United States Patent [19]

Nakano

[11] **3,829,252**

[45] **Aug. 13, 1974**

[54] **SEALING ARRANGEMENT FOR AN AIR COMPRESSOR**

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[22] Filed: **Mar. 20, 1972**

[21] Appl. No.: **235,999**

[30] **Foreign Application Priority Data**

Mar. 20, 1971 Japan 46-19171
Dec. 9, 1971 Japan 46-115781

[52] **U.S. Cl.** **417/482,** 418/142, 418/146
[51] **Int. Cl.** **F04c 21/00**
[58] **Field of Search** .... 418/142, 120, 121, 146; 417/481, 482, 483, 484; 92/121, 122, 125; 123/18 R

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Assistant Examiner—Michael Koczo, Jr.
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

Vanes of an air compressor rotor are provided with end seals and an axially extending peripheral seal. A cylindrical sealing member is positioned at the radially innermost end of each end seal to engage therewith. The cylindrical sealing member and the end seals are urged outwardly by springs. The end seals extend radially outwardly to the outer periphery of the peripheral seal to seal the outer ends of the peripheral seal which normally has a tolerance to allow for thermal expansion.

8 Claims, 15 Drawing Figures

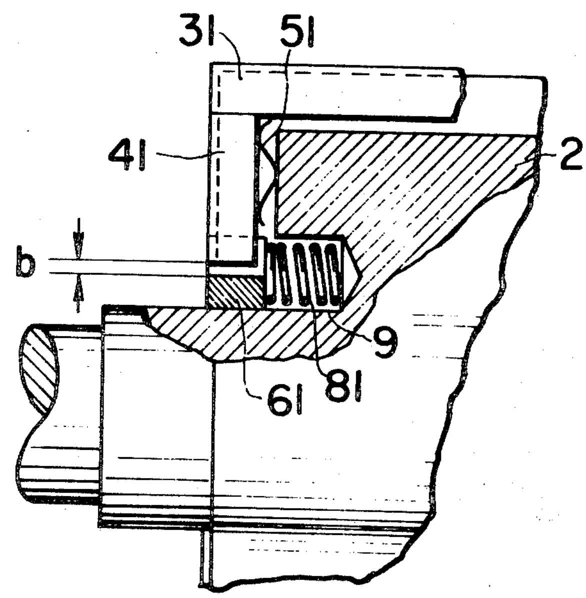


FIG. 1

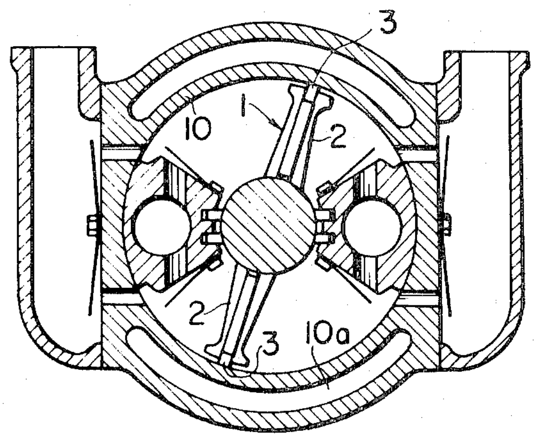


FIG. 2

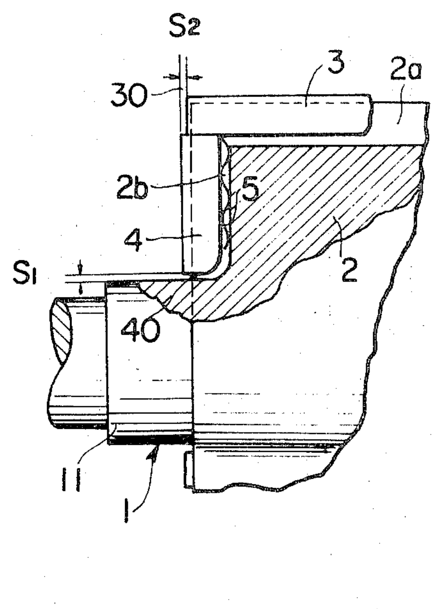


FIG. 3

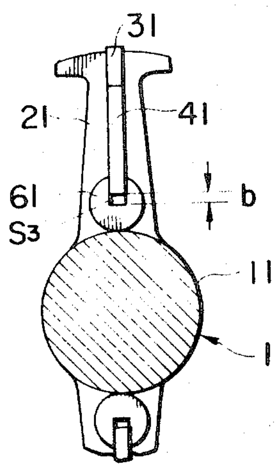


FIG. 4

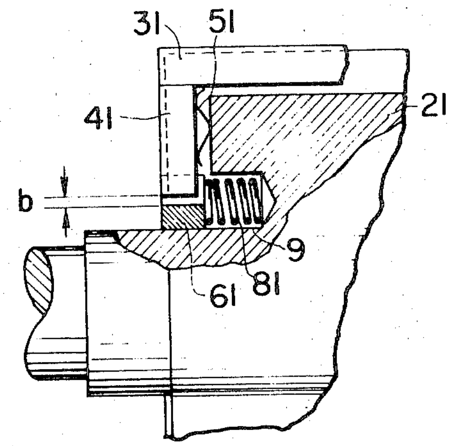


FIG. 5

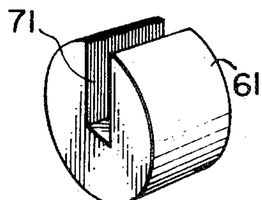


FIG. 6

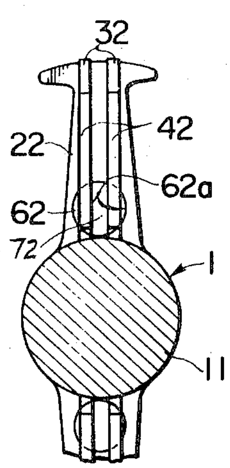


FIG. 7

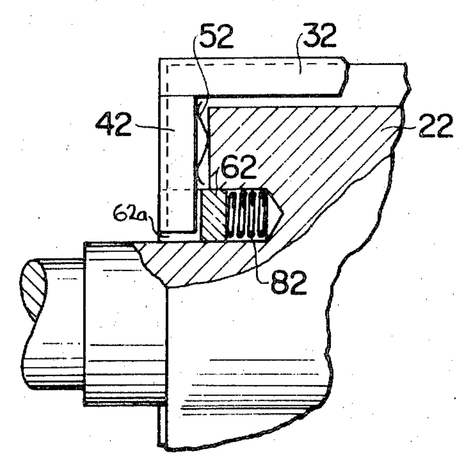


FIG. 8

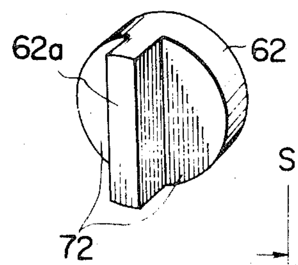


FIG. 9

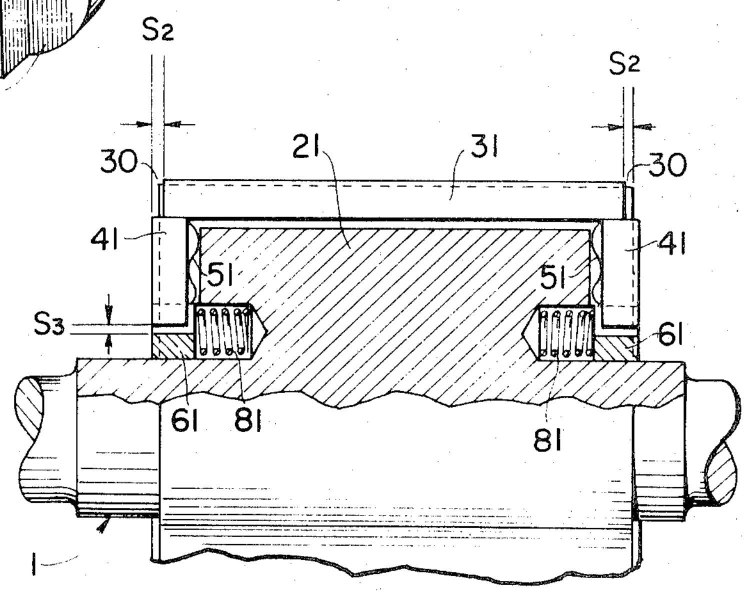


FIG. 10

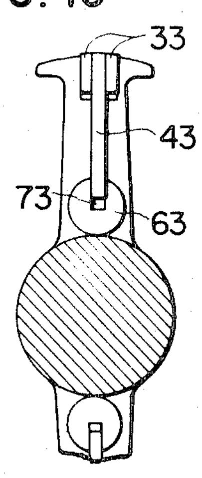


FIG. 11

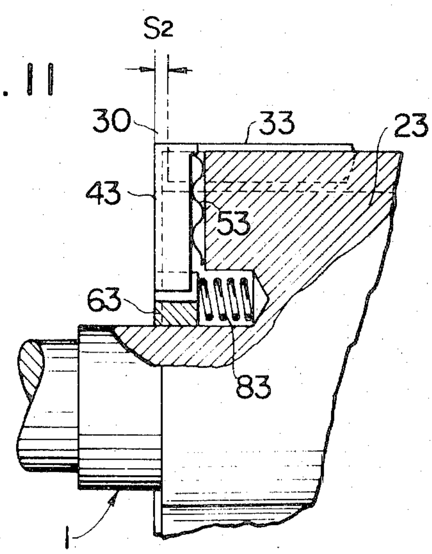


FIG. 12

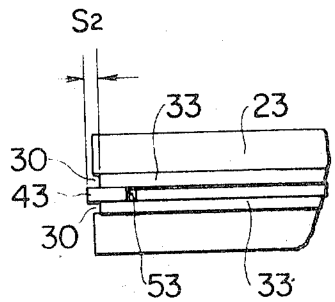


FIG. 13

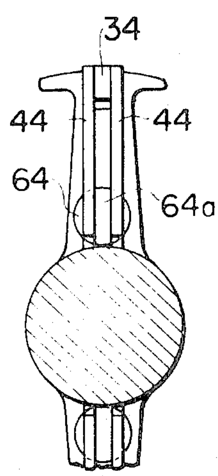


FIG. 14

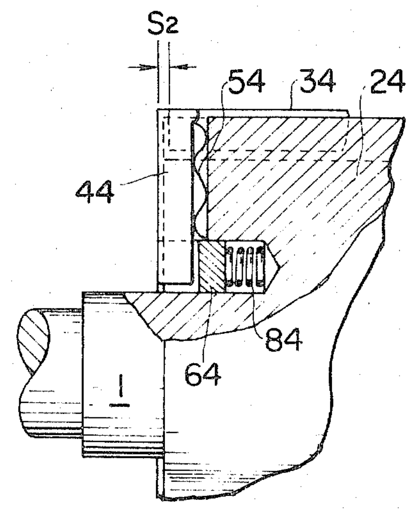
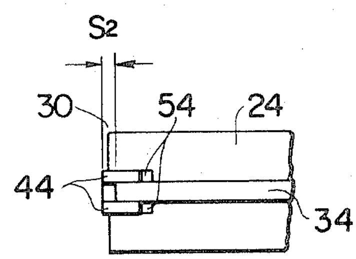


FIG. 15



SEALING ARRANGEMENT FOR AN AIR COMPRESSOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved sealing arrangement for the rotor of an air compressor and specifically for improved seals at the end and along the axial periphery of each vane of an oscillatable rotor type of air compressor.

2. Description of the Prior Art

In one known prior art air compressor, the rotor with vanes thereon is rotatably supported by bearings which are located outside of the rotor cylinder and are hermetically sealed and lubricated. Inside the cylinder, the outer axial peripheral surface and the end surfaces of the vanes of the rotor carry seals which directly contact the internal surface of the cylinder and divide the cylinder into air tight chambers. The sealing material for the seals is a material having a selflubrication effect, such as carbon, TFE (tetrafluoroethylene), and the like, so that the air compressor can be used without oil lubrication of the seals.

In this type of air compressor, the wear of the seals is taken up by outward movement of the seals. This movement is accomplished by centrifugal force for the axial peripheral seal, and by centrifugal force and spring force for the end seals.

FIGS. **1** and **2** show crossectional and longitudinal partial sectional views of conventional prior art air compressors of the type described. Such compressors have a rotor **1** with vanes **2, 2** having grooves **2*a*** in their outer peripheral surface and grooves **2*b*** in their end surfaces for accepting a peripheral seal **3** and end seals **4.** A wave shaped spring biases the end seals axially outward.

