# United States Patent [19]

**Profant**

[11] **3,887,299**

[45] **June 3, 1975**


[54] **NON-ABRADABLE TURBINE SEAL**


[75] Inventor: **Daniel Profant**, Glastonbury, Conn.

[73] Assignee: **The United States of America as represented by the Secretary of the Air Force**, Washington, D.C.



[22] Filed: **Aug. 28, 1973**

[21] Appl. No.: **392,381**

[52] **U.S. Cl.** ..... **415/174**; 415/214

[51] **Int. Cl.** ..... **F01d 11/08**

[58] **Field of Search** ..... 415/113, 172 A, 173, 174, 415/214; 277/96, 233



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,447,957 | 8/1948 | Moore | 415/174 |
| 2,927,724 | 3/1960 | Wardle | 415/113 |
| 2,994,472 | 8/1961 | Botje | 415/174 |
| 3,042,367 | 7/1962 | Welsh | 415/113 |
| 3,146,992 | 9/1964 | Farrell | 415/174 |
| 3,291,382 | 12/1966 | Blackhurst et al. | 415/214 |
| 3,502,596 | 3/1970 | Sowards | 415/174 |
| 3,542,152 | 11/1970 | Adamson | 415/214 |
| 3,575,427 | 4/1971 | Lapac | 415/174 |
| 3,708,242 | 1/1973 | Bruneau et al. | 415/214 |
| 3,720,419 | 3/1973 | Adellizzi | 415/174 |



*Primary Examiner*—Henry F. Raduazo

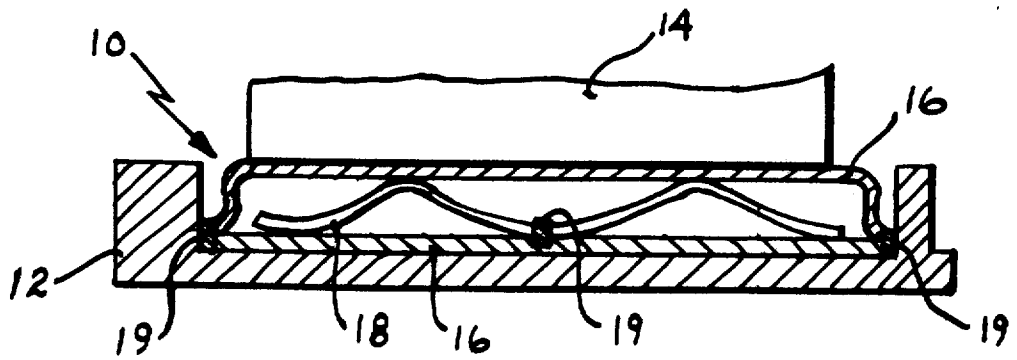
*Attorney, Agent, or Firm*—Jacob N. Erlich



[57] **ABSTRACT**

A non-abradable turbine seal for use between the blade member and surrounding shroud of the turbine engine. The seal may take on a variety of configurations, any one of which constructed to allow deformation thereof by the blade member, either because of rotor growth or shroud eccentricities. The seals are made of oxidation resistant compressible or crushable materials in the form of thin metallic foil, pads, ceramic hollow spheres or thin walled tubing.


