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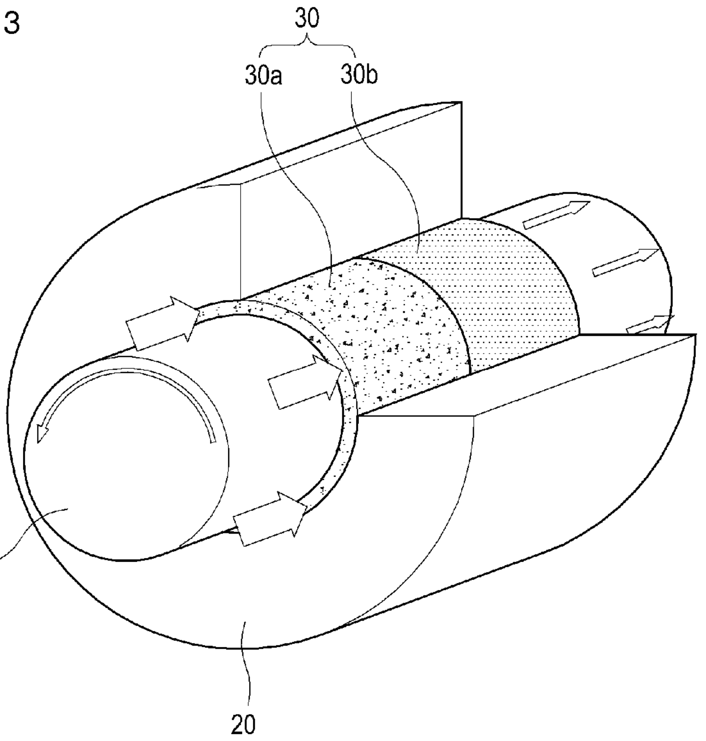
(54) Title: BEARING SEAL FOR GAS TURBINE

Fig. 3



(57) Abstract: A bearing seal for a gas turbine for reducing axial leakage of a working gas of a turbine and for supporting the vertical loads and shear forces efficiently. The seal is disposed on an inner surface of a bearing housing where a rotating shaft is positioned at the center of the bearing housing. The bearing seal includes an elastic porous foil for adjusting leakage of a working gas through the space between the rotating shaft and the bearing housing, wherein a density ratio of the porous foil increases along gas inflow direction. The porous foil is deformed elastically by a dynamic pressure of the working gas leaked around the rotating shaft during rotation of the rotating shaft for making a gap between the porous foil and the rotating shaft.

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Description

BEARING SEAL FOR GAS TURBINE

Technical Field

[1] The present invention relates to a bearing seal for a gas turbine. The present invention can reduce axial leakage of a working gas of a turbine and can support the vertical loads and shear forces efficiently.

Background Art

[2] Generally, a gas turbine rotational device has an in-line gas flow through a gas inlet, a compressor, a combustor, a turbine and outlet. Leakage of the working gas between a rotating shaft of the turbine (or the compressor) and a housing surrounding the rotating shaft deteriorates efficiency of the rotational device. A bearing seal reduces axial leakage of the working gas in the rotational device. Usually, a brush seal is used for reducing such axial leakage.

[3] Figs. 1 and 2 describe the prior art brush seal.

[4] Fig. 1 is a sectional view showing a prior art brush seal of a bearing. Fig. 2 is a perspective view partially showing the brush seal of Fig. 1. As shown in Figs. 1 and 2, a brush seal (3) is mounted to the inner surface of a tubular housing (1) at which a rotating shaft (2) is positioned. The brush seal (3) is made of many setae, one end being fixed to the housing (1) and the other end being free. One end of the brush seal (3) is fixed to a brush holder (4) mounted to the housing (1). The other end, which is free, contacts an outer surface of the rotating shaft (2).

[5] The brush seal (3) can prevent the working gas from leaking. However, the brush seal (3) can be easily worn out by contact with the rotating shaft (2). Thus, there is a problem in the low durability of the brush seal. This is especially a problem in a high speed rotational device, where the brush seal may be worn out very rapidly. Thus, leakage prevention may be deteriorated very rapidly.

[6] Further, the rotational device may have low efficiency because the rotation may be resisted by the frictional force between the brush seal (3) and the rotating shaft (1) when they contact each other.

