frictionally damp out acoustic panel vibrations. The elastomeric retention means elastically suspend the acoustic panels and utilizes viscous damping to damp panel vibrations. Shuttleworth et al. also describe the use of the elastomeric material to create "standoffs" between the acoustic panel and the engine structure, effectively creating another acoustic attenuating cavity (in addition to the cavities disposed inside the acoustic panel) that communicates with the backside of the perforated acoustic panel.

25

30

-2-

U.S. Patent No. 4,449,607 to Forestier et al. entitled "Soundproofing for a Gas Pipe, In Particular for the Fan Jet of a Turbojet, and Equipment for its Fabrication", relates to an acoustic lining means for aircraft engine inlets which comprises an insitu build up of an acoustic panel sandwich of perforated facesheets and a communicating core structure that defines resonant acoustical cavities. A "thru-bolted" fastener is used to retain the composite acoustic panel structure.

U.S. Patent No. 4,759,513 to Birbragher et al. entitled "Noise Reduction Nacelle", shows an acoustic sandwich panel designed to be field "retrofittable" to engine nacelles and thrust reverser structures using conventional fasteners. Birbragher et al disclose a panel composition comprising an inner perforated facesheet and an outer facesheet with honeycomb core therebetween. The inner and outer facesheets are bonded using adhesive film. A plurality of preparations are disclosed for the inner facesheet composition.

U.S. Patent No. 4,825,106 to Anderson entitled "Advanced Composite Aircraft Cowl", shows a one-piece composite engine cowl with integral "cured-in" acoustic attenuating liners. Since the acoustic panels are "cured-in" the structure during the manufacturing process, there is no need for retention means.

Present Aircraft Industry

The aviation industry as a whole is developing and adopting technologies and procedures that reduce airplane related noise in anticipation of increasingly more stringent requirements. In the area of engines only, acoustical treatment of 70-85% of the available inlet and thrust reverser surface area is accomplished due to structural attachment considerations. Current techniques comprise reinforcing acoustic panels in attachment zones with square edged, high-density core and thicker laminates. The reinforced areas are then "thru-bolted" using conventional fasteners which create acoustically dead structural areas. These acoustically dead structural areas reduce the overall acoustic surface area available for noise suppression. Further, present two-piece thru-bolted fastener systems are not economical to manufacture since two-piece fasteners require a countersink operation on the acoustic panel.

-3-

An acoustic panel arrangement of the prior art is shown in FIG. 2 and employs an attachment method that comprises the use of symmetric ply build-ups on laminates 1 and high density core 2 and employs conventional fasteners 3 which extend through the acoustic panel resulting in lost acoustic treatment in attachment area 4. The high density core 2 and thick ply stackups 1 cannot be acoustically treated with a perforated sandwich. Adequate acoustic treatment to satisfy noise requirements in these prior art acoustic panel structures requires added nacelle length which affects performance and weight, and increases cost. Current technology limits treatable area to approximately 85% (of available area) in the engine inlet and 70% in the aircraft thrust reverser. With the prior art attachment approach, the remaining area cannot be acoustically treated.

Summary of the Invention

In view of the disadvantages hereinabove described there is provided herein methods and apparatus for attaching acoustic panels to aircraft structures without loss of acoustic area due to the attachment means. The present invention employs high-strength blind fasteners in combination with acoustic panels having backside laminate and ply build-up areas of increased thickness to retain the blind fastener, react the bearing loads and to provide adequate stiffness for bending.

In accordance with one aspect of the invention, there is provided a sound reduction apparatus for an aircraft engine. The apparatus includes a continuous no-ply perforated laminate, a backside laminate having a ply build up area and a thickness that increases to the ply build-up area to react to bearing loads and to provide stiffness for bending. An acoustic core material is sandwiched between the continuous perforated laminate and the backside laminate. The backside laminate is operable to receive blind bolts therethrough for securing the acoustic panel to a fitting on the engine.

In accordance with another aspect of the invention, there is provided an aircraft engine inlet assembly comprising a ring fitting for attaching the engine inlet assembly to an engine fan and a sound reduction apparatus comprising a continuous no-ply perforated laminate, a backside laminate having a ply build up area and a thickness that increases to the ply build-up area to react to bearing loads and to

-4-

provide stiffness for bending. An acoustic core material is sandwiched between the continuous perforated laminate and the backside laminate. Blind bolts operable to extend through the backside laminate and the fitting secure the acoustic panel to the fitting.

5 In accordance with another aspect of the invention, there is provided an aircraft engine fan duct thrust reverser assembly comprising an engine fan duct thrust reverser having a fitting and a sound reduction apparatus comprising a continuous no-ply perforated laminate, a backside laminate having a ply build up area and a thickness that increases to the ply build-up area to react to bearing loads and to
10 provide stiffness for bending. An acoustic core material is sandwiched between the continuous perforated laminate and the backside laminate. Blind bolts operable to extend through the backside laminate and the fitting secure the acoustic panel to the fitting of the engine fan duct thrust reverser.

 In accordance with another aspect of the invention, there is provided an
15 aircraft engine fan duct thrust reverser fixed structure assembly comprising an engine fan duct thrust reverser fixed structure having a fitting and a sound reduction apparatus comprising a continuous no-ply perforated laminate, a backside laminate having a ply build up area and a thickness that increases to the ply build-up area to react to bearing loads and to provide stiffness for bending. An acoustic core material
20 is sandwiched between the continuous perforated laminate and the backside laminate. Blind bolts operable to extend through the backside laminate secure the acoustic panel to the fitting on the fan duct thrust reverser fixed structure.

