THE JOINT EXAMINATION BOARD

PAPER P6

INFRINGEMENT AND VALIDITY OF UNITED KINGDOM PATENTS

11th March, 1992

10.00 a.m. - 2.00 p.m.

Please read the following instructions carefully. This is a FOUR HOUR Paper.

1. Write on one side of the paper only using BLACK ink. You must write your examination number and the designation of the Paper in the top right hand corner of the sheet. You must not state your name anywhere in the answers.
form.

2. NO printed matter or other written material may be taken into the examination room.

1992 - PAPER 6

INTERPRETATION AND CRITICISM

Your clients (Corporation "A"), a major motor manufacturer, write:-

As you know we always try to second source all our components. One of our suppliers, oil seal manufacturers (Company "B") have recently introduced a new shaft seal that, to be honest, is the best thing since the invention of sliced bread.

Shaft seals rely on maintaining a thin band of oil about a shaft, to provide for lubrication between the seal and the shaft, whilst acting to prevent major leakage of oil either when the shaft is stationary or when it is rotating. In the "good old days" shaft seals always used to leak a little oil, this did no harm mechanically but did not look good in the showroom; cars on display had to have trays underneath to catch the oil drips.

A feedback shaft seal that acts to feed back leakage for one direction only of shaft rotation has been known for many years and is now the industry standard. There is one major problem with this feedback shaft seal; if it is fitted the wrong way round or if the wrong seal is fitted then the seal acts to pump oil out instead of sealing! Clearly, this type of seal cannot be fitted to a shaft that changes its direction of rotation.

As mentioned above, Company "B" have recently developed and launched their new shaft seal that acts to feedback oil for either direction of shaft rotation. The usefulness of this shaft seal for bi-direction shafts and the cost savings in assembly, repair and spares are such that we have to use this seal if we are to remain competitive. Unfortunately Company "B" are being very greedy, they want to charge us significantly more for this new seal when it clearly costs them no more to manufacture it. They are prepared to license other oil manufacturers but, again, they demand a significant royalty.

We have been approached by a foreign oil seal manufacturer (Company "C") who is offering another design of bi-directional feedback shaft seal at a more reasonable price. A description of Company "C's" proposal is enclosed - Document 1.

Please advise us whether we can safely use any of the shaft seals described in Company "C's" proposal, Document 1.

Your searcher finds UK Patent No. 2 for a bi-direction feedback shaft seal, in Company "B's" name and confirms that it is in force, the 5th year's annuity having recently been paid. Further searches reveal UK Patent No. 3 for a mono-directional

feedback shaft seal, also in Company "B's" name, published before the priority date of Patent No. 2 and U.K. Patent Specification No. 4 for a shaft seal and for which the UK Patent expired in 1975.

Using:-

Your client's letter;

Document 1, describing Company "C's" proposed bi-directional feedback shaft seal;

Patent Specification No. 2, for a bi-directional feedback shaft seal;

Patent Specification No. 3, for a mono-directional feedback shaft seal; and

Patent Specification No. 4, for a shaft seal;

draft notes on which you would base a formal opinion to your client as to:-

(a) validity of Patent No. 2; and,

(b) infringement of Patent No. 2 by Company "C's" shaft seal.

Candidates are reminded that marks are awarded for the REASONING displayed in reaching their conclusions. In this particular paper, candidates are NOT expected to deal with the question of whether Company "B" may be able to improve its position by amendment.
DO NOT THEREFORE WASTE TIME ON THE TOPIC OF "AMENDMENT" FOR WHICH THERE ARE NO MARKS ALLOCATED IN THE MARKING SCHEME.

DOCUMENT 1

PROPOSED SHAFT SEAL

Figure 1 is an axial cross-sectional view showing part of a lip-type sealing ring;

Figure 2 shows part of the sealing ring of Figure 1 viewed along the arrow B;

Figure 3 shows part of the sealing ring of Figure 1 viewed along the arrow A;

Figures 4, 5 and 6 are views corresponding respectively to those of Figures 1-3, showing the sealing ring in a worn condition;

Figure 7 is an enlarged isometric detail view of the worn sealing ring of Figs. 4-6.

The sealing ring 1 shown in Figures 1-3 comprises an annular lip 2 of elastomeric material bonded to a metal support ring 3 and arranged to be clamped by the ring 3 in coaxial relationship with a rotatable shaft (not shown), the lip 2 having a sealing area indicated by the edge 4 which engages the rotatable shaft to prevent oil from escaping from a region adjacent one inside surface 5 of the ring to a region adjacent another outside surface 6 of the ring. The sealing lip 2 is pressed into engagement with the shaft by means of a spring 7 in the conventional manner.

The outside surface 6 of the ring is provided with a series of integrally moulded cylindrical projecting studs 8 which are arranged in contact with each other and aligned with their axes

perpendicular to the outside surface 6. The studs have a height of up to 0.020 of an inch and have a diameter of 0.14 of an inch and their radially innermost edges with respect to the ring are clear of the sealing edge 4 by approximately 0.005 of an inch measured in the radial direction of the ring. The radius of the studs 8 is chosen to provide studs which have the optimum efficiency in returning oil.

Figures 4-6 show the condition of the ring 1 after a period of use in which the edge 4 and the radially inner portions of the studs 8 have been worn down to provide a cylindrical annular sealing area 9.

The action of the projecting studs 8 to return oil adjacent the outside surface 6 to the side of the ring adjacent the inside surface 5 is as follows.

When the sealing ring is only slightly worn no oil escapes past the sealing edge 4, and the projecting studs 8 are not brought into action. When the edge has become worn down to such an extent that it is approaching a condition in which on its own it would no longer be able to maintain a meniscus of oil between the sealing area 9 and the shaft S, indicated by broken line in Figure 7, the studs 8 have also become partly worn down, and as shown in Figures 5 and 7 each stud provides a generally dove-tail shaped extension of the edge of the annular sealing area 9.

Oil droplets escaping between the sealing area 9 and the shaft S impinge on the outside surface 6 and encounter one or other of a pair of curved fluid-deflecting side surfaces 10 or 11 formed on each adjacent pair of studs 8.

Figure 7 clearly shows the shape of the worn sealing area 9 and how the side surfaces 10 and 11 of each stud 8 meet the sealing area at an angle of approximately 45°. The droplets encounter the surface 10 or the surface 11 according to the direction of rotation of the shaft relative to the seal.