Disclosure of Invention

Technical Problem

[7] The present invention is conceived to solve the above problems. The present invention may be used in a dynamic pressure bearing that has less friction loss than a bearing having a brush seal. A porous foil with a density ratio varying in an axial direction is disposed on the bearing for adjusting a gap between a surface of a bearing seal and a rotating shaft changeable in proportion to the rotating speed. Thus, the

present invention may provide a dynamic pressure bearing seal of a gas turbine that seals the axial leakage of the working gas efficiently.

Technical Solution

[8] To achieve the objective, a bearing seal for a gas turbine of the present invention disposed on the inner surface of a bearing housing is provided, wherein a rotating shaft is positioned at the center of the bearing housing. The bearing seal comprises an elastic porous foil for adjusting leakage of a working gas through the space between the rotating shaft and the bearing housing with a density ratio of the porous foil increasing in a direction of gas inflow. The porous foil is deformed elastically by the dynamic pressure of the working gas leaked around the rotating shaft during rotation of the rotating shaft for making a gap between the porous foil and the rotating shaft.

[9] The porous foil may include a single porous foil element having a density varying continuously. In contrast, the porous foil may include a plurality of porous foil elements having different density ratios to each other, the porous foil elements being disposed along the rotating shaft.

[10] It is desired that the bearing seal further comprises bump foils disposed at both sides of the porous foil element (or elements).

[11] A top foil can be arranged on the surfaces of the porous foil and the bump foil facing the rotating shaft. Preferably, a gas film formed by the leaked working gas is disposed between the top foil and the rotating shaft during the rotation of the shaft.

[12] A receiving groove for receiving the porous foil and the bump foil may be formed on the bearing housing. Preferably, the porous foil and the bump foil are received in the receiving groove and a shim foil is disposed between the porous and bump foils collectively, and the bearing housing during rotation of the shaft.

Advantageous Effects

[13] The bearing seal of a gas turbine according to the present invention can improve seal's performance of a dynamic pressure bearing while the porous foil, which has a density ratio varying along the rotating shaft, is positioned around a rotating shaft.

[14] Further, according to the present invention, the bump foil is used with the porous foil. Thus, seal performance, vibration damping performance, and shear force supporting performance may be improved.

Brief Description of Drawings

[15] Fig. 1 is a sectional view illustrating a brush seal of a bearing of the prior art.

[16] Fig. 2 is a perspective view partially illustrating a brush seal of Fig. 1.

[17] Fig. 3 is a perspective view illustrating a bearing housing having a bearing seal according to the present invention, the bearing housing being partially removed.

[18] Fig. 4 is a front sectional view illustrating an embodiment of a bearing seal according

to the present invention.

[19] Fig. 5 is a graph illustrating the relationship between density ratio and hardness of a porous foil.

[20] Fig. 6 is a side-sectional view illustrating the bearing seal of Fig. 4, a shear force being applied to the bearing seal.

[21] Fig. 7 is a side-sectional view illustrating the bearing seal of Fig. 4, a load and a shear force being applied to the bearing seal.

[22] Fig. 8 is a side-sectional view illustrating an embodiment having a plurality of porous foils, each having different a density ratio, bump foils being coupled at both ends of the porous foils respectively.

Best Mode for Carrying out the Invention

[23] Referring Figs. 3 to 8, an embodiment of a bearing seal for gas turbine of the present invention is described.

[24] Fig. 3 is a perspective view illustrating a bearing housing having a bearing seal according to the present invention, the bearing housing being partially removed. The present invention relates to a seal of dynamic pressure bearing as illustrated in the drawing. The bearing seal can adjust the amount of a working gas leaked in an axial direction between a rotating shaft (10) and a bearing housing (20). Two porous foil elements (30a, 30b) form a porous foil (30). The elements (30a, 30b) are positioned on an inner surface of the bearing housing (20) around the rotating shaft (10). Each of the elements (30a, 30b) has a different density ratio in an axial direction. Density ratio of the porous foil (30) increases along working gas inflow direction.

[25] The porous elements (30a, 30b) are manufactured of metal chips pressure-molded under a predetermined heat and pressure in a hot plate.

[26] The present invention is not limited to forming the porous foil (30) by two porous foil elements (30a, 30b) as described in the above embodiment. It is understood that the porous foil (30) may be formed by an arrangement of more than two porous foil elements, or by a porous foil element having a density ratio varying continuously.