 In accordance with another aspect of the invention, there is provided a method of securing to a fitting of an aircraft engine an acoustic panel comprising an acoustic
25 core material sandwiched between a continuous no-ply perforated laminate and a backside laminate having a ply build up area, a thickness that increases to the ply build-up area and an adhesive surface which may have fillets and irregularities. The method involves installing blind bolts through the ply build-up area of the backside laminate and the fitting such that collars on the blind bolts are deformed to clamp up
30 over fillets and other irregularities on the adhesive surface of the backside laminate.

 The invention described herein allows the entire attachment area to be treated, except for a narrow edge closeout area.

-5-

As a result of the present acoustic panel utilizing backside fitting attachment acoustic panel material and labor costs are reduced, mainly by the elimination of high-density core and associated tooling. A significant labor savings for fastener installation is also realized over the prior art structure of FIG. 2. For example, a labor of savings of approximately 9 hours may be realized.

Brief Description of the Several Views of the Drawing

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is an isolated perspective view of an engine inlet assembly incorporating an acoustic panel in accordance with a first embodiment of the invention.

FIG. 2 is a fragmentary cross section of a prior art acoustic panel assembly.

FIG. 3 is a fragmentary cross section taken along lines 3-3 of FIG. 1 of an acoustic panel assembly in accordance with the first embodiment of the invention.

FIG. 4 is a fragmentary cross section taken along lines 4-4 of FIG. 1 of the acoustic panel assembly shown in FIG. 3.

FIG. 5 is an isolated perspective view of an engine fan duct thrust reverser assembly incorporating inner and outer acoustic panels of the type shown in FIGS. 3 and 4.

FIG. 6 is a fragmentary cross section of the engine fan duct thrust reverser taken along lines 6-6 of FIG. 5 showing a translating sleeve acoustic panel assembly incorporating an acoustic panel of the type shown in FIGS. 3 and 4.

FIG. 7 is an isolated perspective view of an engine fan duct thrust reverser fixed structure assembly incorporating an inner acoustic panel of the type shown in FIGS. 3 and 4.

FIG. 8 is a fragmentary cross section taken along lines 8-8 of FIG. 7 of the inner acoustic panel assembly of FIG. 7.

FIG. 9 is a fragmentary cross section taken along lines 9-9 of FIG. 7 of the inner acoustic panel assembly of FIG. 7.

Detailed Description

As shown in Figures 3 and 4, a composite acoustic panel forming part of an aircraft engine inlet is constructed such that a suitable acoustic core material is sandwiched between a continuous perforated laminate 9 and a backside laminate 10. The continuous perforated laminate 9 is formed with no ply build-up and the backside laminate has a thickness that increases to a ply build-up area which enables the panel to react to bearing loads and to provide adequate stiffness for bending. Other panel stiffening methods include, for example, a double sandwich construction with a suitable core material.

The acoustic panel may be attached to a fan case of the engine by an aluminum attach ring-fitting 6, for example. The attachment between the ring-fitting 6 and the composite panel 7 is made by a double row of blind bolts 5 at a suitable spacing and pitch. For a 120" inlet diameter, this equates to approximately 500 fasteners. The blind bolts 5 are used to backside fasten the metal fitting 6 to the increased thickness ply build-up area of the backside laminate 10 of the composite acoustic panel 7. When the blind bolts are installed, a collar thereon is deformed such that it clamps up over fillets and other irregularities on an adhesive surface 8 of the backside laminate 10.

For engine nacelle applications, such as on the engine nacelle shown in Figure 1, the blind bolts 5 shown in Figures 3 and 4 should be fatigue rated and capable of a lengthy service life in a sonic fatigue and vibratory environment with cyclic loading. The blind bolts 5 should offer good compliance to the irregular inner surface of the backside laminate 10.

Referring to Figures 5 and 6, the composite acoustic panel described above is shown in use in an engine fan duct thrust reverser assembly.

Referring to Figures 7-9, the composite acoustic panel described above is shown in use at various locations in an engine fan duct thrust reverser fixed structure assembly.

While a preferred embodiment of this invention has been illustrated and described, it will be appreciated that various changes can be made therein without

-7-

departing from the spirit and scope of the invention. Hence, the invention can be practiced otherwise than as specifically described herein.

-8-

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A sound reduction apparatus for an aircraft engine, the apparatus comprising:

5

a continuous no-ply perforated laminate;

10

a backside laminate having a ply build up area and a thickness that increases to said ply build-up area to react to bearing loads and to provide stiffness for bending;

15

an acoustic core material sandwiched between the continuous perforated laminate and the backside laminate;

wherein said backside laminate is operable to receive blind bolts therethrough for securing said acoustic panel to a fitting on said engine.

2. An aircraft engine inlet assembly comprising:

20

a ring fitting for attaching said engine inlet assembly to an engine fan;

a sound reduction apparatus comprising:

25

a continuous no-ply perforated laminate;

30

a backside laminate having a ply build up area and a thickness that increases to said ply build-up area to react to bearing loads and to provide stiffness for bending;

an acoustic core material sandwiched between the continuous perforated laminate and the backside laminate;

-9-

blind bolts operable to extend through said backside laminate and said fitting to secure said acoustic panel to said fitting.

5 3. An aircraft engine fan duct thrust reverser assembly comprising:

an engine fan duct thrust reverser having a fitting;

a sound reduction apparatus comprising:

10

a continuous no-ply perforated laminate;

a backside laminate having a ply build up area and a thickness that increases to said ply build-up area to react to bearing loads and to provide stiffness for bending;

15

an acoustic core material sandwiched between the continuous perforated laminate and the backside laminate;

20

blind bolts operable to extend through said backside laminate and said fitting to secure said acoustic panel to said fitting of said engine fan duct thrust reverser.