In such prior art construction, there is a problem of leakage, especially, when the peripheral seal wears. Such wear allows the end seals **4** to move radially outward, as viewed in FIG. **2,** to create a space **40** having the dimension S_1 between the inner end of end seal **4** and the outer surface of axial shaft **11** of rotor **1.** In other words, when the outer surface of peripheral seal **3** wears, both peripheral seal **3** and end seals **4** are forced outwardly by centrifugal force, thus, creating the space **40** of dimension S_1. As the dimension S_1 increases, the amount of air leaking through the seals from one side of the vane to the other increases; and the efficiency of the air compressor deteriorates notably.

In this type of air compressor, there is also a problem of leakage due to the provision of a tolerance to accommodate thermal expansion. The peripheral seal **3** varies in its length according to the variation in temperature within the cylinder. When the gas is compressed, the temperature rises; and although the cylinder **10** is cooled by cooling water in passage **10*a*** in the cylinder wall, the rotor **1** is heated to a high temperature so that thermal expansion of the seals cannot be ignored. The expansion of seal **4** can be accommodated by space **40.** Expansion of peripheral seal **3** cannot be accommodated unless a tolerance or space is allowed. Particularly, peripheral seal **3,** since it has a comparatively large length, has a corresponding thermal expansion which requires that a tolerance space **30** be provided at opposite ends thereof. Moreover, where the seal **3** is made of TFE or similar high molecular compound, the

thermal expansion is quite significant; i.e., about 20 to 30 times as great as that of the metallic material of the cylinder and rotor. Therefore, a clearance **30** having a dimension S_2, as shown in FIG. **2,** is required in order to accommodate thermal expansion of the peripheral seal **3.** Clearance space **30** also causes leakage of air from one chamber to another of the cylinder and adversely affects the performance of e compressor.

Thus, in conventional air compressors of the prior art type described above, there has been a significant problem of leakage due to the required clearance spaces **30** and **40.** Accordingly, it has long been desired in this art that seals should be improved to prevent such leakage while accommodating both thermal expansion and wear of the seals.

SUMMARY OF THE INVENTION

This invention provides a sealing arrangement for air compressors of the known type in which the thermal expansion is accommodated while leakage is prevented and wear of the seals is accommodated while leakage is prevented. Moreover, the sealing arrangement of this invention can easily be incorporated in a conventional air compressor and is quite simple in construction. The seal maintains high performance of the compressor over a long period of time and enables the use of a high molecular compound such as TFE for the sealing material, which compound would ordinarily be difficult to use due to its great thermal expansion, but has other beneficial properties, such as high abrasion resistance, high chemical resistance, self-lubrication effect, and a generally desirable performance as a sealing material.

These desirable results are obtained and the shortcomings of the prior art are overcome by providing an additional seal at each end of the rotor and at the inner radial end of each end seal. This additional seal is contacted by the side of the end seal and itself is flush with the surface of the rotor shaft. Clearance is allowed between the inner radial end of the end seal and the additional seal, but no leakage occurs because the side of the end seal is in contact with the additional seal. This prevents leakage around the radially innermost end of the end seal. Leakage through and past the ends of the peripheral seal is prevented by having the sides of the end seal overlap the sides of the peripheral seal at the radially outermost end of the end seal so that this outermost end of the end seal seals the clearance space which must be provided for the peripheral seal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** show, as mentioned above, a transverse sectional view and a partial longitudinal sectional view of a prior art air compressor with seals which are improved by the sealing arrangement of the present invention;

FIG. **3** is an end view of a air compressor rotor with vanes and seals in accordance with a first embodiment of this invention;

FIG. **4** is a partial side view of the rotor with vanes as shown in FIG. **3** partly broken away in section;

FIG. **5** is a perspective view of a slotted cylindrical sealing member employed in the first embodiment of the invention as shown in FIGS. **3** and **4**;

FIG. **6** is an end view of a rotor with vanes in accordance with a second embodiment of this invention;

FIG. 7 is a partial side view of the rotor with vanes shown in FIG. 6 partially broken away in section;

FIG. 8 is a perspective view of a cylindrical tongued sealing member employed in the second embodiment of the invention shown in FIGS. 6 and 7;

FIG. 9 is a partial side elevation of a rotor with vanes partly broken away and shown in longitudinal section in accordance with the first embodiment of this invention illustrated in FIGS. 3–5;

FIG. 10 is an end view of a rotor with vanes partially cut away in accordance with a third embodiment of this invention;

FIG. 11 is a partial side elevation of the rotor with vanes of FIG. 10 partially broken away in longitudinal section;

FIG. 12 is a partial top plan view of the rotor vane shown in FIGS. 10 and 11;