On striking the curved surfaces 10 or 11 the droplets tend to be reflected back across the sealing area 9 from the region of the outside surface 6 to the region of the inside surface 5.

The sealing rings described above have the advantage that they will tend to last longer than conventional lip seals. Conventional lip seals lose their effectiveness as the sealing edge is worn down, causing an increase in oil film thickness under the lip, and the relatively thick film tends to break down and permit oil to escape. In this worn condition the seals in accordance with the invention provide a pumping action which tends to return any oil which may leak past the sealing area and thus prolongs the effective life of the seal.

Moreover, in the sealing rings described above, in the unworn state of the ring, the radially innermost edge of each stud with respect to the sealing ring is disposed radially outwardly of the radially innermost portion (constituted by the sealing edge 4 in Figures 1 to 3) of the annular lip, and the pumping action therefore only becomes effective when the sealing edge has worn down. This provides a further important advantage in that when the sealing ring is initially fitted to a shaft the pumping action does not result in a tendency for the sealing edge to run dry, and this enables a satisfactory oil film to be maintained under the lip when the lip is in an unworn

condition, thus further increasing the life of the seal. This feature is not, however, an essential feature of the invention, and for some applications such as to eccentric or non-circular shafts, or in operation to seal viscous fluids or fluids at low temperatures, the region of the ring adjacent the studs may be formed, for example by trimming, to provide a pumping action in the initial unworn state of the seal.

Another advantage of the provision of cylindrical studs as in the example described above is that the oil return formations which are produced have curved fluid-deflecting side surfaces which present a decreasing angle to the circumferential direction as they near the sealing edge region. The effect of this is that the pressure tending to force fluid back across the seal increases as the sealing edge region is approached.

FIG.1

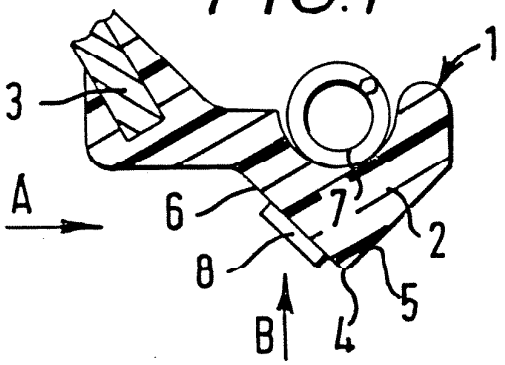


FIG.4

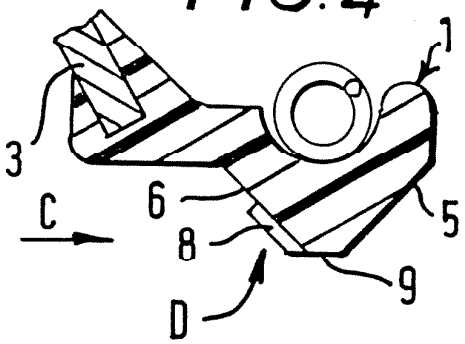


FIG.2

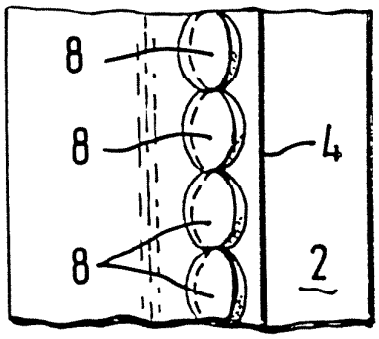


FIG.5

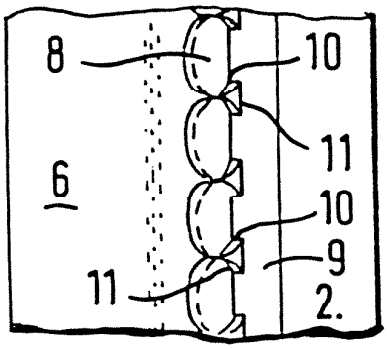


FIG.3

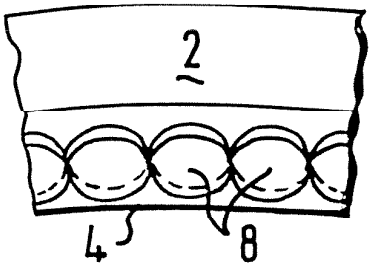
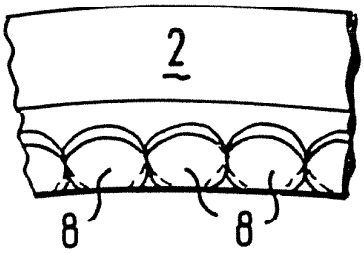