25 4. An aircraft engine fan duct thrust reverser fixed structure assembly comprising:

an engine fan duct thrust reverser fixed structure having a fitting;

a sound reduction apparatus comprising:

30

a continuous no-ply perforated laminate;

-10-

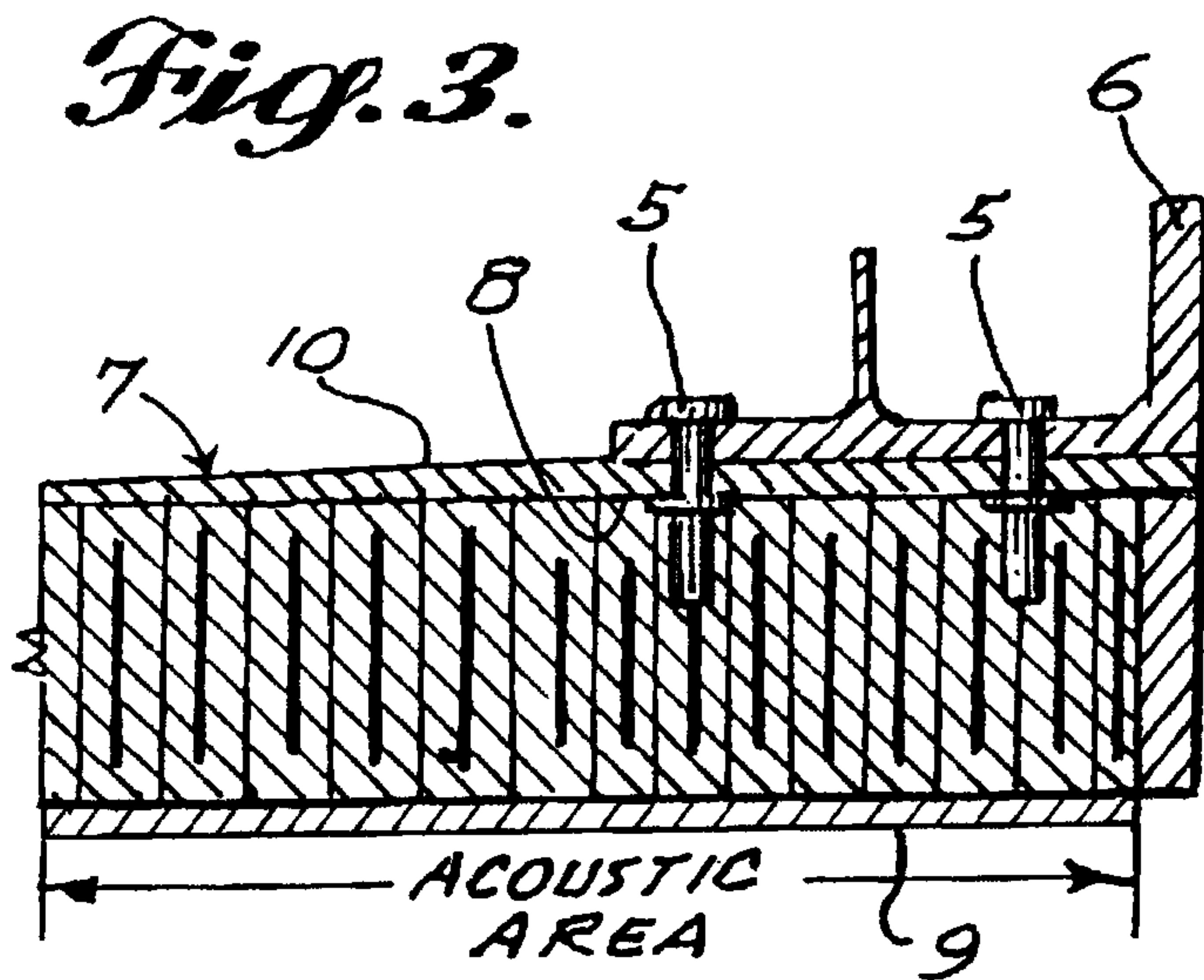
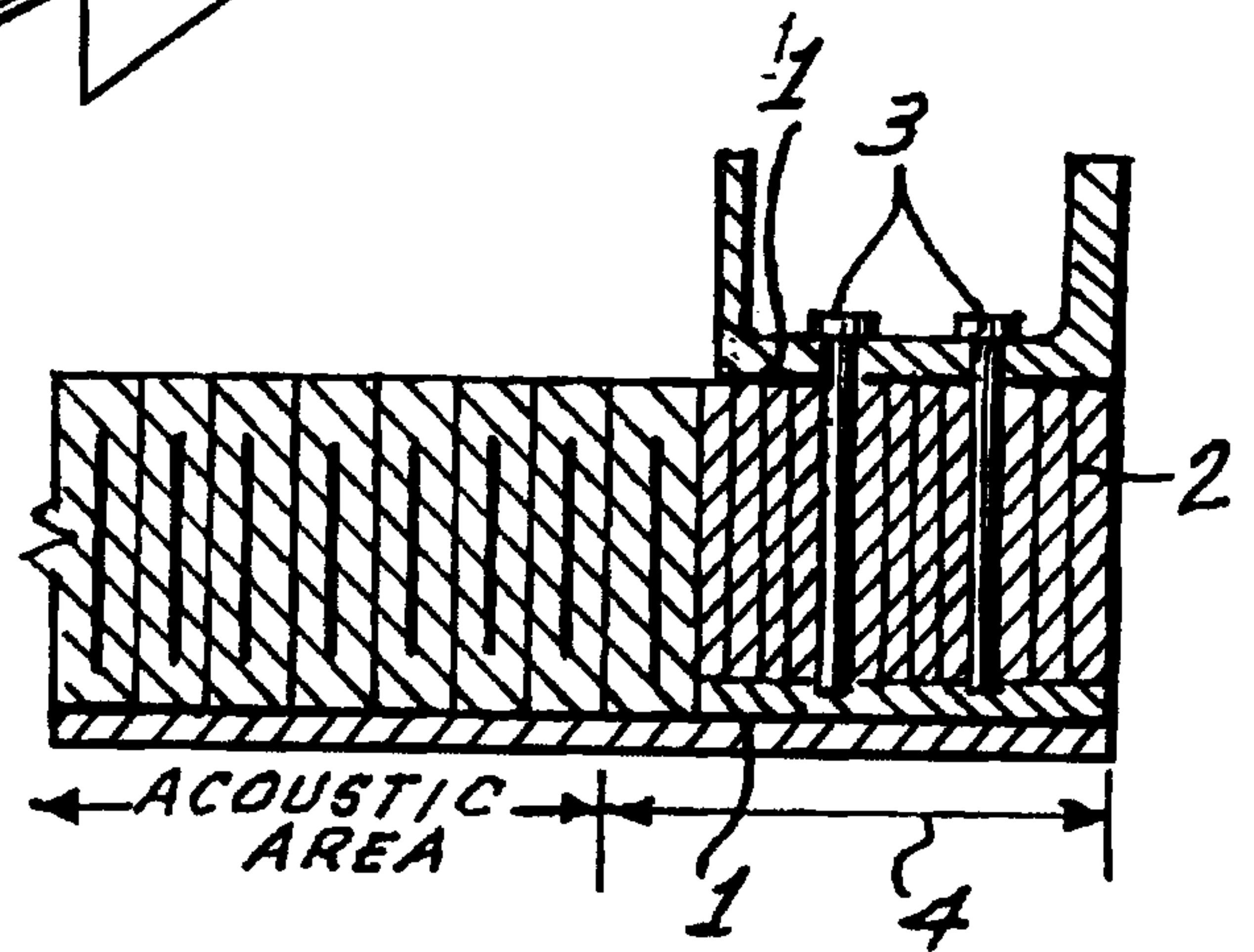
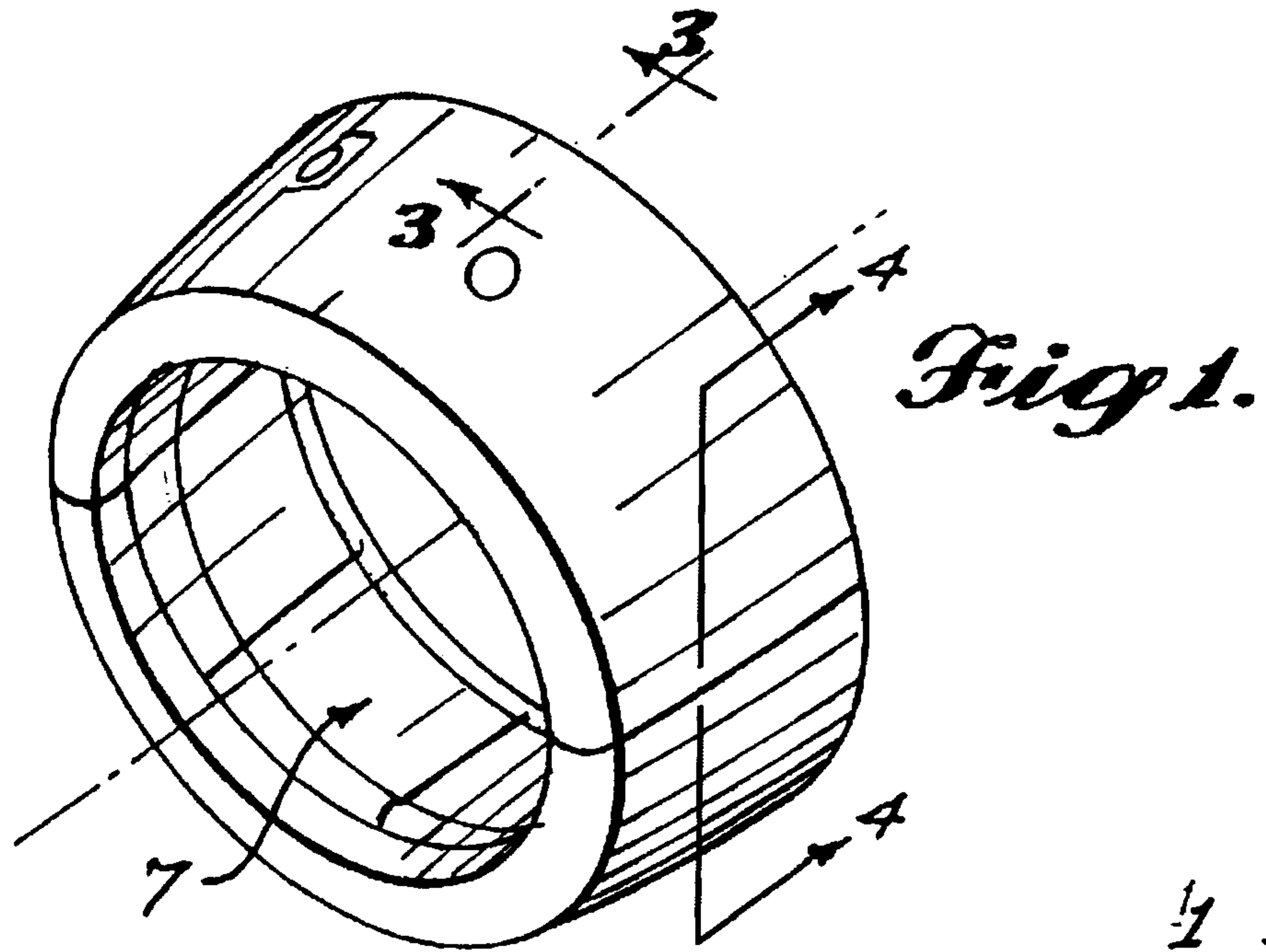
a backside laminate having a ply build up area and a thickness that increases to said ply build-up area to react to bearing loads and to provide stiffness for bending;

5 an acoustic core material sandwiched between the continuous perforated laminate and the backside laminate;

10 blind bolts operable to extend through said backside laminate to secure said acoustic panel to said fitting on said fan duct thrust reverser fixed structure.