FIG. 13 is an end view of a rotor with vanes partially broken away and illustrating a fourth embodiment of this invention;

FIG. 14 is a partial side elevation view of the rotor with vanes of FIG. 13 partially broken away in longitudinal section; and

FIG. 15 is a partial top view of the vane of the rotor as shown in FIGS. 13 and 14.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 3–5 illustrate a first embodiment of the present invention utilizing an additional seal in the form of a cylindrical sealing member **61** having a slot or groove **71** provided therein which is accommodated in a circular blind hole axially bored in the end of vane **21**. A compression spring **81** is disposed in the hole for urging the sealing member **61** outwardly. An end seal **41** is mounted on the end of vane **21** and is slidable radially and urged axially outward by spring **51**. The radially innermost end of seal **41** is contained within groove or slot **71** in solid cylindrical sealing member **61**, as shown in FIGS. 3 and 4. The outer periphery of sealing member **61** contacts the outer surface of the shaft **11** of rotor **1**, as shown in FIGS. 3 and 4. All other portions of the rotor vanes and seals of the FIGS. 3–5 embodiment including the peripheral seal **31** are of the same construction as a conventional prior art air compressor rotor vane and seal assembly. FIG. 9 shows the complete assembly of the FIGS. 3–5 embodiment.

In operation, if end seal **41** wears or the end of seal **61** wears, it will still be kept in contact with the end of the cylinder by the urging of springs **51** and **81**. Moreover, when the outer surface of the peripheral seal **31** wears and end seal **41** moves radially outward by centrifugal force, there will still be no leakage or clearance space between the radially innermost end of seal **41** and the shaft **11** because of additional sealing member **61** and the fact that the sides of the end of end seal **41** are in contact with the groove or slot **71** in seal member **61**. Seal member **61** cannot move radially since it is contained within a complementary hole in vane **21**. Thus, when wear occurs on the outermost surface of peripheral seal **31** and end seal **41** moves radially outwardly, the space increases as indicated by dimension *b* in FIGS. 3 and 4 and dimension S_3 in FIG. 9. However, this space is enclosed by the sealing member **61** so no leakage occurs at this point from one side of the vane to the other; therefore, leakage at the radially innermost end of the end seals is precluded even when the peripheral seal wears until the wear reaches a predetermined maximum limit.

A second embodiment of this invention is shown in FIGS. 6–8. In this embodiment, there is a cylindrical sealing member **62** having a tongue **72** formed by a pair of cutaway portions **62***a*; and this seal **62** is inserted into a circular hole in the vane **22** in the same manner that plug **61** was inserted in hole in vane **21**. Again, the periphery of the shaft **11** is in contact with the periphery of the seal **62**. A compression spring **82** urges the seal **62** axially outward. The end seal is two sealing pieces **42, 42** mounted in side-by-side parallel relation and radially slidable with their radially innermost ends in contact with the sides of tongue **72**. A spring **52** urges each seal **42** axially outwardly. In this embodiment, the peripheral seal is also made up of two sealing pieces **32, 32** in alignment with the end seals **42, 42**. The operation is similar to the FIGS. 4–6 embodiment in that tongue **72** serves together with end seals **42** to preclude leakage under the radially innermost end of seals **42** even when the outer surface of peripheral seals **32** wears and end seals **42** move radially outward. Thus, again, leakage at the end of the end seal adjacent the rotor shaft is prevented until abrasion and wear of the peripheral seal reaches a predetermined limit.

As can be seen from the above, the first two embodiments prevent leakage at the ends of the rotor adjacent the rotor shaft (i.e., adjacent the radially innermost end of the end seal); and this accomodates the wear of the peripheral seal. As mentioned above, however, there is also a problem in the prior art regarding leakage at the ends of the peripheral seal (i.e., at the radially outermost ends of the end seal) due to the necessity for taking thermal compensation into consideration. In the first two embodiments, this leakage has not been considered or taken into consideration. In practice, however, there is also leakage at the ends of the peripheral seal caused by providing clearance spaces S_2 to accommodate thermal expansion, as shown in FIG. 9. In other words, until the peripheral seal 31 of FIG. 9 thermally expands to take up the clearance spaces S_2, again there will be leakage from one side of the vane to the other through the spaces. However, due to sealing member **61**, there will be no leakage through space S_3. The third and fourth embodiments of the invention prevent leakage through space S_2 of FIG. 9 by providing an overlap of the end and peripheral seals.