FIG.6



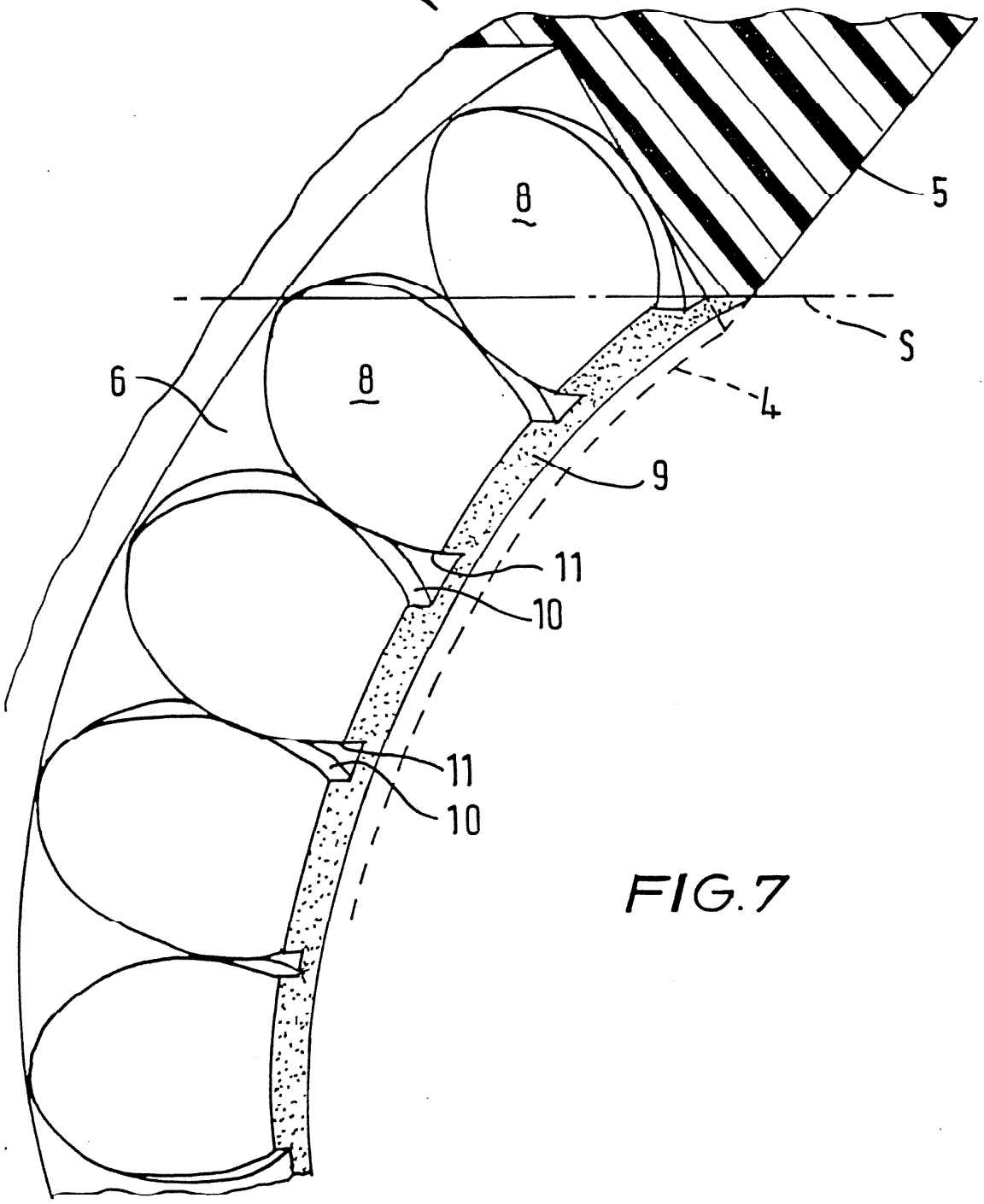


FIG.7

PATENT No.2

A BI-DIRECTIONAL FEEDBACK SHAFT SEAL

This invention relates to shaft seals, also known as oil seals, designed for sealing against fluid leakage along shafts, such as engine crankshafts or motor vehicle drive-transmission shafts, which are difficult to seal because of such factors as shaft deflection, torsional oscillation and eccentricity in motion.

It has long been known that the sealing of such shafts can be improved by providing at the sealed periphery some form of return feed screw, or feed-back scroll, formed by a helical ridge or groove on the shaft or seal surface. By suitable selection of the direction of the helix in relation to the normal direction of rotation of the shaft, the effect of relative rotation is to feed back oil or other fluid tending to leak past the seal.

The most convenient way of providing a feed-back effect is to form the required ridge or groove on the sealing periphery of the seal so that shaft modification is not required and the seal will operate on the cylindrical surface of any shaft of the appropriate size. Our United Kingdom Patent Specification No.3 discloses such a uni-directional feedback shaft seal.

Known feed-back seals will give satisfactory results in one direction of rotation for which they are designed but for reversible shafts, in particular motor vehicle drive or transmission shafts, there is a requirement for a feed-back seal which will serve in either direction of rotation.

The present invention provides a shaft seal of a known lip type but designed to provide a feed-back effect in either direction of rotation.

According to the present invention, a shaft seal comprises a moulded sealing ring of resilient material having a peripheral sealing lip with a circumferential sealing band between inner and outer frusto-conical surfaces, in which the outer surface is provided with at least one pair of oppositely-directed vane surfaces meeting the sealing band at an angle.

In a preferred embodiment of the present invention, at least one arcuate vane surface member is provided on the outer surface, with the ends intercepting the sealing band respectively in opposite peripheral directions.

For the best results, and also taking into account the moulding of a preferred seal as described below, the meeting angle of the vane surfaces is small, preferably between 1° and 5°.

Usually, in a sealing ring as manufactured, the sealing band is an edge formed by the junction of the frusto-conical surfaces but initial wear of the sealing ring in use, known as "bedding-in", axially widens the edge to a narrow band, also known as the "contact band". A corresponding band could however be formed, instead of an edge, in manufacture of a sealing ring.

In the seal of the present invention, the vane surfaces act like helical pump vanes to feed back oil tending to leak past the sealing edge and it has been found that oppositely-directed vane surfaces intercepting, i.e. meeting or extending into, the sealing band at a small angle are effective to feed back oil in either direction of shaft rotation.

This duo-directional effect is surprising, since it would be expected the oppositely-directed similar vane surfaces would have equal and opposite effects on the oil, and the effect is not at present fully understood.

However, the sealing effect of a resilient lip shaft seal is not fully understood, there being variable factors which are difficult to observe or determine, such as the deflection of the resilient lip as a result of lip-loading and shaft movement and the existence of an oil film between the lip and the surface against which it seals.

What has been established by tests is that seals in accordance with the present invention do give a duo-directional feed-back effect.

A shaft seal in accordance with the present invention will be described, by way of example, with reference to the Drawings, in which:-

Fig. 1 is a plan view of an internal lip type shaft seal in accordance with the present invention;

Fig. 2 is a diametral axial section on the line II-II of Fig.1, but to an enlarged scale;

Fig. 3 is a similar section but on the line III-III of Fig.1; and,

Fig. 4 is a detail isometric view of the shaft seal of Fig. 1, but with all angles and sizes exaggerated for illustrative purposes, and in the worn condition.

The seal illustrated is basically of a known kind, comprising a moulded sealing ring of oil-resistant synthetic rubber or like elastomeric resilient material, the ring being of channel-section having an outer cylindrical wall 1 stiffened by an L-section reinforcing ring 2, to form a holding portion for mounting the seal in a shaft housing, and a flexible flange 3 embraced by a spring 4.

The inner periphery of the flange 3 provides a sealing lip, to seal around the cylindrical surface of a shaft, having a circular sealing edge 5 formed by the junction of a moulded frusto-conical outer surface 6, which faces outwardly away from the sealed fluid when the seal is in use, and a cut

frusto-conical inner surface 7, which faces the sealed fluid in use.

As so far stated, the seal illustrated is of known construction and, in one prior art construction, the outer frusto-conical surface is known to have been moulded with a screw thread or helical ridges or grooves so as to give a feed-back effect, due to relative shaft rotation, on fluid leaking past the sealing edge. The effect of the screw or helical formation is that only one end of each thread intercepts the sealing edge so that each thread only presents one vane surface to the sealing edge, and as all the vane surfaces will intercept the sealing edge in the same direction, such a seal can only have a single or uni-directional feed-back effect.

