(12) UK Patent Application (19) GB (11) 2 013 287 A

(21) Application No 7904252
(22) Date of filing 7 Feb 1979
(23) Claims filed 7 Feb 1979
(30) Priority data
(31) 7569/78
(32) 24 Feb 1978
(33) United Kingdom (GB)
(43) Application published
8 Aug 1979
(51) INT CL[2]
F16J 15/52
(52) Domestic classification
F2B 13C12 13C3
F1A 1A2 3C
(56) Documents cited
GB 1399396
GB 1192143
GB 1165886
GB 1142857
GB 1108107
GB 1027641
GB 984335
GB 978396
GB 963025
GB 763187
(58) Field of search
F2B
F2T

(71) Applicants
Fluid Transfer Limited,
Griffin Mill Estate, Thrupp,
Stroud, Gloucestershire
(72) Inventors
George Washington
Burrage
(74) Agent
Mewburn Ellis & Co

(54) Seals

(57) A flexible seal (2) comprises thickened inner and outer annular rims and a considerably thinner intermediate web integrally connected therewith. The seal has a pre-established configuration in which the rims are axially offset relative to each other so that the seal has a generally frusto-conical form. Curved section transition regions of comparable radial extent to the rims themselves blend into the rims and the web and provide a gradual change of section thickness therebetween. In one application the seal is mounted in a pump, being clamped by its rims between an axially reciprocating drive rod (22) and the pump housing (28). The seal is mounted under an initial radial compression such that in the operation of the pump its web is kept continuously in compression, or at most is subjected to tension in a small part of the reciprocating cycle.