[27] Fig. 4 is a front sectional view illustrating an embodiment of a bearing seal according to the present invention. As shown in Fig. 4, the bearing seal (30) comprises a porous foil (30) positioned on the inner surface of the bearing housing (20), a bump foil (40) disposed on each of the axial front end and rear end of the porous foil (30), and a top foil (50) forming a gas film of working gas leaked between the top foil (50) and the rotating shaft (10). A shim foil (60) is positioned on the lower surface of the porous foil (30) and the bump foil (40). The shim foil (60) protects the bearing housing (20) surface and produces friction between the porous foil (30) and the bump foil (40). Fig. 4 illustrates a sectional view of the bearing and the rotating shaft in a radial direction

(density ratio of the porous foil (30) not shown). The density ratio of the porous foil (30) varies axially, increasing along the working gas inflow direction.

[28] The porous foil (30), the bump foil (40), the top foil (50) and the shim foil (60) may be manufactured from a beryllium copper, stainless steel, Inconel series steal material, or the like.

[29] Preferably, one end of each foil is fixed to the bearing housing (20) and the other end is free. The bearing housing (20) has a receiving groove (21) for receiving the porous foil (30) and the bump foil (40).

[30] The shim foil (60) can be received in the receiving groove (21). The porous foil (30) has a principal function to reduce axial leakage of the working gas of the gas turbine. However, the shim foil contacts the bump foil (40) for dissipating the vibration energy and protecting the bearing housing (20).

[31] Dynamic and static characteristics of the porous foil (30) can be changed by the density ratio. It is understood that if the density ratio of the porous foil increases, then the working gas leakage will be reduced and the porous foil will be hardened, and dynamic damping characteristics will be improved. The density ratio may be expressed as the following:

[32] MathFigure 1

[Math.1]

$$Density\ ratio = \frac{Mass\ of\ porous\ elastic\ body}{(Volume\ of\ porous\ elastic\ body \times Density\ of\ porous\ elastic\ body)}$$

[33] The amount of working gas leakage can be controlled by adjusting the density ratio of the porous foil (30).

[34] Fig. 5 is a graph illustrating a relationship between a density ratio and hardness of a porous foil. As shown in Fig. 5, the hardness can be changed in proportion to the density ratio of the porous material. It is desired that hardness of the porous foil (30) and the bump foil (40) are the same. The porous foil (30) is made from Inconel or stainless steel in this illustrative embodiment. The hardness of the bump foil (40) should be in the range from 8×10^{10}[N/m^3] to 1.1×10^{11}[N/m^3]. Thus, the preferred density ratio of the porous foil (30) is about 0.7.

[35] Hereinafter, function and effects of an illustrative embodiment of the bearing seal for a gas turbine according to the present invention will now be described.

[36] One end of the porous foil (30) is fixed to the inner surface of the bearing housing (20) and the other end is free. The porous foil (30) contacts the rotating shaft (10) when the rotating shaft (10) is in a stationary state. The rotation of the rotating shaft (10) generates dynamic pressure of the gas, which pushes the porous foil (30) toward the bearing housing (20). Thus, the porous foil (30) and the rotating shaft (10) have a

gap therebetween without contact. That is, the dynamic pressure applied around the rotating shaft (10) acts as a plain seal while the porous foil (30) acts as a brush seal. Thus, the porous foil can reduce axial leakage of the working gas efficiently.

[37] In the present invention, the density ratio of the porous foil (30) varies along the axial direction for adjusting the gap between the top foil (50) and the rotating shaft (10) in proportion to the rotating speed of the rotating shaft (10). The density ratio increases along the working gas inflow direction. Thus, if the leaked working gas having passed through a porous foil (3a) with low density ratio meets the porous foil (3b) with a high density ratio, an orifice-like effect will occur. That is, the top foil which is relatively less resisted may be pressurized. With this effect, a variable gap bearing seal structure in proportion to the pressure of working gas can be achieved. Increasing the rotational speed of the rotating shaft (10) will increase the pressure of working gas. Thus, the gap between the top foil (50) and rotating shaft (10) may be narrower at high speeds than in low speeds. Consequently, friction between the rotating shaft (10) and the seal can be considerably reduced by the wider gap in an initial rotating state, and the leakage of working gas of a gas turbine can be considerably reduced by the narrower gap in proportion to increasing rotation speed. Further, less friction results in improved durability