The novel feature of the present invention is the provision on the surface 6 of a stepped series of substantially L-section, peripheral, co-planar, ring-like ridges 8a, 8b. As most clearly shown in Figs 2 and 3, the ring ridges 8 each lie in a plane that is at a small angle (about 1°) to the plane of the sealing edge. The angle and size of the ring ridges have been exaggerated and their number much reduced in the figures for purposes of illustration.

The ring ridge 8a closest to the sealing edge 5 intercepts the sealing edge in such a way that part of the ring is missing, leaving the ridge ends 9a and 10a or the ring ridge 8a to meet the sealing edge at the above-mentioned angle of 1°, but in opposite directions (see Fig.3).

In the sealing ring as moulded, at least two of the ring ridges 8a and 8b cross the plane of the sealing edge 5, that is formed by cutting the inner frusto-conical surface 7, and thus those arcuate portions of the ring ridges 8a and 8b beyond the plane of the sealing edge 5 are cut off, leaving the remainder of the ring ridges each with two ends, 9a, 10a

and 9b and its un-illustrated other end, respectively intercepting the sealing edge 5.

As is most clearly shown by Figure 4, ends 9a and 9b of ring ridges 8a and 8b intercept the sealing edge 5 which, having been bedded-in by initial wear in use, is modified to a sealing band of greater axial width. The other end 10a of ring ridge 8a is also shown. The vaned shape of the ring ridge ends intercepting the sealing band can clearly be seen.

CLAIMS:

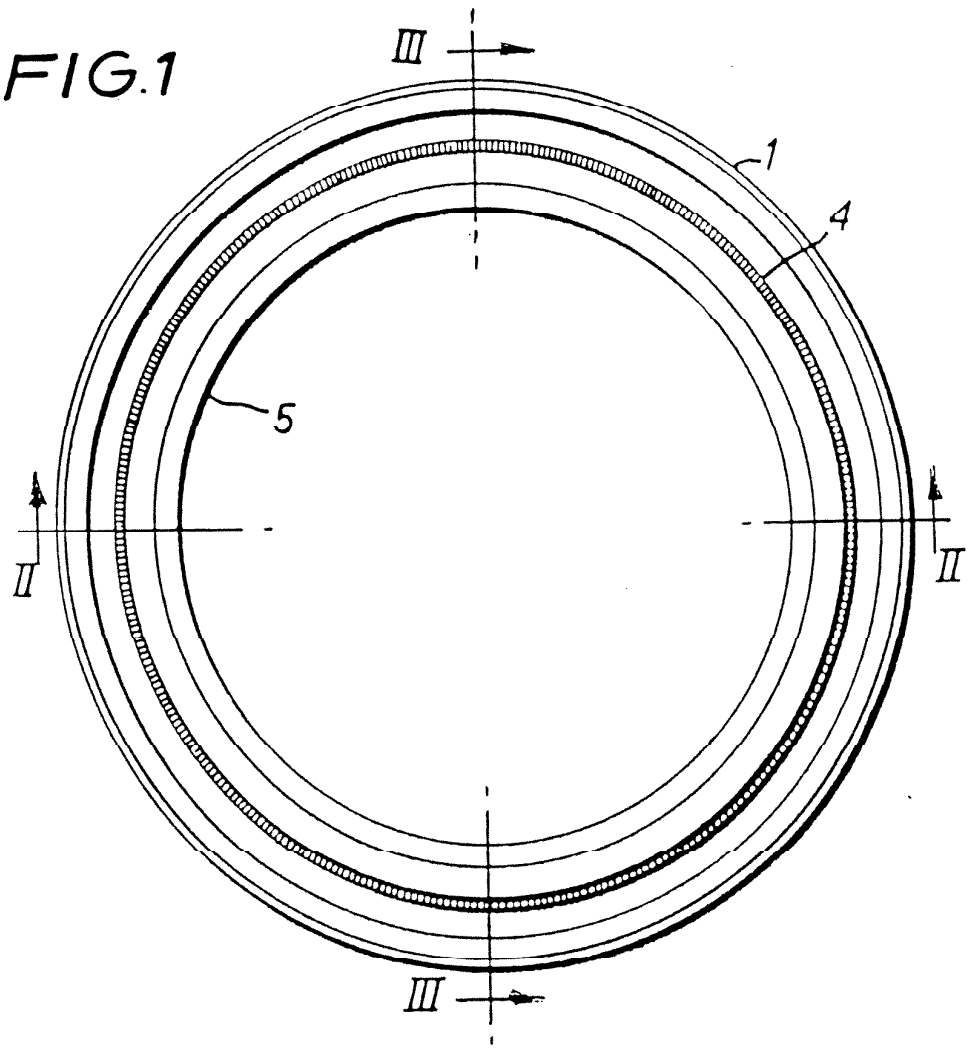
1. A shaft seal comprising a moulded sealing ring of resilient material having a peripheral sealing lip with a circumferential sealing band between inner and outer frusto-conical surfaces, in which the outer surface is provided with at least one pair of oppositely-directed vane surfaces meeting the sealing band at an angle.

2. A shaft seal as claimed in claim 1, wherein at least one arcuate vane surface member is provided on the outer surface, with the ends intercepting the sealing band respectively in opposite peripheral directions.

3. A shaft seal as claimed in claim 1 or claim 2, wherein a stepped series of substantially L-section, peripheral ,co-planar, ring-like ridges are provided on the outer surface; the ring ridges each lying in a plane that is at a small angle to the plane of the sealing edge.