A third embodiment of this invention is shown in FIGS. 10–12. A cylindrical member **63** having a slot **73** therein is similar to the seal shown in FIG. 5 and is inserted into a blind circular hole in vane **23**. A spring **53** urges end seal **43** outwardly, and a spring **83** urges seal member **63** outwardly as in the first two embodiments. The end seal **43** in this embodiment, however, overlaps the ends of the peripheral seals **33**, as shown in FIGS. 10 and 12. The peripheral seal **33** is a pair of sealing pieces **33** and **33** which are mounted parallel to one another so that the side surfaces contact side surfaces of end seal **43**. The radially outermost end of end seal **43** extends outwardly to the outermost surface of peripheral seal **33**, as shown in FIGS. 10 and 11. The ends of peripheral seal pieces **33, 33** are less than the length of the cylinder by a clearance dimension S_2 shown in FIGS. 11 and 12 to allow for thermal expansion.

Even when the peripheral seal **33** is contracted in the cold state and clearance S_2 exists, there will be no leakage because the space S_2 is blocked by the radially outermost ends of overlapping end seal **43**; and seal **43** is always urged against the inner periphery of the cylinder by centrifugal force.

A fourth embodiment of this invention is illustrated in FIGS. **13–15.** The fourth embodiment is similar to the third embodiment, except there is a single peripheral seal **34** and a pair of end seals **44** sandwiching the peripheral seal between the radially outermost ends and sandwiching the tongue **64***a* of seal **64** between the sides of the radially innermost ends. The end seals **44** again overlap the necessary clearance space S_2 allowing for thermal expansion of the peripheral seal **34.** The cylindrical seal **64** is identical to seal **62** of the second embodiment. In other words, the fourth embodiment is a combination of the second embodiment and a reversal of the third embodiment; and the third embodiment is a combination of the first embodiment with additional peripheral seals straddling the end seal to prevent leakage at the ends of the peripheral seal. In the third and fourth embodiment, leakage is prevented, not only at the space between the radially innermost ends of the end seal and the rotor shaft, but also at the radially outermost ends of the end seal or ends of the peripheral seal; and accommodation for both wear and thermal expansion of the peripheral seal is provided.

I claim:

1. A sealing arrangement for an air compressor of the oscillating-vane type having a vaned rotor provided with end seals and a peripheral seal on each vane, the rotor being on an axial shaft concentric with an outer housing, the improvements in the sealing arrangement:

a sealing member accommodated by a hole in each end of the vane adjacent the axial shaft of the rotor, the hole preventing the sealing member from moving in any direction except axially and the hole contacting the periphery of the rotor shaft; and

a spring means in the hole for urging the sealing member axially outward, the radially inner end of the end seal contacting the sealing member in air tight engagement in either circumferential direction and the end seals being movable relative to the sealing member in a radial direction to accommodate wear of the peripheral seal without allowing leakage between the radially innermost ends of the end seal and the rotor shaft.

2. A sealing arrangement for an air compressor as defined in claim **1** wherein the sealing member is provided with a groove of a shape to receive the radially innermost end of the end seal which is inserted into the groove.

3. A sealing arrangement for an air compressor as defined in claim **1** wherein the sealing member is provided with a tongue between a pair of cutaway portions, and the end seal consists of a pair of seal pieces mounted parallel to one another with their radially innermost ends in engagement with the sides of the tongue.

4. A sealing arrangement for an air compressor as defined in claim **1** wherein the radially outermost end of the end seal overlaps the end of the peripheral seal to seal clearance spaces provided at the ends of the peripheral seal to accommodate thermal expansion of the peripheral seal.

5. A sealing arrangement for an air compressor as defined in claim **4** wherein the peripheral seal is a pair of sealing pieces mounted parallel to one another and sandwiching between the sides of their ends the end seal.

6. A sealing arrangement for an air compressor as defined in claim **4** wherein the peripheral seal is sandwiched between the radially outermost ends of a pair of parallel end seal pieces.

7. A sealing arrangement for an air compressor as defined in claim **1** wherein the sealing member is of cylindrical shape, the hole therefor is of cylindrical shape, and has its axis parallel to the axis of the rotor.

8. A sealing arrangement as defined in claim **7** wherein the radially outermost end of the end seal abuts the underside of the end of the peripheral seal and is in the same radial plane.

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