[38] Fig. 6 is a side-sectional view illustrating the bearing seal of Fig. 4, a shear force being applied thereto. As shown in Fig. 6, working gas is leaked between the top foil (50) of the bearing seal and the rotating shaft and a shear force is produced like the arrow. There are several vesicles in the porous foil (30), making it difficult to mount the fastener for fastening the porous foil (40) to the bearing housing (20). Further, it may be fragile to shear force since its deformation direction is irregular. Thus, the bump foil (40) mounted on the front end and the rear end of the porous foil (30) can support the shear force efficiently.

[39] Fig. 7 is a side-sectional view illustrating the bearing seal of Fig. 4, a load and a shear force being applied thereto. The hardness of the bump foil (40) is close to that of the porous foil (30) for supporting the vertical load efficiently. As shown in Fig. 7, vertical loads and shear forces act simultaneously during the rotation of the rotating shaft. The higher the density ratio of a porous foil (30) is, the less the gas moves through the porous foil (30). Thus, the bearing seal can considerably reduce axial leakage of working gas and the seal performance can be improved when it uses the porous foil (30). One end of the bump foil (40) can be pin jointed or welded to the inner surface of the bearing housing (20). Thus, the bump foil (40) can be mounted on the bearing housing (20) strongly and can support the axial shear force.

[40] In other words, the density ratio of the porous foil varies along the axial direction for maximizing sealing function. Further, the bump foil (40) is positioned at both ends of

the porous foil (30) for maximizing vibration damping effects and supporting axial shear force well.

[41] Fig. 8 is a lateral sectional view illustrating an embodiment having a plurality of porous foils, each having a different density ratio with respect to each other. Bump foils are coupled at both ends of the porous foils respectively. In this embodiment, the bump foils (140a, 140b) are positioned at both ends of the porous foil elements (130a, 130b) respectively, and density ratios of the porous foil elements are different to each other. The characteristics of each bump foil may match those of the corresponding porous foil. Thus, there are advantages for reducing the axial leakage of working gas and for supporting vertical loads and shear forces.

[42] In embodiments of bearing seals described above, the multiple porous foil elements having density ratios different to each other are arranged. But, the present invention is not limited to these embodiments. The present invention may have a porous foil having a density ratio continuously varying along an axial direction.

[43] While the present invention has been described and illustrated with respect to a preferred embodiment of the invention, it will be apparent to those skilled in the art that variations and modifications are possible without deviating from the broad principles and teachings of the present invention, which should be limited solely by the scope of the claims appended hereto.

Claims

[1] A bearing seal for gas turbine comprising:
a porous foil positioned on an inner surface of a bearing housing, a rotating shaft being disposed at the center thereof, the porous foil including a porous elastic body for adjusting leakage of working gas between the rotating shaft and the inner surface of the bearing housing,
wherein the density ratio of the porous foil increases along the gas inflow direction,
wherein the porous foil is elastically deformed by dynamic pressure of leaked working gas around the rotating shaft during rotation of the rotating shaft so as to maintain a gap between the porous foil and the rotating shaft.

[2] The bearing seal of Claim 1, wherein the porous foil is formed having a single porous foil element having a continuously varying density ratio.

[3] The bearing seal of Claim 1, wherein the porous foil is formed having a plurality of porous foil elements, each of the porous foil elements having density ratios different to each other, the porous foil elements being arranged along the rotating shaft.