5. A method of securing to a fitting of an aircraft engine an acoustic panel comprising an acoustic core material sandwiched between a continuous no-ply perforated laminate and a backside laminate having a ply build up area, a thickness that increases to said ply build-up area and an adhesive surface which may have fillets and irregularities, the method comprising:

20 installing blind bolts through said ply build-up area of said backside laminate and said fitting such that collars on said blind bolts are deformed to clamp up over fillets and other irregularities on the adhesive surface of the backside laminate.



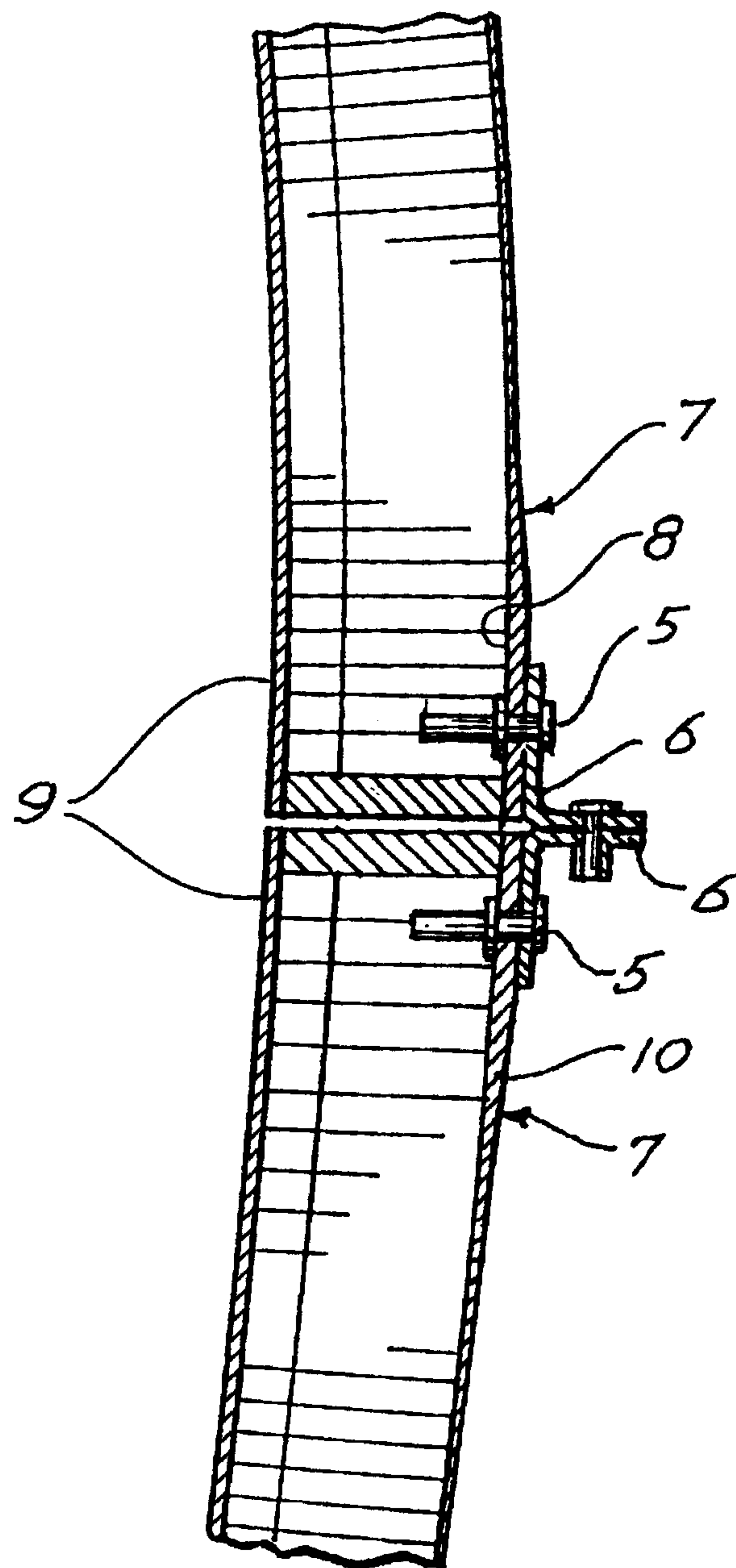


Fig. 4.