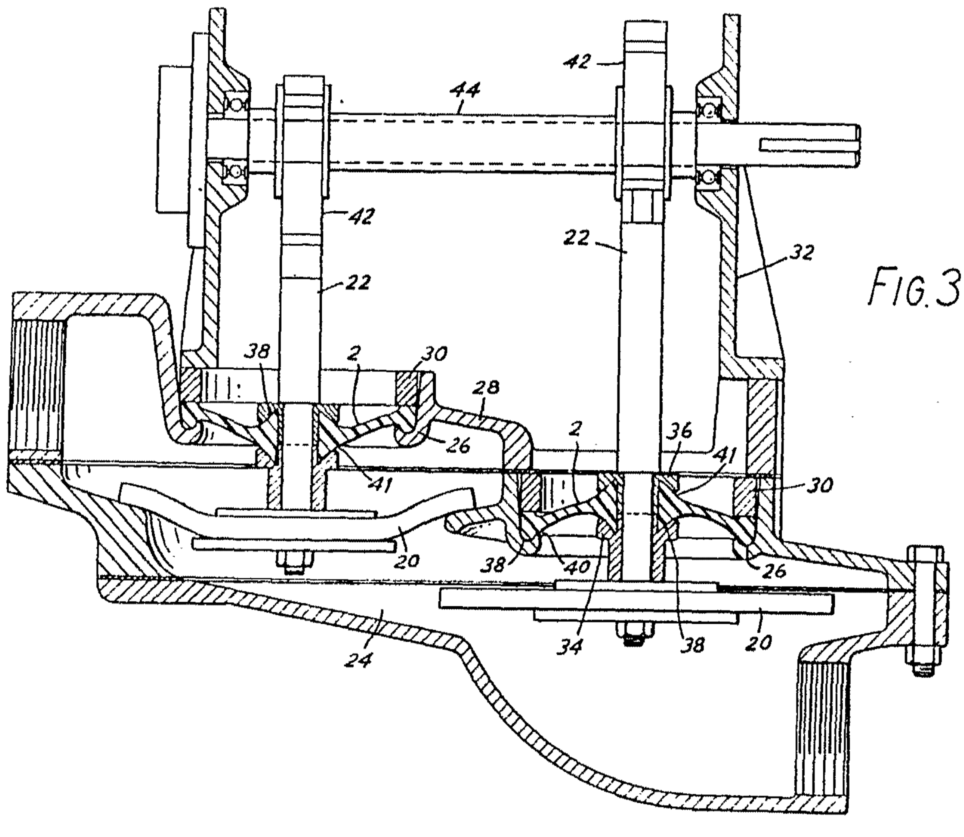


FIG.3

GB 2 013 287 A

1/2 2013287

FIG. 1

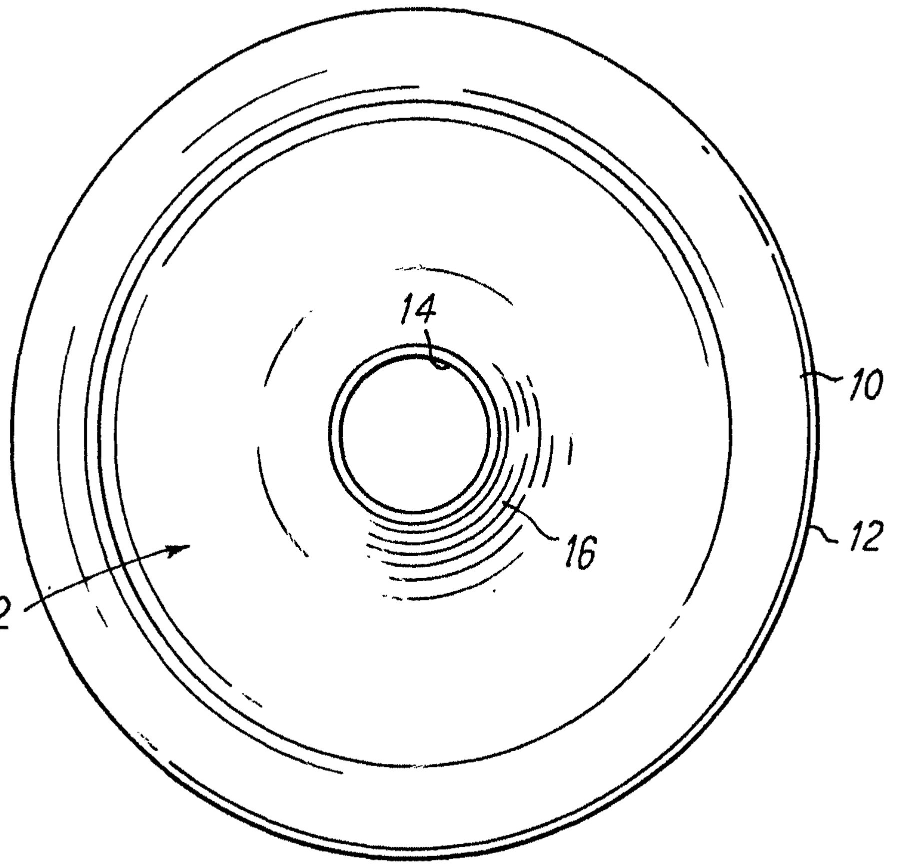


FIG. 2

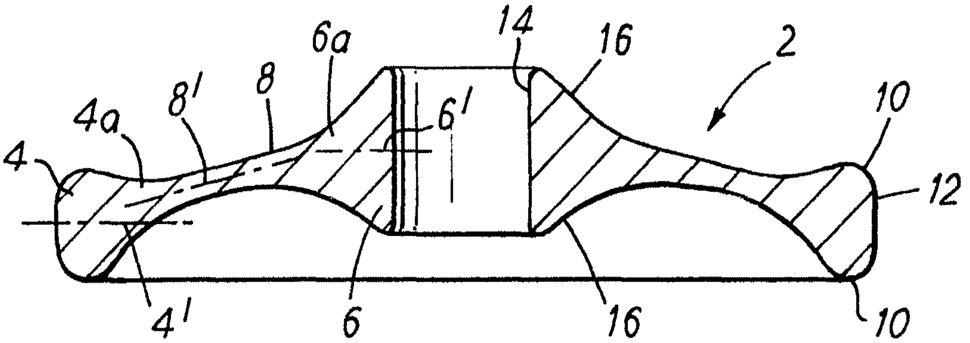
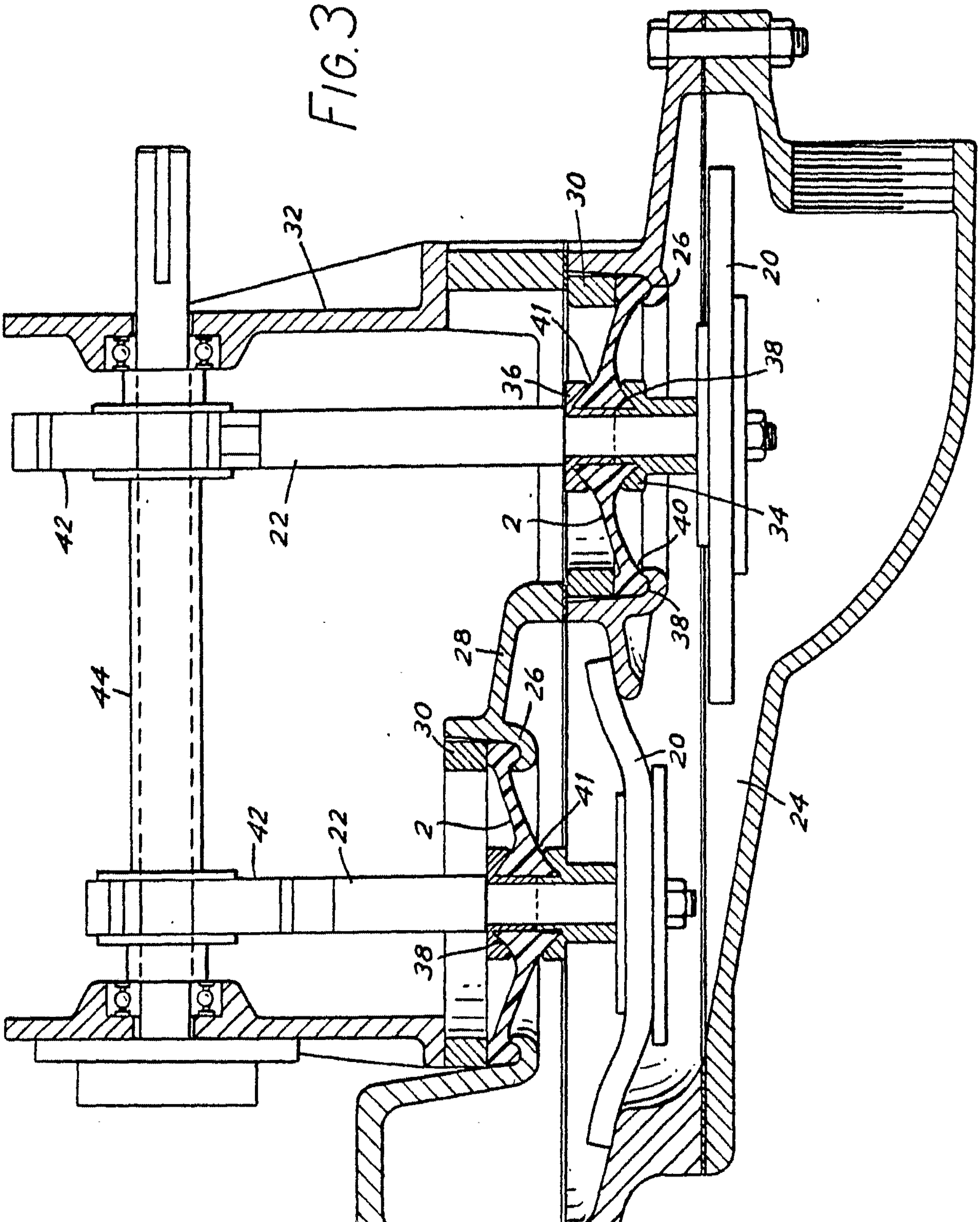


FIG. 3



SPECIFICATION

Improvements in or relating to seals

This invention relates to flexible seals and to constructions employing flexible seals, including mechanisms such as fluid pumps.

When it is required to seal between two members that have a relative reciprocating movement it may be preferred to use a glandless seal, that is to say a seal that has portions fixed to the respective members and the seal being composed of a rubbery material capable of deformation to accommodate the relative movement between the members. As compared with a sliding seal, leakage can be positively prevented but because the seal material is subjected to continuously varying stresses as the reciprocating movement is performed there is a possibility that it will fail prematurely, especially if subjected to large tension stresses, as rubbery materials tend to be weak in this kind of loading. While high stresses can be avoided by making the seal extremely flexible, in many applications this is undesirable as it leads to uncontrolled deformations. In the case of a pump, for example, such deformations can seriously reduce the pumping rate.