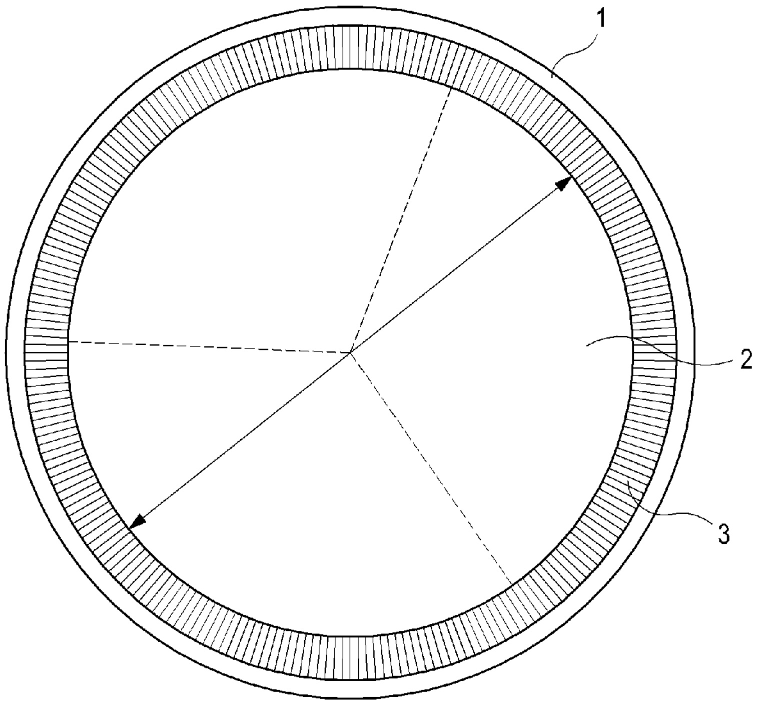
[4] The bearing seal of any one of Claims 1 to 3, further comprising bump foils disposed on both ends of each porous foil element.

[5] The bearing seal of Claim 4, wherein a top foil is positioned on the surfaces of the porous foil and the bump foil facing the rotating shaft for forming a gas film of the leaked working gas between the top foil and the rotating shaft during rotation of the shaft.

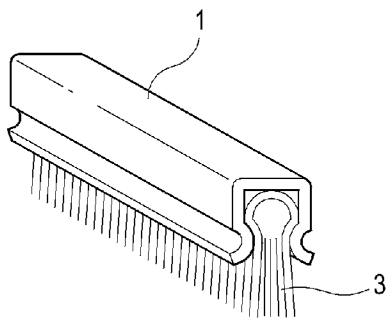
[6] The bearing seal of Claim 1, wherein a receiving groove for receiving the porous foil and the bump foil is formed on the bearing housing.

[7] The bearing seal of Claim 6, wherein a shim foil is disposed on the receiving groove between the porous and the bump foils collectively, and the bearing housing during the rotation of the shaft.

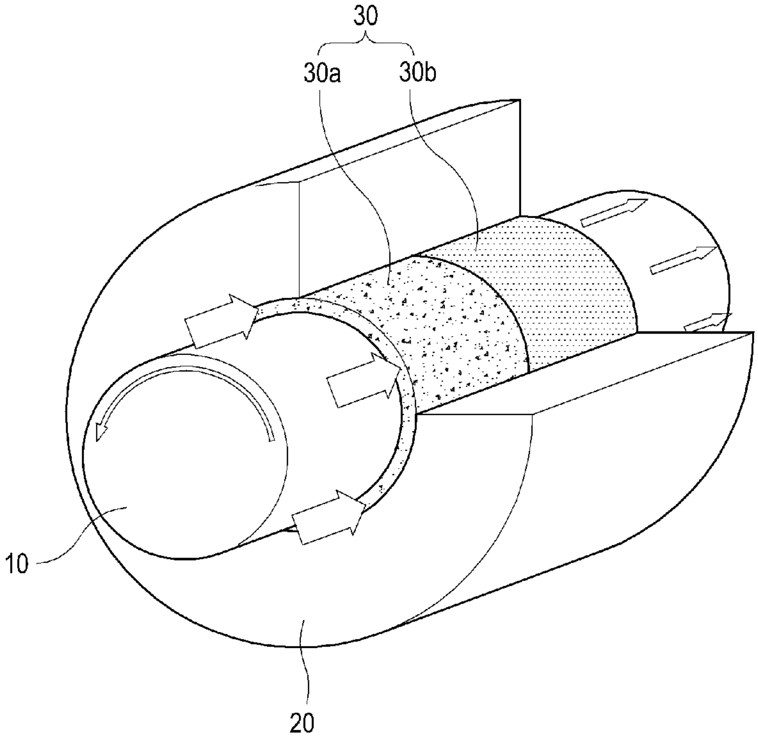
[Fig. 1]