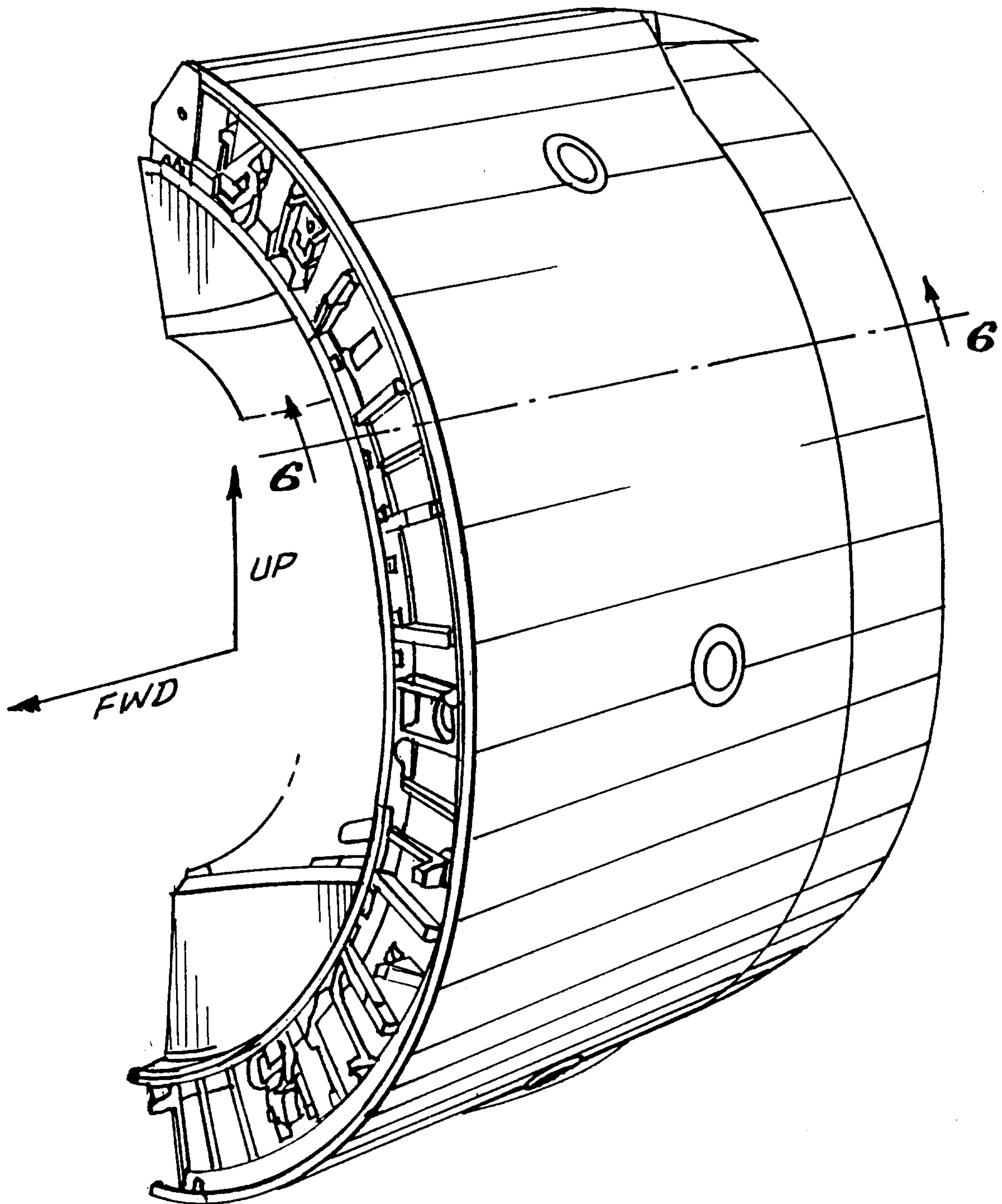


Fig. 5.

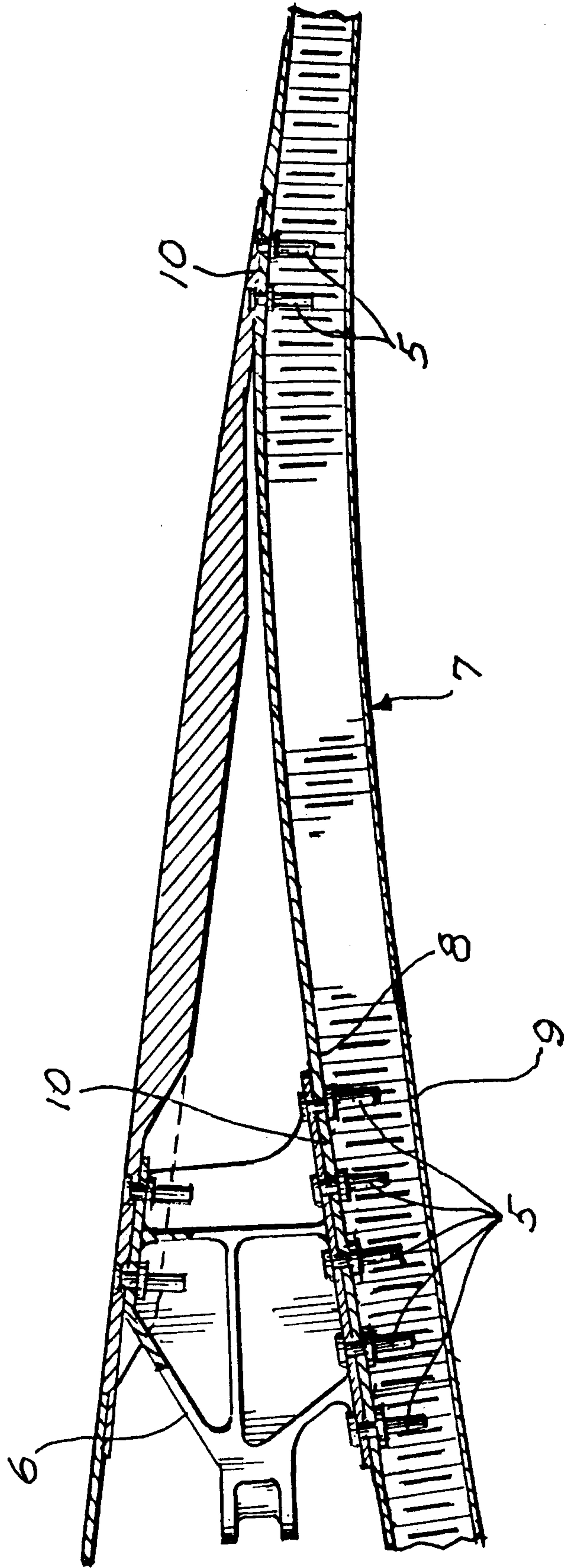


Fig. 6.