**3 Claims, 5 Drawing Figures**



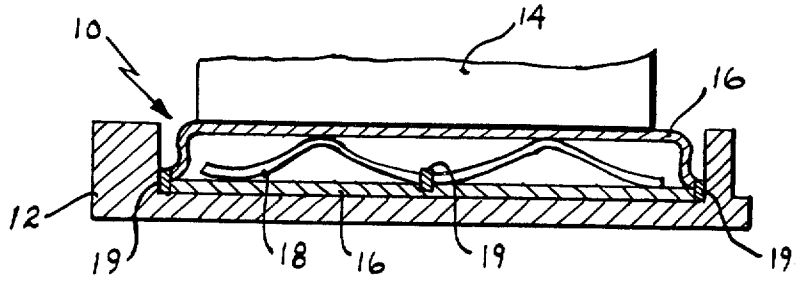



FIG. 1

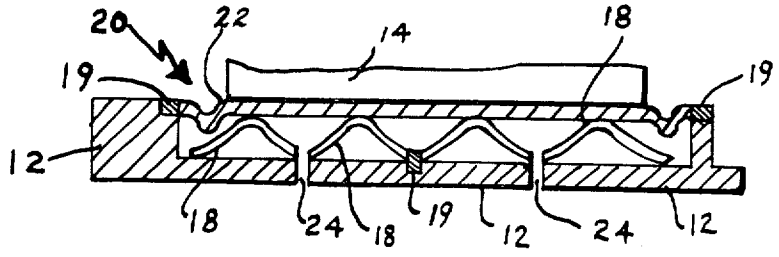



FIG. 2

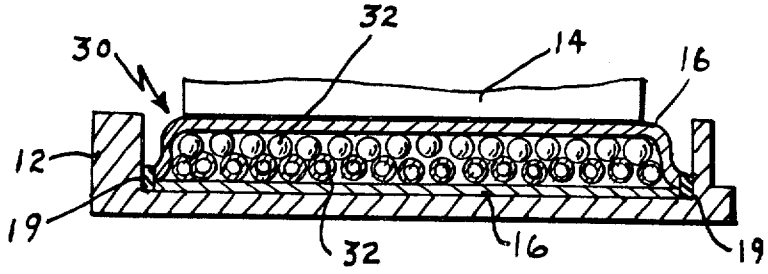



FIG. 3

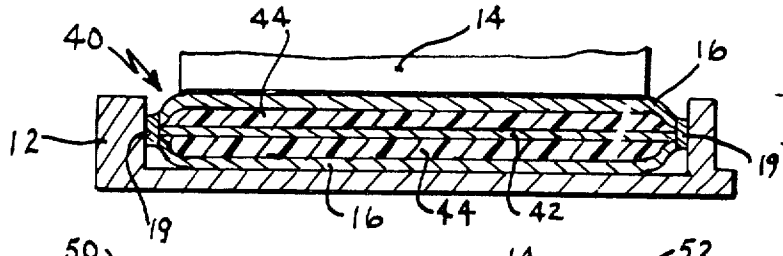



FIG. 4

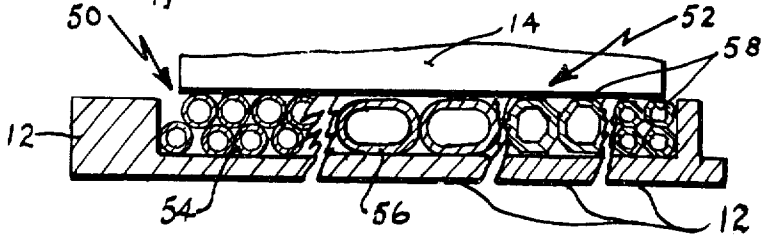



FIG. 5

# NON-ABRADABLE TURBINE SEAL

## BACKGROUND OF THE INVENTION

This invention relates generally to seals to be used with turbine blades, and more particularly, to compressible or crushable seals which permit the deformation thereof by either rotor shroud eccentricities or rotor growth.

It is well known that the efficiency of the gas turbine engine is dependent in part upon the dimensional tolerances that are maintained during the production of the engine assembly. A particularly difficult dimensional tolerance to maintain is concerned with the peripheral seal between the free ends of the rotor blades and the surrounding casing. The use of abradable sealing materials as a lining for the casings is well known in the art. Such materials have been used to avoid damage due to the rubbing contact of the rotor blades with the compressor casing and further, to effect the necessary seal between the moving parts.

The problems encountered by the use of abradable turbine outer seals are numerous. For example, these seals have either oxidized and/or eroded in the severe turbine environment or conversely, the more dense materials that resist erosion are not sufficiently abradable and cause excessive blade wear. In addition, the relatively high processing temperature required to manufacture such abradable materials creates problems of distortion and dimensional inaccuracy in the seal structure. As a result of such high processing temperature requirements, the abradable seal material is difficult to repair or patch after assembly in an engine or in an engine component.

## SUMMARY OF THE INVENTION

The instant invention sets forth a plurality of seal structures which are compressible or crushable and thereby overcome the problems set forth hereinabove.

The seals set forth in this invention permit seal deformation by either the turbine shroud eccentricities or the rotor growth but yet avoid the erosion which has occurred in porous, metallic abradable seal material utilized in the past. These seals are capable of being inserted within the shroud or spacer which surrounds the the blade member of a conventional turbine engine and may take on a variety of configurations. For example, they may be formed of foil and subsequently brazed or welded to the shroud in such a manner to permit lateral movement thereof or in another modification the foil may be crimped to minimize tensile stresses during deformation in the engine. Additionally, cooling openings may be inserted in the shroud. Furthermore, the seal may take on the form of hollow spheres or folded sections manufactured of compressible metal or ceramic felt. Also this filler material may be in the form of thin walled tubes joined together and then brazed within the shroud.

It is therefore an object of this invention to provide a non-abradable, compressible or crushable seal which is capable of use between relatively moveable parts.

It is another object of this invention to provide non-abradable seal material which is strong and lightweight.