4. A shaft seal substantially as described with reference to or as shown by the Drawings.

FIG.1



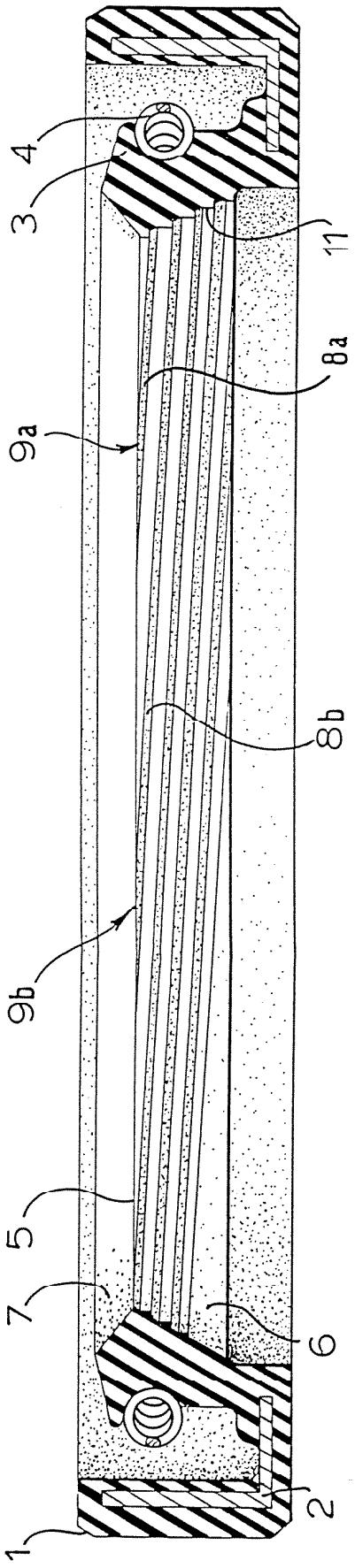


FIG.2

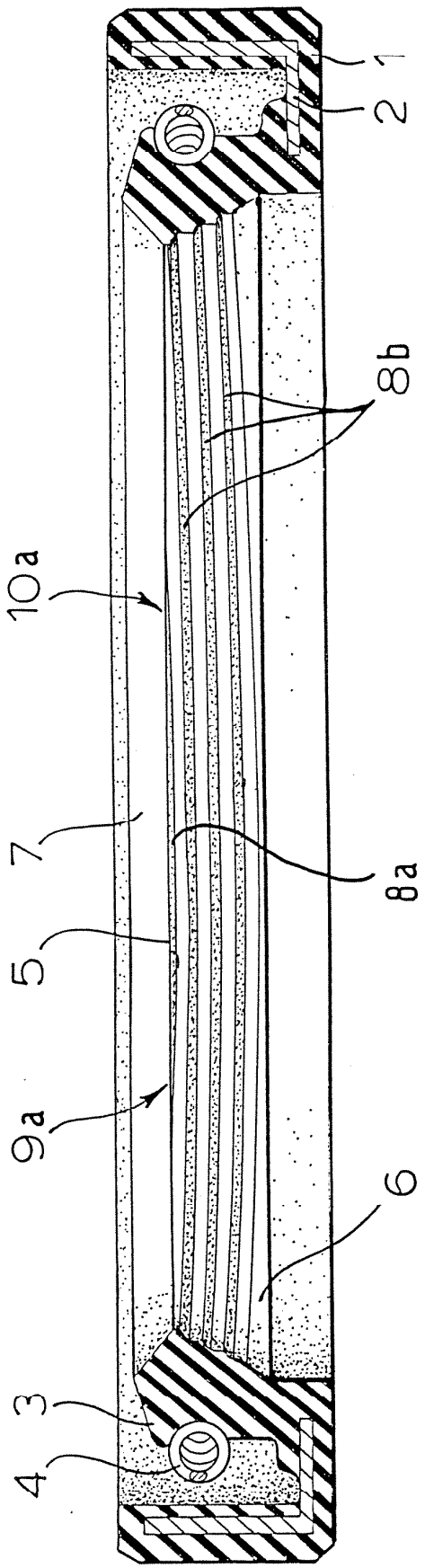


FIG.3

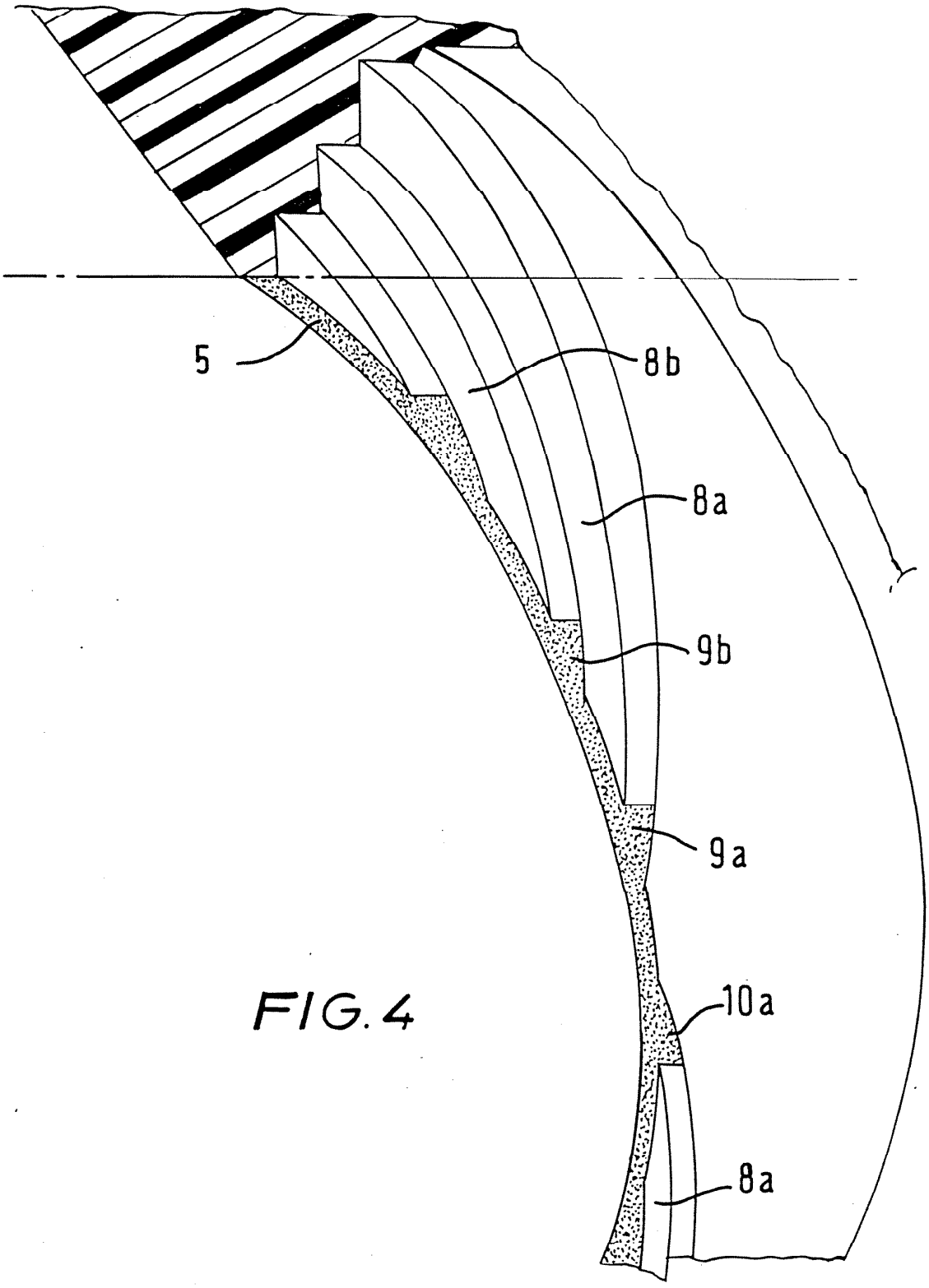


FIG. 4

PATENT NO.3.