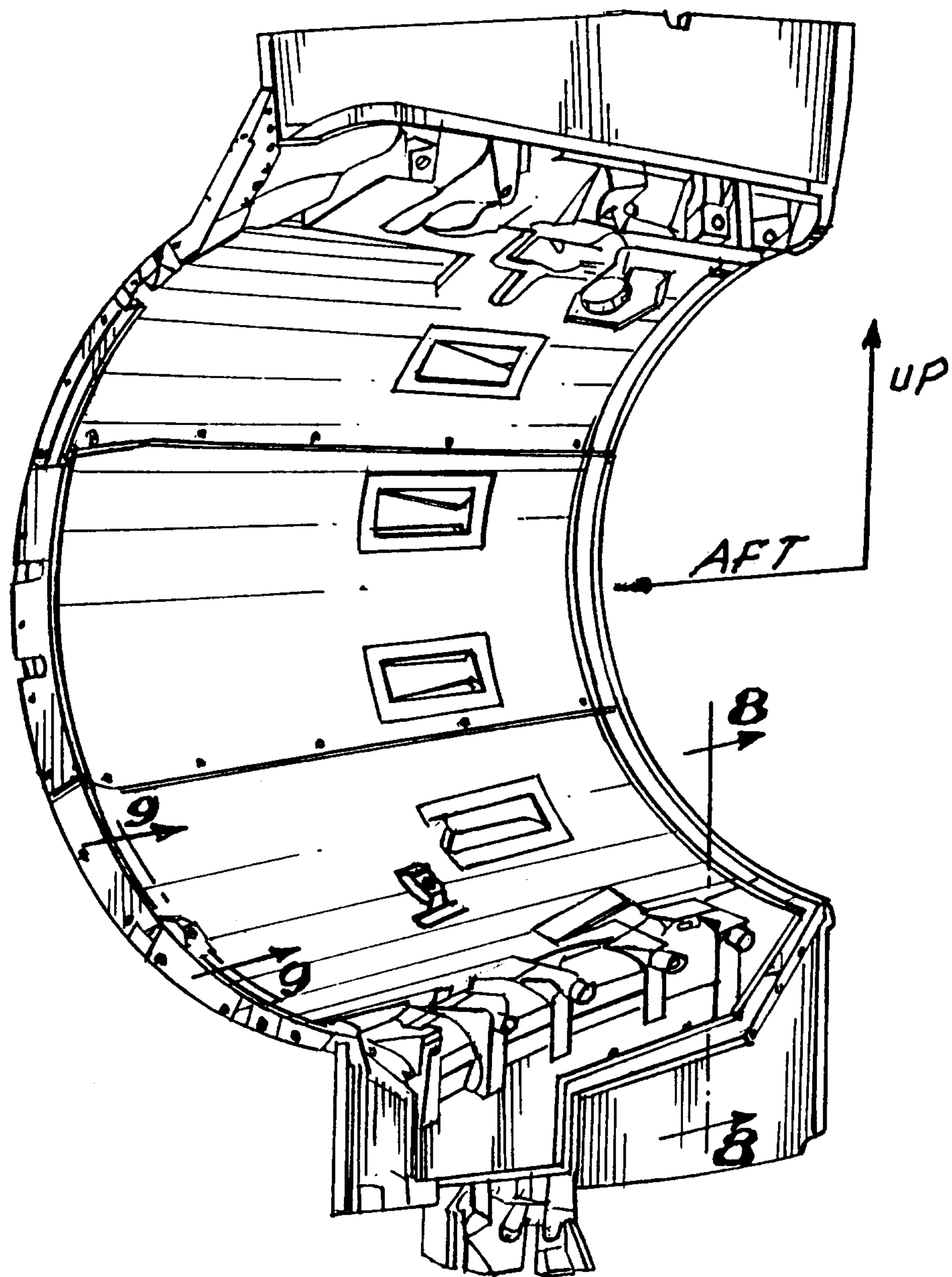


Fig. 7.

Fig. 8.