UK patent specification 1 111 153 discloses a pump having glandless seals and discusses the advantages of such seals and the problems that can arise from their elastic deformation. The solution offered by this earlier invention is to employ a seal in the form of a thick ring in the annular gap between a piston-like actuator and the pump casing that is held in radial compression between the two parts so that its radial width is hardly any greater than its axial depth. the effect of the radial compression on the seal is in fact to give an almost barrel-like cross-section. Such an arrangement obviously allows the actuator to perform only a very limited length of stroke. Moreover, it is found necessary to provide a supplementary seal axially spaced from the actuator, between the casing and a connector rod that operates the actuator and that is driven from an eccentric rotary shaft.

A major disadvantage of this earlier construction is that the axially deep, radially narrow form of the seal is a requirement of the design but it severely limits the maximum stroke of the actuator. Moreover, because of the shape of the seal cross-section, it is impossible to locate it firmly in position without there being sliding movements between the locating faces of the casing and actuator and the adjoining surfaces of the seal. In addition, the thick section of the seal will result in relatively high internal stresses, with a consequent increase in temperature that can eventually cause the properties of the seal material to deteriorate.

According to one aspect of the invention, there is provided a flexible seal for application between members one of which reciprocates relative to the other, comprising an annular element formed of resilient material and which is stable in a pre-established configuration, said element having inner and outer edge portions which are relatively thicker than an intermediate integrally connected web portion between said edge portions and said pre-established configuration providing that said inner and outer edge portions are axially offset, one relative to the other.

The seal may thus have a generally frusto-conical configuration defined by a median plane of the web portion with said thicker inner and outer edge portions extending axially to both sides of said median plane, and in preferred embodiments a web portion the radial extent of which is substantial in comparison to that of its edge portions.

According to another aspect of the present invention there is provided a flexible seal for a member relatively axially displaceable in a mounting, wherein the seal comprises inner and outer edge portions for sealing engagement with the member and the mounting respectively and has a cross-section in which the end regions forming said edge portions are each substantially deeper than an integrally connected intermediate web portion which is deformable with said relative displacements, transition regions connecting said web portion and the respective edge portions and each having a curved profile providing a progressive change of thickness of the seal section between the portions they connect. Such transition regions are found to have a beneficial effect when the seal is assembled under radial compression, and assist the seal to deflect in the required manner with the movement of said displaceable member.

According to a further aspect of the invention there is provided an assembly comprising a member axially movable relative to a housing and a seal as aforesaid between them, said seal being assembled under radial compression between the member and the housing, means for sealing engagement between the seal and the member and between the seal and the housing, each said engagement means comprising clamping means that grip the respective inner and outer edge portions of the seal cross-section without engaging the adjoining portions of the associated transition regions between said edge portions and their intermediate web portion.

One advantageous application of the invention may be in a diaphragm pump wherein the seals are employed between reciprocating drive rods carrying the pump diaphragms and a housing of the pump, in which the diaphragms are clamped by their central region to respective drive rods and are movable towards and away from seatings in the pump casing in phased sequence to produce a flow of fluid through the pump.

The invention will be described in more detail with reference to the accompanying drawings.

Figs. 1 and 2 are a plan view and a transverse cross-section of a seal according to the invention, and

Fig. 3 is a cross-sectional view of a pump embodying seals of the form shown in Figs. 1 and

2.

Referring to Figs. 1 and 2, the seal 2 is generally annular but has a shallow conical form. the shape of the radial cross-section of the seal is somewhat similar to the shape of a dumb-bell, having relatively deep inner and outer portions 6 and 4, respectively, that form thickened rims at the inner and outer edges of the annulus. These rim portions 4 and 6 and joined by and integrally connected with a thinner radially extended web section 8 which blends into the rim portions through curved transition regions 4*a*, 6*a* respectively. The axial depth of the web section is only approximately 6% the seal outer radius.

In its original or unstressed form and as shown in cross-section in Fig. 2 the inner enlarged rim portion 6 of the seal is in concentric relation to but is axially offset from the outer rim portion 4 though a minor part of the rim portions 6 is nested within the portion 4, i.e. these rim portions overlap each other in the axial direction. This gives the seal a generally frusto-conical configuration with the conical generator on which the median line 8′ of the web section 8 lies being at an angle of some 75° to the central axis of the seal, this angle of course representing the half cone angle. If extended inwards and outwards the median line intersects the inner and outer rims intermediate their axial thickness.

