PATENT SPECIFICATION (11) 1 598 926

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(21) Application No. 45665/77 (22) Filed 3 Nov. 1977
(23) Complete Specification filed 24 May 1978
(44) Complete Specification published 23 Sept. 1981
(51) INT CL³ F16J 15/16
(52) Index at acceptance F2B 13CX6

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(19)

(54) IMPROVEMENTS IN BRUSH SEALS

(71) We, ROLLS-ROYCE LIMITED, a British Company of 65 Buckingham Gate, London SW1E 6AT, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to brush seals.

Brush seals for use as fluid seals for gas turbine applications and are described in our UK Patent Specification No. 1,450,553.

In this specification there is described a seal in which one of the sealing elements comprises a plurality of tightly packed bristles sandwiched between and projecting from, a pair of side-plates, and the other sealing element comprises a co-operating sealing surface. The bristles are integrally joined with the side-plates. In a preferred form of the seal, the side-plates are annular and the bristles project from between the side-plates with a circumferential component of direction.

In such seals it is important that the bristles retain their flexibility, which requires that a minimum length of each bristle is free to bend, and yet if the lengths of the exposed bristles are too long, the bristles are easily damaged.

According to the present invention a brush seal comprises a mass of bristles packed together to form a seal against passage of fluid therethrough, said bristles being sandwiched between, and joined with, a pair of side-plates and having free ends projecting from at least one edge of the pair of side-plates at an angle thereto in the plane of the element, both side-plates extending over substantially the whole length of the bristles so that, in use, the side-plates always remain clear of a co-operating sealing element, at least one of the side-plates being relieved on its bristle-contacting face over a sufficient distance from said one edge to allow freedom for the bristles to move relative to the side-plates.

The minimum length of projecting bristle will usually be just equal to the clearance needed between the edge of the side-plate and the co-operating sealing surface. In the case of a seal in which there is relative rotation between the two sealing elements, this clearance must be sufficient to take into account not only manufacturing tolerances and differential thermal expansions but also the centrifugal growth and possible eccentricity of the rotating component. The angle of the bristles to the edge of the side-plate must be in the direction of relative rotation of the co-operating sealing element.

The word "relieved" as applied to the bristle-contacting face of the side-plate should be taken to include not only machining a recess in the face of an otherwise flat plate, but also bending or joggling the plate to produce an offset portion which produces said clearance.

When there is a high pressure difference across the seal it is the side-plate on the upstream, or high pressure side, only of the seal which is relieved.

It is an important consequential feature of such a seal that the sealing element should not be fitted into position the wrong way round, i.e. so that the relieved side-plate appears on the low pressure side of the seal, or that the angle at which the bristles emerge from between the side-plates is opposite to the direction of relative rotation of the co-operating sealing element.

According to a further aspect of the invention therefore, the sealing element is provided with a baulking feature to prevent incorrect assembly. The baulking feature may take the form of projections, or an outwardly turned lip or flange on one side of the seal, and may provide the means for connecting the seal to engine structure.

In a seal in which there is relative rotation between the sealing elements, the brush element is preferably connected to static structure and the surface of the co-operating sealing element is preferably provided with a coating to reduce the tendency of the bristles to "pick up" on the rotating surface. The coating is advantageously an antifriction coating also to reduce bristle wear.

The seal may be used as a gas or liquid seal, for example, in an engine application it may be used as an oil or air seal.

An example of the invention will now be described in more detail with reference to the

accompanying drawings in which:

Fig. 1 illustrates an enlarged sectional side elevation of a brush seal between relatively rotating parts in a machine; and

Fig. 2 is a section on the line II—II of Fig. 1.

The seal comprises a first sealing element including a plurality of metallic bristles 1 sandwiched between a pair of annular side-plates 2 and 3 respectively, to form a completely annular brush. At their radially outer ends the bristles are welded at 9 to the side-plates. The projecting free ends of the bristles are positioned to run against a second, co-operating sealing element 10 which may be a plain cylindrical surface. The bristles project with a circumferential component of direction which is the same as the direction of relative rotation of the co-operating sealing element 10. The angle which the bristles make with a radial line may be up to 60° but is preferably 45°. In the preesnt example, the brush element is fitted to static structure 11 and the second element 10 rotates.

In order to allow flexibility for the bristles, the side-plate 2 is relieved on its bristle-contacting face to define a clearance 4 between the bristles and the face of the plate. This allows the radial depth of both side-plates to be such that only the minimum gap 5 is left between the radially inner edge of each plate and the surface of the co-operating sealing element. This gap 5 allows for relative radial movement of the two elements of the seal during operation of the seal.

The side-plate relief may be obtained by machining an otherwise flat surface of the side-plate, or by joggling or bending the side-plate an appropriate amount during its manufacture.

The relieved side-plate is positioned on the upstream or high pressure side of the seal so that the pressure difference across the seal, which tends to bend the bristles axially, urges the bristles into contact with the downstream side-plate which supports the bristles across its whole radial depth. Where the pressure difference is small however, e.g. 1 psi or less, both side-plates may be relieved if desired.