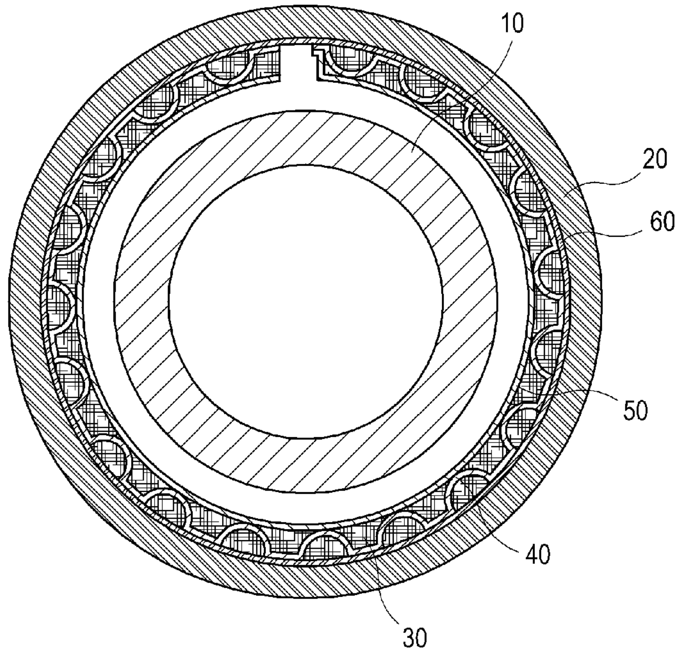
[Fig. 2]



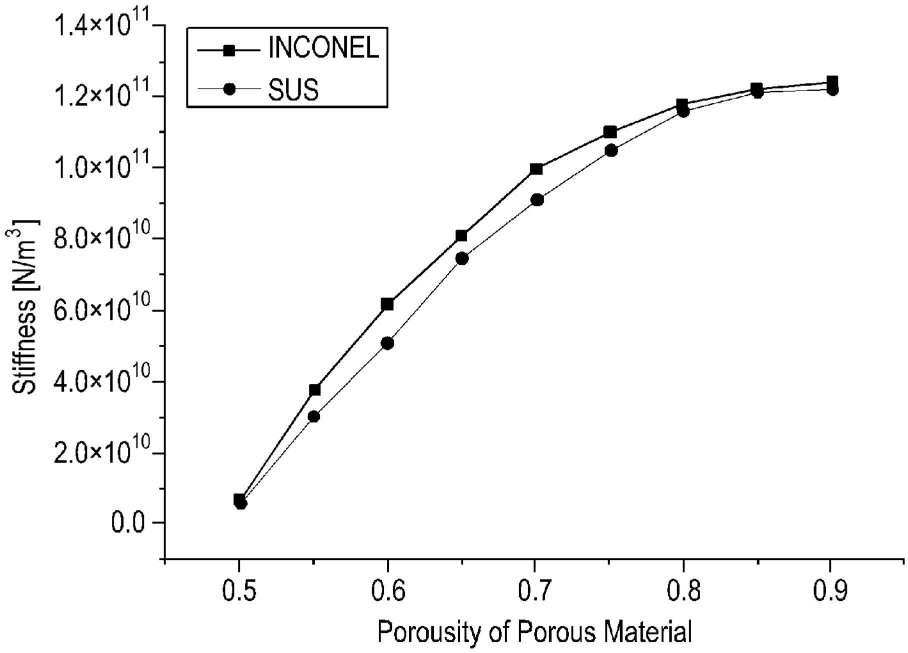
[Fig. 3]



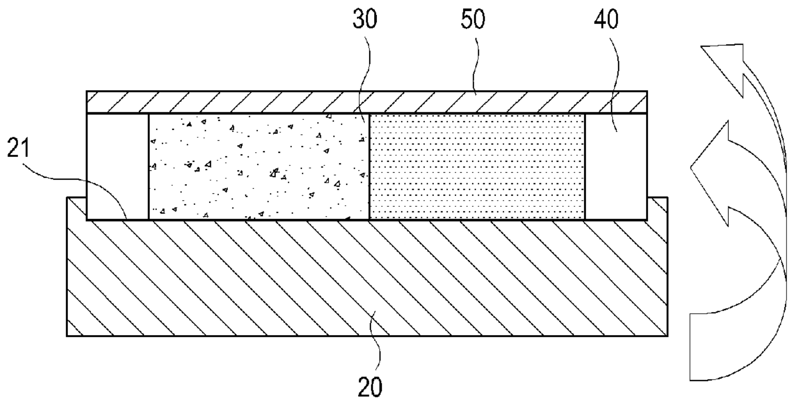
[Fig. 4]



