United States Patent

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[54] **CERAMIC CROSSARM SEAL FOR GAS TURBINE REGENERATORS**

8 Claims, 4 Drawing Figs.

[52] U.S. Cl. 277/96, 165/9

[51] Int. Cl. F16j 15/34

[50] Field of Search 277/232, 227, 81, 96, 102, 113; 165/9

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ABSTRACT: A thin walled steel case has a ceramic shoe projecting through an opening in one side thereof. Externally facing shoulders along the longitudinal edges of the shoe bear against the edges of the case. A fibrous resilient ceramic material fills the remainder of the case and is located between the bottom of the shoe and the base of the case to adsorb deflecting forces.

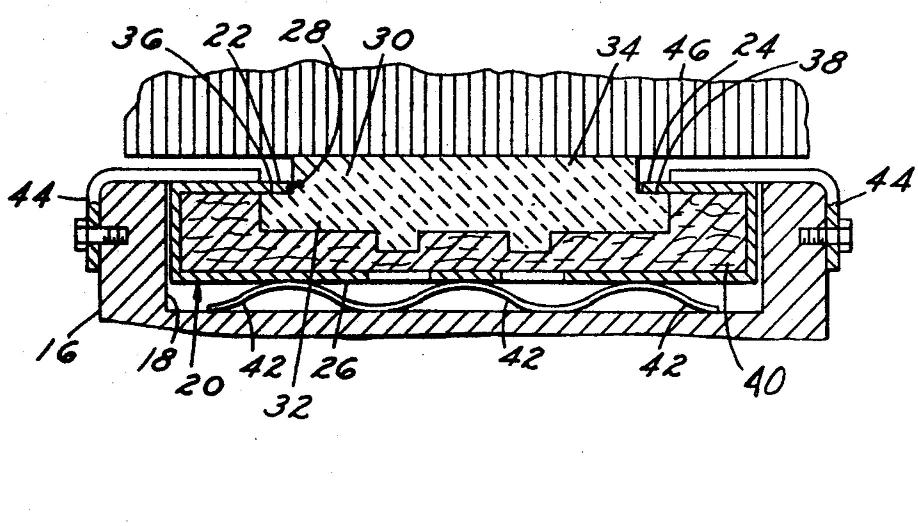


FIG. 1

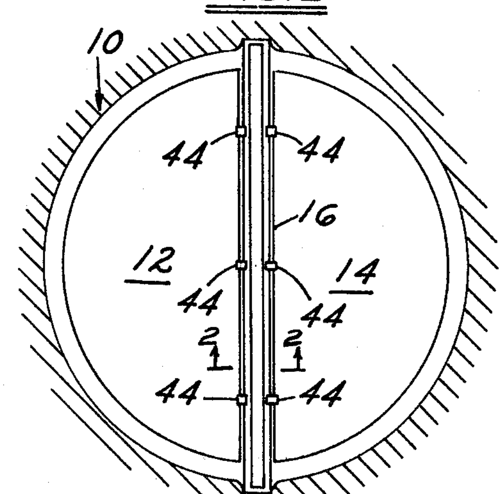


FIG. 2

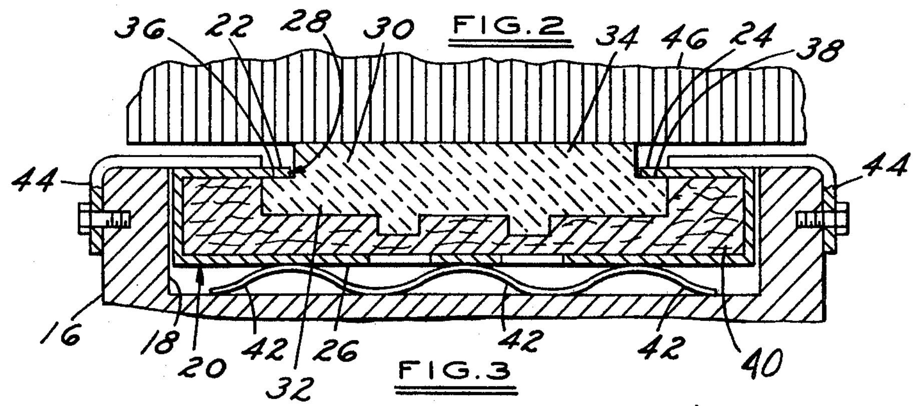


FIG. 3

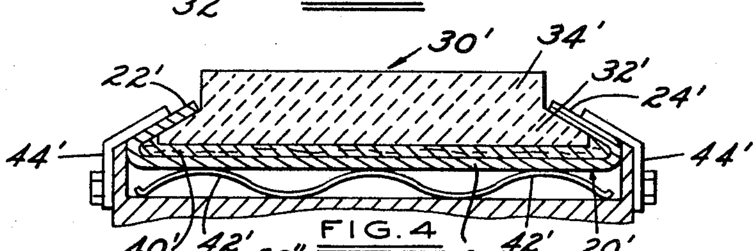
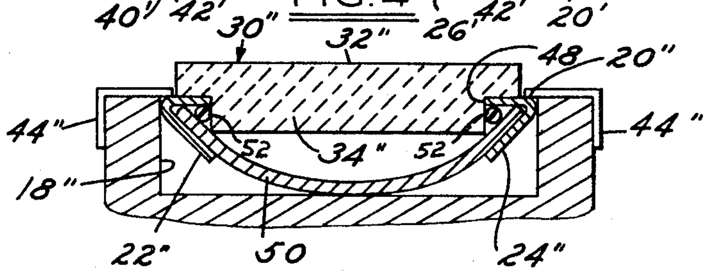


FIG. 4



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CERAMIC CROSSARM SEAL FOR GAS TURBINE REGENERATORS

SUMMARY OF THE INVENTION

Crossarm seals for gas turbine engine regenerators are subjected to widely varying temperature gradients both laterally across the seal and longitudinally along the seal. Coated metal seals have been used as the crossarm and have performed satisfactorily as far as friction and wear are concerned, but the differences in expansion coefficients of the metal shoe and the ceramic regenerator produce forces and distortion that lead to gas leakage.

This invention provides a seal for use in rubbing against a ceramic regenerator that can be made of the same ceramic material as the regenerator. The rubbing shoe of the seal thus has thermal expansion characteristics closely approximating the thermal expansion characteristics of the corresponding regenerator. In addition, the seal is capable of absorbing minor manufacturing variations between the regenerator and the engine housing. The seal comprises a thin walled case member having a base and longitudinal edges folded partially back over the base to define a longitudinal opening in one side of the case member. A structurally integral ceramic shoe is positioned in the opening of the case member. Externally facing shoulders along the longitudinal edges of the ceramic shoe bear against the edges of the case member forming the opening. A resilient material is located in the case member between the base of the case member and the inner surface of the ceramic shoe where the resilient material urges the ceramic shoe out of the case so the outer surface of the ceramic shoe bears against the moving ceramic regenerator.

A typical case member has a substantially rectangular cross section with a longitudinal opening in one of the larger walls. Alternatively the case can have a truncated triangular cross section. A groove is formed in the top of the bulkhead separating the two gas flow passages of the engine housing and the case member can be mounted in the groove on top of additional spring elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a gas turbine engine showing a crossarm seal made according to this invention.