A MONO-DIRECTIONAL FEEDBACK SHAFT SEAL

This invention relates to shaft seals for sealing, against oil leakage, the ends of engine crankshafts, especially the rear, or drive transmission, end of an automotive engine crankshaft which has long presented a difficult sealing problem.

Difficulty in sealing the ends of a crankshaft is inherent in the function of the crankshaft which, due to its shape and intermittent loading, must be subjected to deflections and torsional oscillations so that the ends of the crankshaft cannot maintain a constant co-axial relationship with a surrounding seal.

Engine design is also an important factor affecting crankshaft seals, particularly as regards access and drainage of oil to and from the seals and mounting or housing of the seals.

The present invention is concerned with lip-type shaft seals, i.e. rubber ring seals which each have a flange which bears as a sealing lip around the shaft. The invention is based on a study of the problem of crankshaft sealing and how the problem can be met by lip seals.

The study has shown that sealing due to wiping contact of the lip on the shaft should be supplemented by some form of feed-back scroll or return screw for oil tending to escape past the sealed periphery.

To meet the above requirement there is provided, according to the invention, an engine crankshaft seal consisting of a circular ring moulded from a heat-resistant and oil-resistant synthetic rubber, the ring having a co-axial annular channel defined by an outer holding annulus, stiffened by a rigid ring insert, and an inner annular flange including a flexible web portion, the inner periphery of the flange having a sealing lip formed by two frusto-conical surfaces of

the flange converging towards the axis of the ring to define an inner circumferential lip edge and the frusto-conical surface further from the channel having moulded therein a multi-start screw thread which meets the lip edge at two or more points and of which more than two crests are intersected by any radial section axially through the ring.

Further features of the invention are included in the following description of an example of a seal in accordance with the invention and shown in the drawings wherein:-

Fig. 1 is an axial section of a crankshaft seal in accordance with the present invention; and,

Fig. 2 is an enlarged isometric detail view of part of the ring of Fig. 1.

The drawings show a circular seal ring moulded from synthetic rubber and having an outer holding annulus 1, stiffened by an L-section metal ring insert 2, and an inner flange 3 comprising a flexible web portion 3a and a sealing lip formed by two convergent frusto-conical surfaces 4 and 5.

The lip surface 5 is moulded with a multi-start screw thread, generally indicated as 6, of substantially triangular cross-sectional tooth form. The screw thread meets, at several points, an inner circumferential lip edge 7 defined by the surfaces 4 and 5 converging towards the axis X-X of the seal ring.

As is well known, a multi-start screw thread consists of a series of parallel helical thread portions, called "starts", and in the seal illustrated the screw thread 6 has four starts 6a, 6b, 6c, and 6d.

In Figure 1 two of the starts 6a and 6d, can be seen meeting the lip edge 7 and any radial section axially through the ring, such as the two radial sections shown respectively at the top and bottom of the drawing, intersects the crests of all the starts.

Figure 2 illustrates, in a very exaggerated manner, the one thread 6a intercepting the sealing edge 7.

We have found that, for efficient sealing, there should be at least two starts of the screw thread, to meet the lip

edge 7 at two or more points, and the number and helical length of the starts should be sufficient for more than two crests of the screw thread to be intersected by a radial section axially through the ring. The crests of the screw thread represent the effective portions of the screw thread which feed back oil on relative rotation of the crankshaft journal and also form supplementary sealing lips, rather like labyrinth grooves, against oil leakage under static conditions. A succession of more than two crests across the leakage path for oil has been found necessary for good sealing under both running and static conditions.

The screw thread should not have more than twenty starts because, within the usual dimensions for crankshaft seals, with a greater number of starts the helical length of each start can only be small and the starts cannot overlap enough to provide an effective series of screw thread crests across the oil leakage path, particularly under static conditions.