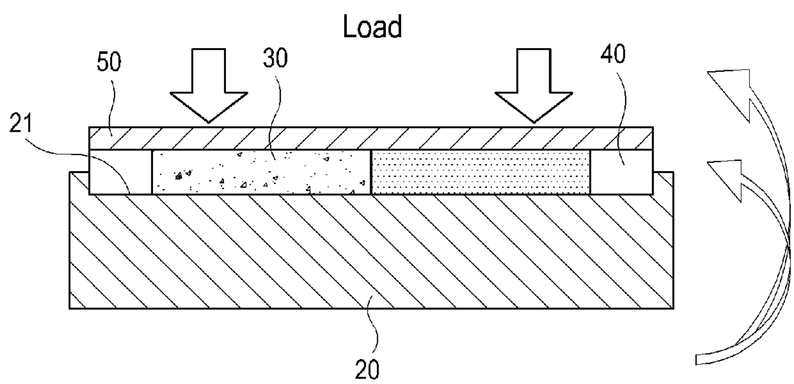
[Fig. 5]



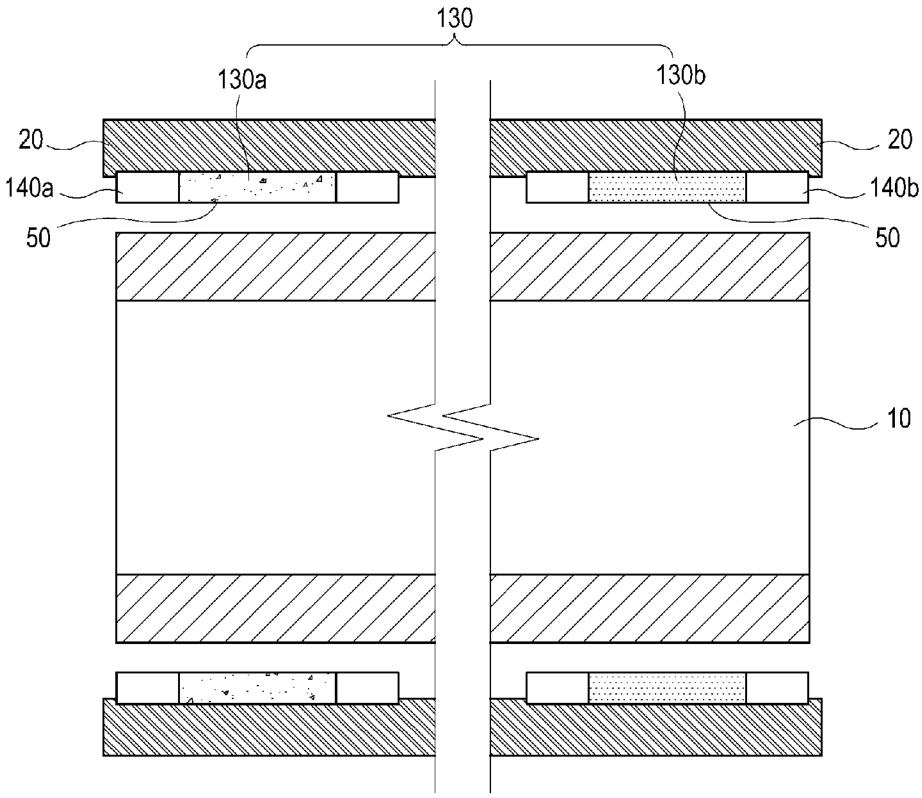
[Fig. 6]



[Fig. 7]



[Fig. 8]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/005415

A. CLASSIFICATION OF SUBJECT MATTER

F16C 33/78(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 8 F16C 17/04, F16C 27/02, F16C 32/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models since 1975
Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS (KIPO internal) & Keywords: foil and porous and (conti* or differ*) and (density or porocity or elasti* or deform*)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
23 JULY 2008 (23.07.2008)

Date of mailing of the international search report
24 JULY 2008 (24.07.2008)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/005415

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