FIG. 2 is a cross-sectional view taken along line 2—2 in FIG. 1 showing a seal made with a case having a rectangular cross section.

FIG. 3 is a cross-sectional view similar to FIG. 2 of a seal case having a truncated triangular cross section.

FIG. 4 is a cross section of a seal having a case made with an inverted truncated triangular section. A folded spring is located between the case edges and a ceramic shoe is mounted in the base of the triangular case.

DETAILED DESCRIPTION

The housing of a gas turbine engine is represented by numeral 10 in FIG. 1. Housing 10 contains two semicircular gas passages 12 and 14 separated substantially along a diameter by a bulkhead 16. A shallow groove 18 having a substantially rectangular cross section is cut into the upper surface of bulkhead 16 as shown in FIG. 2.

A seal assembly is made by forming a thin walled case member 20 into a rectangular shape having a width fitting into groove 18. Case member 20 typically is made of a metal such as stainless steel. The longitudinal edges 22 and 24 of case member 20 are folded partially back over its base 26 to define a longitudinal opening 28.

Positioned in opening 28 is a structurally integral ceramic shoe 30. Shoe 30 typically is made of ceramic materials such as zirconia, strontia, or other metallic oxides and halides and comprises a wide portion 32 reducing to a narrow portion 34 at externally facing shoulders 36 and 38. Shoulders 36 and 38 fit against the lower surfaces of edges 22 and 24 with narrow portion 34 projecting outward through opening 28. A resilient material 40, which can be a fibrous ceramic such as glass wool, fills the remainder of the case member with a significant depth of the resilient material positioned between the bottom surfaces of shoe 30 and base 26 of the case member. The resilient material cushions any sudden impacts or loads and also assists in absorbing dimensional changes caused by the thermal expansion.

The seal assembly is located in groove 18 on top of a leaf type spring 42 and a plurality of metal L-shaped clamps 44 fastened to the sides of bulkhead 16 project over the upper edges of case member 20 to hold the seal assembly in place in the groove. A ceramic regenerator 46 then is mounted for rotation above the seal assembly where the regenerator bears against the upper surface of shoe 30. Since thermal expansion coefficients of the regenerator and the shoe are substantially equal, thermally induced dimensional changes produce similar behavior of the regenerator and the shoe. Good contact between the shoe and the regenerator is maintained throughout a wider temperature range to insure good sealing during all phases of engine operation. Any variations that might occur are absorbed readily by the resilient material 40 or by spring 42.