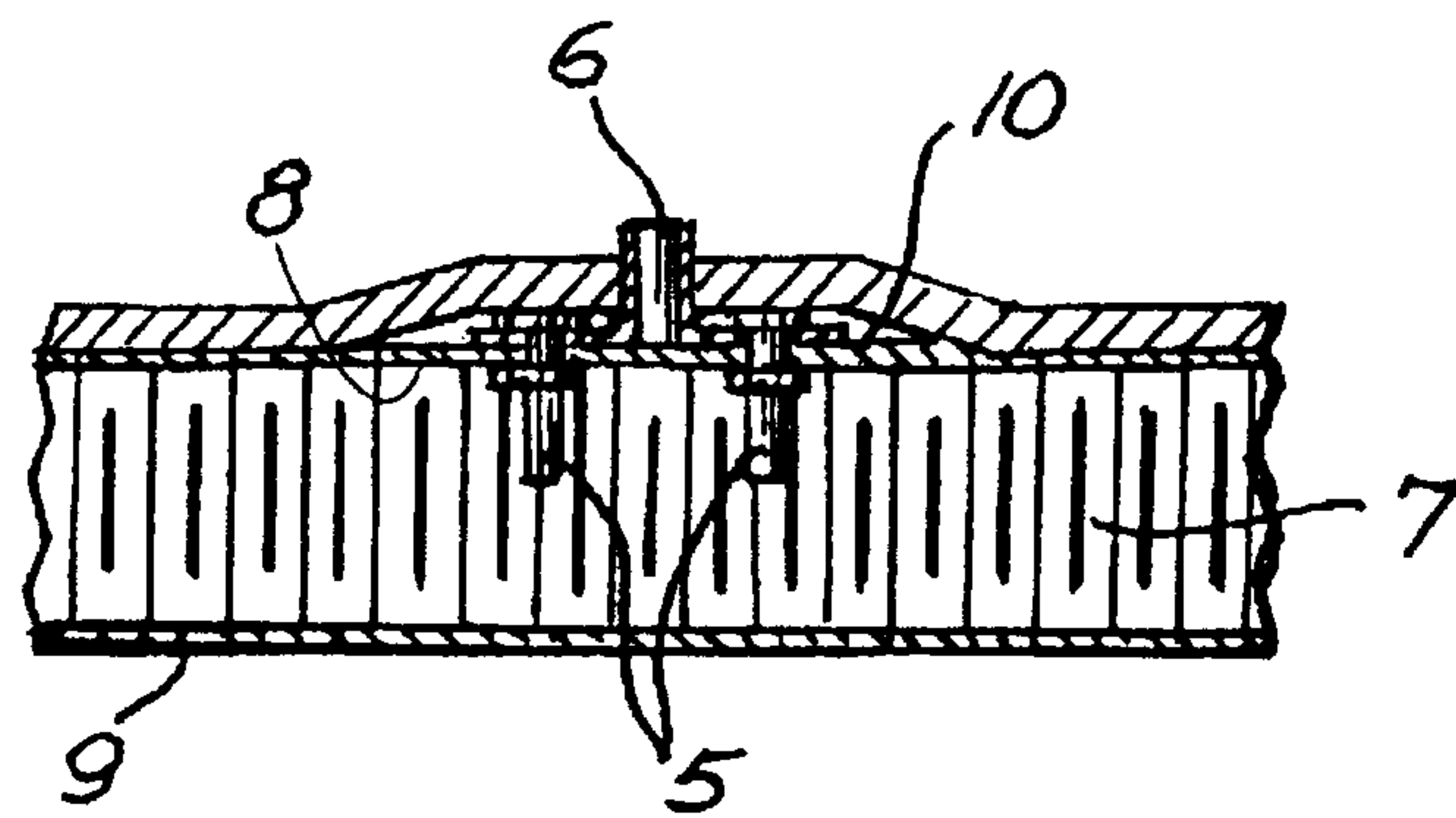
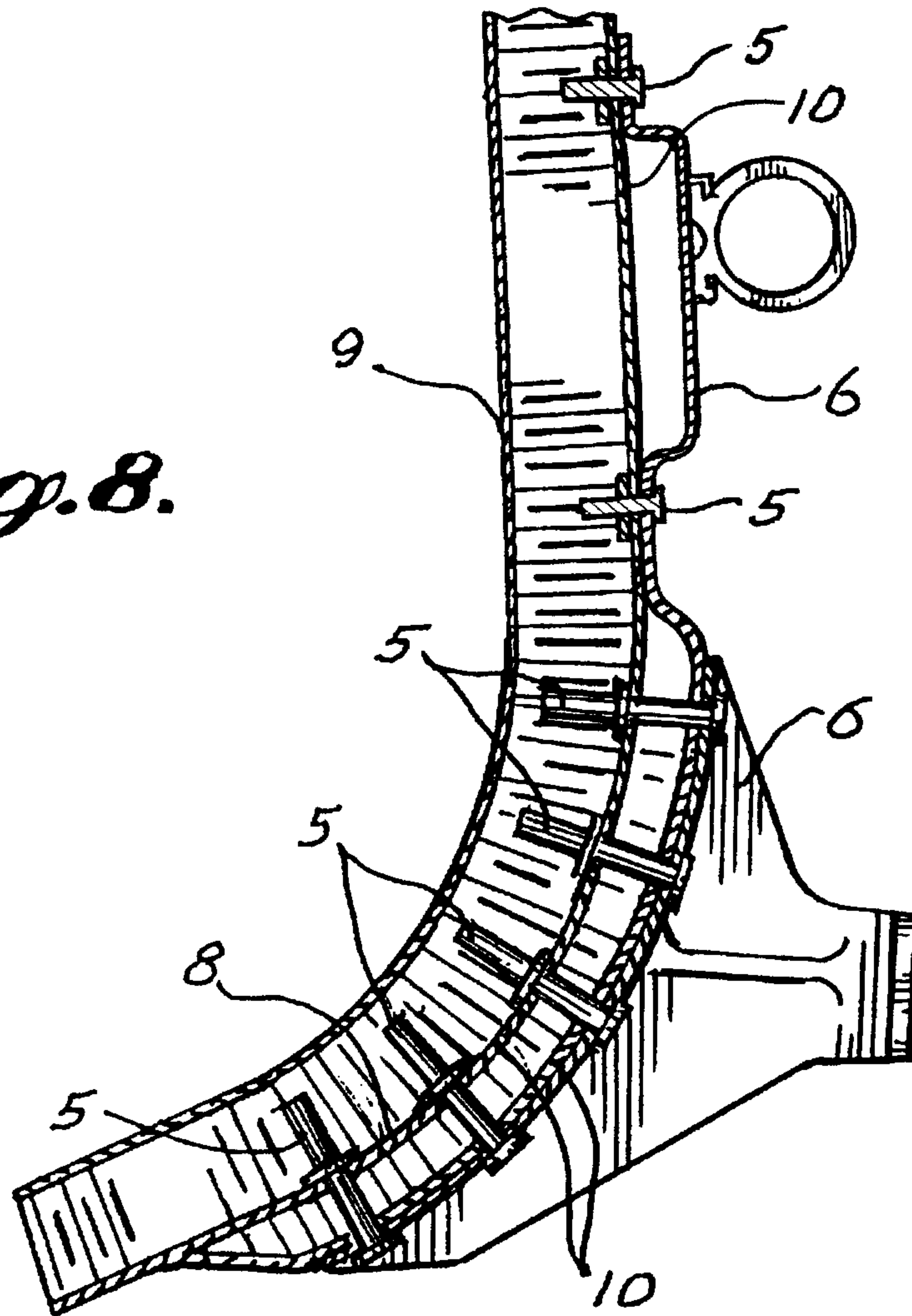


Fig. 9.