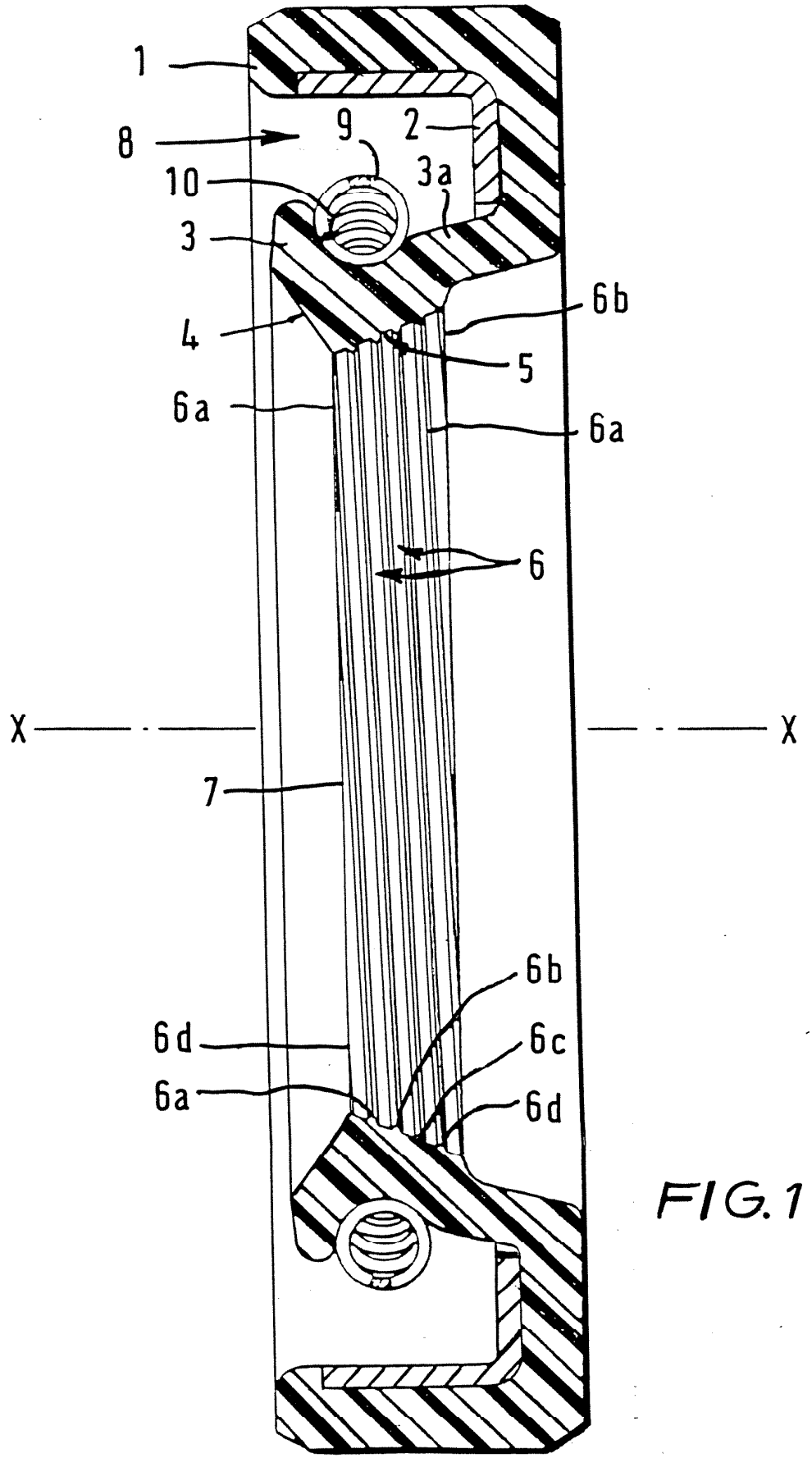
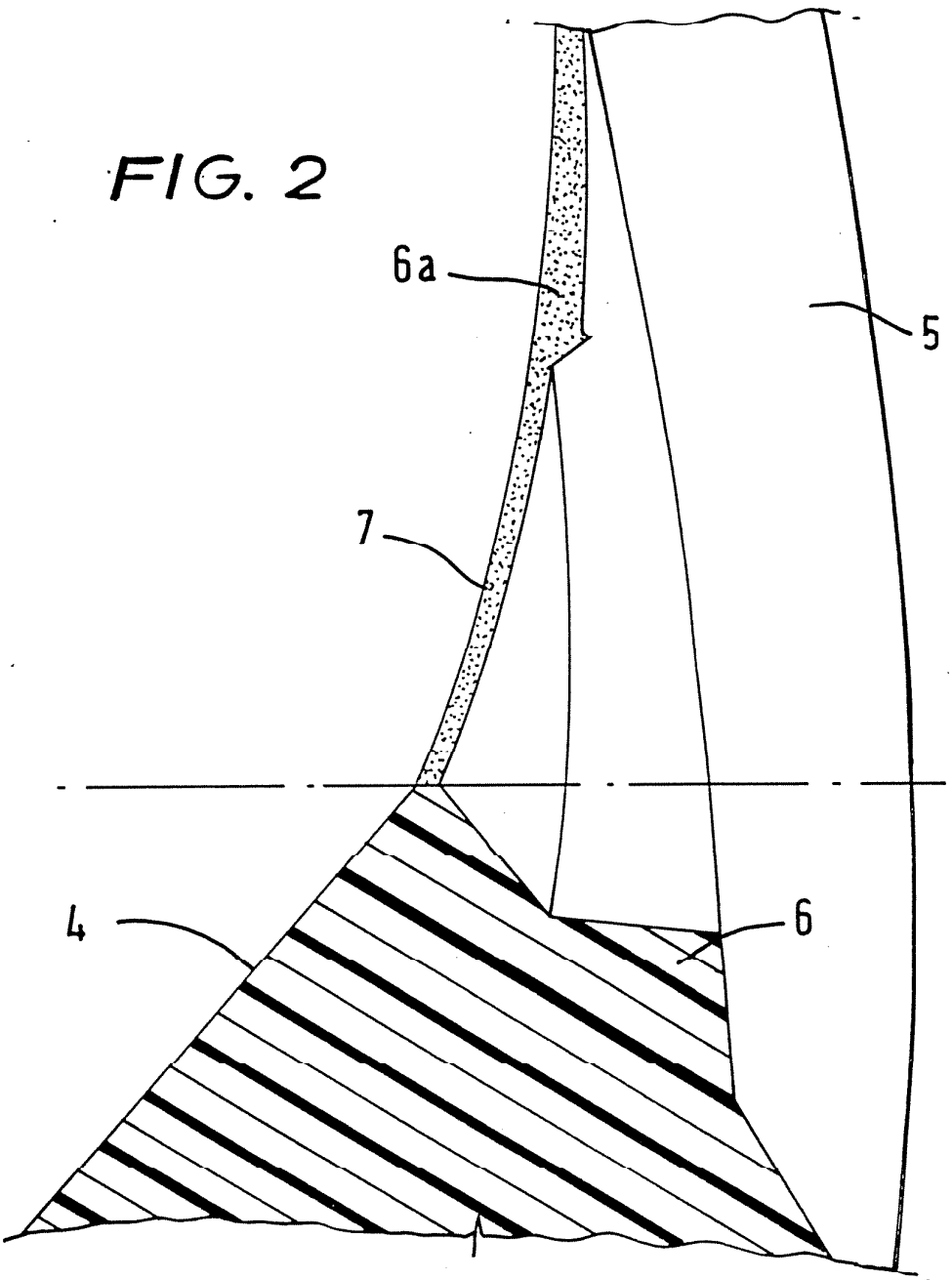