At initial installation, case 20 is moved downward in groove 18 by the force exerted by the regenerator on the seal. Spring 42 absorbs the force and applies a sealing load that holds the upper surface of the shoe against the regenerator. The spring urges the case upward to absorb shoe wear and also seals the area between the groove and the case.

Referring to the alternate construction shown in FIG. 3, case member 20′ has the cross section of a truncated triangle with edges 22′ and 24′ projecting upward above base 26′. The wider portion 32′ of the shoe 30′ has a trapezoidal cross section with its angled sides corresponding to the angles of the edges 22′ and 24′. Narrow portion 34′ of shoe 30′ is substantially rectangular and has a width corresponding to the width of the opening defined by edges 22′ and 24′. A layer of resilient material 40′ is positioned between the base of shoe 30′ and the base of case member 20′ and a leaf-type spring 42′ is positioned between the base of the case member and the bottom of the groove. Clamps 44′ are fastened to the sides of bulkhead 16′ and have upper legs angled over the projecting edges of case 20′ to hold the case in place on top of the bulkhead.

The FIG. 3 construction reduces any tendency of the ceramic shoe to tip laterally under the forces exerted by the rotating regenerator. Broader surface contact thus is maintained between the surface of the shoe and the regenerator, which reduces regenerator wear.

In the more flexible alternate construction shown in FIG. 4, case member 20″ is an inverted version of case member 20′ that has a longitudinal slot 48 cut into base 26″. The ends of the case member lack both the slot 48 and opening 28″ and thus connect the two sides of the case member together. A flexible metal leaf 50 is positioned between downwardly facing edges 22″ and 24″ and lengths of wire 52 are positioned between the shoe and the ends of the leaf to hold the leaf in position while permitting leaf flexing. Shoe 30″ has its wide portion 32″ projecting upward out of the case and a narrow portion 34″ located within the case. Clamps 44″ fastened to the bulkhead retain the seal assembly in groove 18″.

Flexing of metal leaf 50 absorbs vertical movement of shoe 34″ caused by distortion or other forces. Leaf 50 also can tilt on the bottom of groove 18″ to absorb any distortion. In addition, the leaf seals the area between the seal and the housing.

Thus this invention provides a seal that has thermal characteristics substantially similar to the characteristics of a ceramic regenerator. The seal installation compensates for wear and readily absorbs load differentials. Seals of the invention can be used at the periphery or diameter of a rotating regenerator.

I claim:

1. In a gas turbine engine having a housing and a rotating regenerator mounted in said housing, a seal for said rotating

regenerator having good oxidation resistance, good dimensional stability throughout a wide temperature range, and a low coefficient of friction and low wear when rubbing against a ceramic material, said seal comprising

a thin walled case member having a base and longitudinal edges folded partially back over said base to define a longitudinal opening in one side of said case member,

a structurally integral ceramic shoe positioned in said opening, said ceramic shoe having externally facing shoulders along its longitudinal edges, said shoulders bearing against the edges of said case forming said opening, and

resilient material located in said case member between the base of the case member and the inner surface of said ceramic shoe, said resilient material urging said ceramic shoe out of said case member so the outer surface of said ceramic shoe bears against a moving ceramic material to seal the surface between the ceramic material and the ceramic shoe.

2. The engine of claim **1** in which the resilient material comprises a cushion made from fibrous ceramic material.

3. The engine of claim **2** in which the case member has a substantially triangular cross section with one of the angles thereof being truncated to form said opening, and the shoe member has a trapezoidal lower portion mounted within said case, said trapezoidal lower portion being integral with a rectangular upper portion projecting through said opening.

4. The engine of claim **3** comprising spring means located outside of said case member for maintaining contact between said ceramic shoe and said moving ceramic material.

5. In a gas turbine engine having a housing and a rotating regenerator mounted in said housing, a seal for said rotating regenerator comprising

a case member having a base and longitudinal edges folded over said base to define a longitudinal opening in one side of said case member, said case member being mounted in a groove in said housing, and

a ceramic shoe positioned in said opening of said case, said shoe bearing against said rotating regenerator.

6. The engine of claim **5** comprising spring means located between said case and the bottom of said groove for urging said case member out of said groove, said spring means maintaining said shoe in contact with said regenerator and sealing the area between said case and said groove.

7 The engine of claim **6** in which the spring means is a foil member having its longitudinal edges retained in said case member and its central portion bowed away from the case member, said central portion bearing against the bottom of said groove.

8. The engine of claim **6** in which the case member has a substantially triangular cross section, said case being truncated across one of its corners to form said opening, said case member mounted in said groove with the side opposite the truncated angle facing the bottom of the groove, and the shoe has a trapezoidal lower portion mounted within the longitudinal edges of the case, said trapezoidal portion being integral with a rectangular portion extending through said opening.