To prevent the sealing elements being fitted the wrong way round the upstream side-plate, which has the relieved face, is provided with a flange 6 at its radially outer periphery as a baulking feature and which forms the means for connecting the seal to static structure. The connection may be by means of rivets 7 or any other suitable releasable connection. Thus, the sealing element can be a replaceable item.

As an alternative construction the sealing element may be fitted in a seal carrier which has the baulking feature so that the side-plate itself need have no flange, but then it may be necessary to introduce a baulking feature onto the sealing element to prevent it being fitted into the seal carrier the wrong way round.

The area of the surface on the second sealing element 10 which is contacted by the bristles, is provided with a coating 8 which may have anti-friction properties. The coating is of a material which is compatible with the brush bristles and which reduces the tendency of the bristles to "snag" or "pick up" on the rotating member. For example, using "NIMONIC" wires for the bristles, an aluminium oxide coating has been found to be suitable. The oxide coating is ground to a surface finish of 0.8 μm.

The seals may be used for sealing gases or liquids for example, in a gas turbine engine the seals may be used as air or oil seals. For an effective seal the bristle density per 25 mm at the bore circumference preferably lies between 2250 and 2650.

The bristles may contact the surface of the co-operating sealing element 10 with a slight interference to assist sealing.

The brush sealing element may also fit into the static structure with an interference fit between the surfaces indicated by reference numeral 12, to prevent rotation of the brush. Further, in the case of an oil seal, notwithstanding an interference fit between the surfaces, the axial length of the surfaces 12 must be at least 6 mm to provide an effective oil seal.

WHAT WE CLAIM IS:—

1. A brush seal element comprising a mass of bristles packed together to form a seal against passage of fluid therethrough, said bristles being sandwiched between, and joined with, a pair of side-plates and having free ends projecting from at least one edge of the pair of side-plates at an angle thereto in the plane of the element, both side-plates extending over substantially the whole length of the bristles so that, in use, the side-plates always remain clear of a co-operating sealing element, at least one of the side-plates being relieved on its bristle contacting face over a sufficient distance from said one edge to allow freedom for the bristles to move relative to the side-plates.

2. A brush seal element as claimed in claim 1 and wherein the relief of the bristle-contacting face of the side-plate is effected by forming a bend in the side-plate.

3. A brush seal element as claimed in claim 1 and wherein the relief of the bristle-contacting face of the side-plate is effected by machining a recess in the face of the plate.

4. A brush seal element as claimed in any preceding claim and wherein a baulking feature is provided on one side of the element to prevent fitting of the seal element the wrong way round in use.

5. A brush seal element as claimed in claim 3 and in which the baulking feature comprises a flange connected to one of the side-plates.

6. A seal between two components of a machine comprising a brush seal element as

claimed in any preceding claim connected to one component and a co-operating sealing surface, on the other component, the bristles of the seal element extending between the two components into contact with the sealing surface.

7. A seal as claimed in claim 5 and wherein the side-plates of the seal element extend to within a small clearance of the sealing surface.

8. A seal as claimed in claim 5 or claim 6 and in which a pressure difference is established across the seal, and the side-plate of the seal element which has its bristle-contacting face relieved is disposed on the higher pressure side of the seal.

9. A seal as claimed in any one of claims 5 to 7 and wherein there is relative rotation between the two components of the machine, the sealing element is annular and the bristles are angled circumferentially in the direction of relative rotation of the co-operating sealing member.

10. A brush sealing element substantially as hereinbefore described with reference to the accompanying drawings.

11. A seal substantially as hereinbefore described with reference to the accompanying drawings.

For the Applicants,
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Chartered Patent Agent.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale

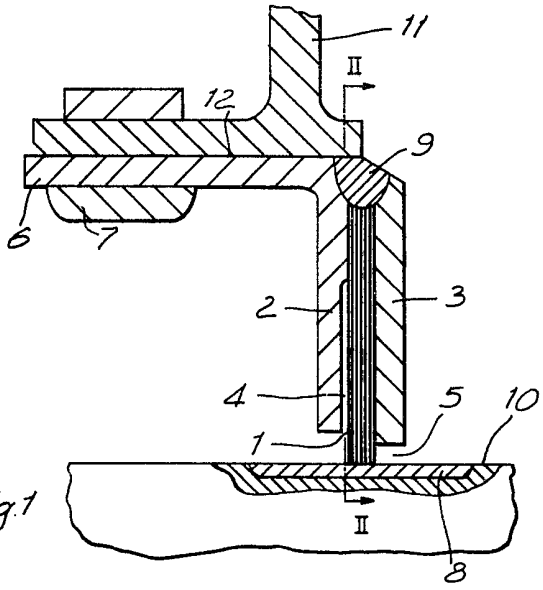

Fig.1

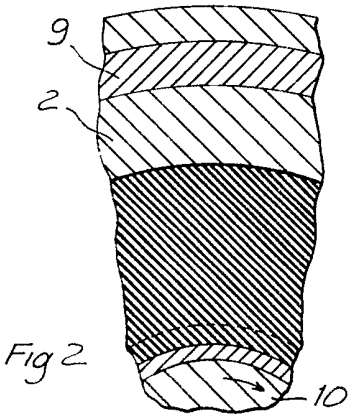

Fig 2