FIG. 1

FIG. 2



PATENT NO. 4

A SHAFT SEAL

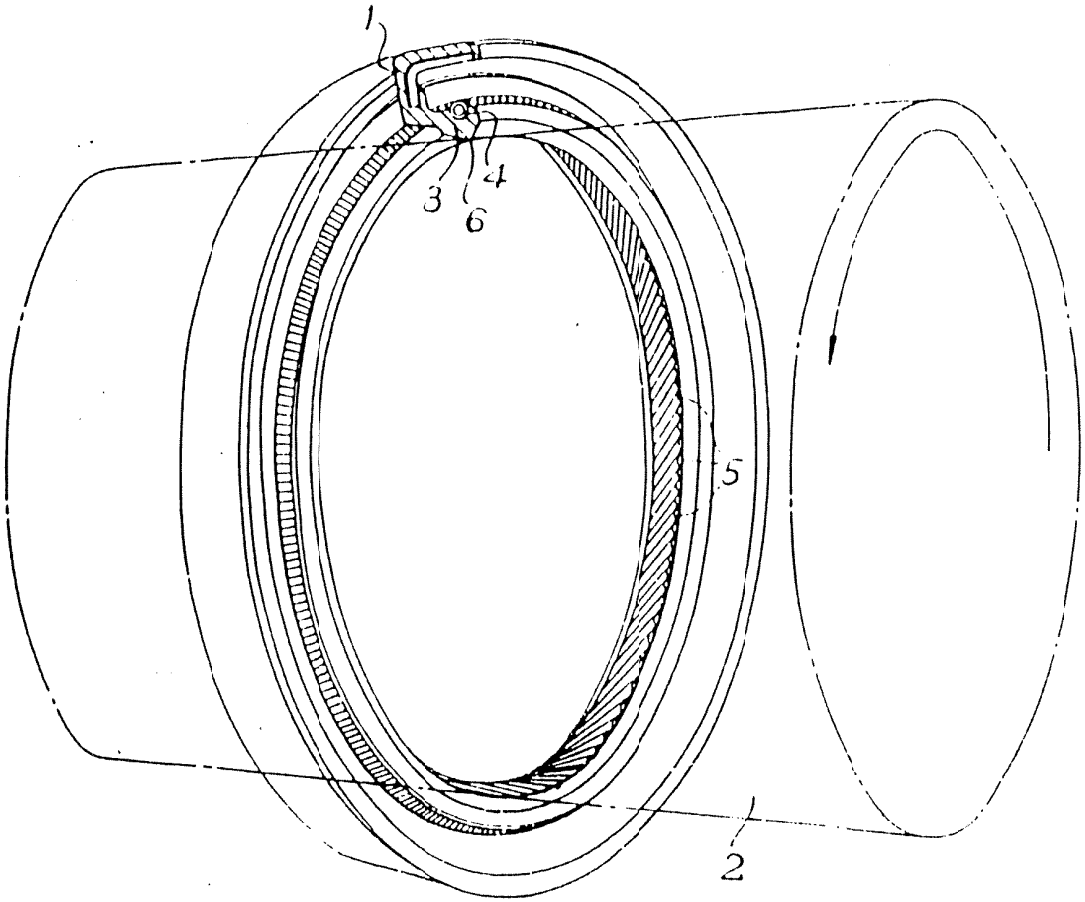
The present invention relates to a shaft seal for effecting sealing between a shaft and a surrounding part, the seal comprising a resilient sleeve with a conical sliding surface on a sealing lip which is of rubber for example and is spring-biased against the counter surface.

In order to improve the sealing action it is already known to provide a roughening of the surface of the shaft similar to rifling. The grooves of the rifling repel the medium to be sealed off. It is further known to mill or vulcanise rifling grooves in the sliding surface of the sealing lip. The last-mentioned arrangement has the advantage that the sealing lip is not damaged by the sharp edges of the roughened surface of the shaft.

It has also been proposed to provide ribs inclined to the main axis of the seal on the sliding surface. In contrast to grooves, the ribs have the property of flattening when the sealing lip is expanded. This occurs in particular in the region of the narrow zone of application of the sealing lip. (the zone is narrow because of the conical sliding surface). Tearing of the lip is avoided with certainty, whilst the repelling action is fully retained. Due to the resilient deformability of the material of the lip, in spite of the relatively high ribs there forms at the front edge, (that is the edge where the diameter of the conical sliding surface is smallest) a closed annular surface which prevents the emergence of oil even in a stationary condition.

In accordance with the present invention the ribs on the sliding surface are approximately semicircular in cross-section, the angle of inclination o the ribs to a plane normal to the shaft axis is between 20° and 45°, and the clear distance between the feet of adjacent ribs is greater than the height of the ribs.

Fig. 1.



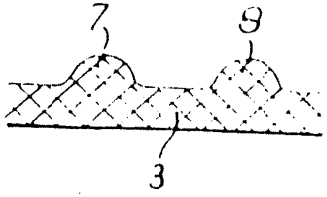


Fig. 2.

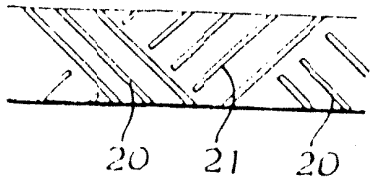


Fig.

This facilitates impression of the ribs into the sliding surface to form the above mentioned closed annular surface and with this in view it is preferable to round off the transitions of the ribs into the sliding surface. The ribs can be 0.2 mm. high or less for example.

In order to prevent, right from the beginning, the existence of free spaces between the sealing lip and the surface of the shaft, it is further proposed to cause the ribs to merge smoothly into the front edge of the sliding surface of the sealing lip.

The invention also extends to seals the ribs of which are not all directed the same way i.e., the ribs can be inclined partly to one side and partly to the other.

Some embodiments of the invention are illustrated in the accompanying drawing, in which:-

Fig. 1 shows in part sectional elevation a shaft seal drawn over a shaft,

Fig. 2 shows a sectional view of ribs and

Fig. 3 is a profile view.

The shaft seal 1 surrounds the shaft 2 with its sealing lip 3 pressed radially in on to the shaft by a tubular spring 4. The sliding surface of the sealing lip 3 is coned and provided with ribs 5 which are pressed flat in the zone of the front edge 6 of the sealing lip 3. The ribs 5 incline away from the front edge 6 of the sliding surface in the direction opposite to the normal direction of rotation of the shaft 2. This has the effect of repelling the medium to be sealed off which medium is on the front edge side of the seal (the right hand side in Fig. 1).

In Fig. 2 the ribs 7, 8 are shown as being semicircular and merge with a slight rounding into the surface of the sealing lip 3.

The profile illustrated in Fig. 3 shows oppositely inclined ribs 20, 21 and according to the direction of rotation the ribs 20 exert a sucking action inwardly or the ribs 21 exert a sucking action outwardly. The relative force of these actions can be varied as required by making the

numbers of ribs 20 and 21 different and by making the dimensions and spacings of the ribs 20 and 21 different.