It is a further object of this invention to provide a seal material which is economical to produce and which utilizes conventional, currently available components that lend themselves to standard mass producing manufacturing techniques.



For a better understanding of the present invention together with other and further objects thereof reference is made to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

## DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view of one embodiment of the non-abradable turbine seal of this invention, shown partially in cross section;

FIG. **2** is a side elevational view of another embodiment of the non-abradable turbine seal of this invention, shown partly in cross section;

FIG. **3** is a side elevational view of a further embodiment of the non-abradable turbine seal of this invention, shown partly in cross section;

FIG. **4** is a side elevational view of still another embodiment of the non-abradable turbine seal of this invention, shown partly in cross section; and

FIG. **5** is a side elevational view of further embodiments of the non-abradable turbine seal of this invention, shown partly in cross section.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to FIGS. **1–5** of the drawing which set forth the plurality of non-abradable turbine seals of the instant invention. The turbine seals will be represented by numerals **10, 20, 30, 40** and **50** in FIGS. **1–5** of the drawing, respectively, and like elements in each figure will be identified by like numerals.

Generally, a shroud or spacer **12** cooperates with and surrounds a blade member **14,** one of which rotates with respect to the other in a conventional turbine arrangement. For example, blade member **14** can be attached to a rotating compressor wheel (not shown) or shroud **12** can be carried between and rotate with rotating compressor wheels (not shown) opposite a stationary blade member **14.** Located within shroud **12** and opposite blade member **14** is the turbine seal **10,** 20, 30, 40 or **50** of this invention.

Reference is now made to FIG. **1** of the drawing which sets forth a rectangular-shaped non-abradable compressible seal **10** made up of a foil material **16.** This seal **10** forms a housing which is secured within shroud **12.** Foil **16** is of nominal **5-10** mil thickness and manufactured of an oxidation resistant and easily deformable metal such as NiCrAlY, FeCrAlY, Hastelloy X. Within foil housing **16** is a foil strip **18** of similar material to foil **16** but of sine-wave configuration. The foil housing **16** as well as the sine-wave foil **18** are welded or brazed together at appropriate places **19.** The configuration as shown in FIG. **1** permits the lateral movement of turbine seal **10** under the action of blade **14.**

Reference is now made to FIG. **2** of the drawing. The turbine seal **20** set forth therein has an upper foil member **22** made of any suitable easily deformable material as set forth hereinabove fixedly secured to shroud **12** with a plurality of curved foil sections **18** located therebetween. A plurality of apertures **24** are located within shroud **12** and allow for the admittance of cooling air or other fluid during the operation of the turbine. It should also be pointed out that apertures **24** are capable of being used within any embodiment shown in FIGS. **1–5.**

FIG. **3** sets forth a crushable turbine seal **30** having an outer structure **16** similar in nature to the outer

structure **16** in FIG. **1.** In the embodiment shown in FIG. **3,** however, the sine-wave foil strip **18** is replaced by a plurality of crushable metal or ceramic hollow spheres **32.** This arrangement again allows for the deformation of seal **30** under the action of blade **14.**

FIG. **4** sets forth turbine seal **40** which contains therein a straight piece of foil material **42** within an outer foil housing **16** and further contains therein compressible metal or ceramic felt or matte **44** of about 10–15% density.

FIG. **5** illustrates a turbine seal **50** which takes the form of a plurality of thin walled tubular shaped elements **52.** Elements **52** may be of a cylindrical shape **54,** oval shape **56** or hollow elements of any other desired configuration **58.** Any suitable deformable material as set forth hereinabove can be utilized in their manufacture.

The non-abradable seals **10, 20, 30, 40** and **50** of this invention are capable of being interchanged within shroud **12** depending upon the type of blade **14** or shroud **12** construction. With the non-abradable seals set forth hereinabove virtually all problems heretofore encountered with abradable seals have been eliminated.



Although this invention has been described with reference to a variety of embodiments which will be understood to those skilled in the art, this invention is also capable of further embodiments within the spirit and scope of the appended claims.

I claim:

**1.** In a turbine engine comprising a rotating blade member and a surrounding fixed shroud wherein said improvement comprises a non-abradable seal having an outer housing located within and fixed to said shroud, said outer housing being made of an easily deformable foil material and a thin deformable foil material of sine-wave configuration being located within said outer housing with the peaks and depressions of the sine-wave being directed axially and facing the rotating blade member; thereby allowing for the lateral displacement of said seal under the action of said rotating blade member.

**2.** In a turbine engine as defined in claim **1** wherein said foil material is between 5–10 mils thick.

**3.** In a turbine engine as defined in claim **2** wherein said foil material is NiCrAlY.

* * * * *