As seen in Fig. 2 the upper and lower or axially opposite faces 10 of the outer rim are radiused but the rim is non-circular in section, having a height or axial length substantially greater than its radial width. The radially outer face 12 of the outer rim has mainly a flat cross-sectional form and is therefore substantially cylindrical in configuration. The inner rim is considerably deeper axially of the seal than is the outer rim and it has a wedge-like profile comprising a cylindrical innermost face 14 axially opposite faces 16 that are radially outwardly convergent. Both these faces are oppositely inclined at a large angle, 45° in the illustrated example.

Both the inner and outer rim sections have respective axes of symmetry 4′, 6′ perpendicular to the seal axis. This symmetry in each case extends nearly to the junction of the rim with its adjoining transition region 4*a* or 6*a*, as can be more clearly seen in Fig. 3. The curved transition region 6*a* gives a tapering thickness to the section over a substantial distance comparable with the radial extent of the inner rim 6 itself. The curved transition region 4*a* is also of substantial radial extent, although smaller than that of the region 6*a*. In both instances the radial extent of the transition region should not be substantially less than the radial extent of the associated rim, and preferably it is greater than said rim radial extent.

In use, as applied in pumps and similar applications, the seal is secured in place with some radial compression, e.g. the outer radius may be compressed by some 3% to 5% from its free state. The mounting of the seal will be more clearly seen in Fig. 3 which illustrates the use of two of the seals described grouped in a glandless diaphragm pump in which the diaphragms 20 are secured to and are reciprocated by drive rods 22 to pump fluid through the pump in the arrowed direction and the seals 2 are secured between the drive rods and the pump casing to enclose the pump fluid passage 24.

The outer periphery of each seal is clamped onto a seating 26 in lower casing parts 28 by a clamping ring 30 that is urged against the seal when the upper casing part 32 is secured to the lower casing part, and an adhesive may also be applied between the seal outer rim and the seating 26 and clamping ring 30 to further secure these parts. The seal inner periphery is gripped between opposed collars 34, 36 on the drive rod.

The seal engagement faces 38 of the casing seatings for the underside of the outer rims are profiled to match the radiused bottom face of each seal outer rim and the flat faces 14 forming the outer rim outside face. The profile of these engaging surfaces does not, however, follow the shape of the thickened rims into the junction with the thinner web, where they terminate at a clearance 40 from the seal surface. The clamping rings 30 have flat bottom faces and also do not engage the full radial extent of the outer rims.

The clamping collars 34, 36 each have a V-section profile that closely matches the engaging face of the wedge-section inner rim of the seal, but they do not extend quite as far radially outwards as does said wedge-section portion of the seal. Also, the outer edge of each seal-engaging face of the collars 34, 36 has a small radius 41 that prevents the collar from biting sharply into the flexible seal material at this point, both due to the initial assembly compression and the subsequent deformation of the seal in operation.

The drive rods are reciprocated 180° out of phase by respective eccentrics 42 on a rotary drive shaft 44. The manner in which the fluid is pumped will not be described further here as it is already described in some detail in the specification of UK Patent No. 1 399 742 which shows a diaphragm pump that similarly employs diaphragms that have free outer peripheries and that are reciprocated out of phase of each other to generate a pumping flow.

Fig. 3 illustrates the two diaphragms at opposite end positions of the pumping stroke, from which it will be clear that a substantial length of stroke is obtainable. The conical configuration adopted by the right-hand seal shown in Fig. 3, is at most, at the same or at a slightly larger cone angle as compared with the free state configuration of the seal. In other words, the precompressed seal material will go into tension, if at all, only in the final stage of the upstroke and the tension forces will not be large, therefore. Conversely in the downstroke the material is compressed further beyond its precompression state as it moves towards the configuration shown by the left-hand seal in Fig. 3.

It is thus arranged that, with the precompression applied to the seal, the reciprocating movement of the drive rod is performed with the material of the seal remaining in compression, or passing only momentarily into tension so that it is in compression for the major part of its usage. This result is assisted by the fact that clamping force on the seal is not applied to the transitional regions between the rims and the intermediate web of the seal, so that the development of tension forces in these regions is at least partly avoided by the material flow under compression from the clamped rims, and rubbing of the material in these regions is also avoided. The non-circular form of the rims at their clamping surfaces ensures that they will not slip and lose the clearances. The precompression also has the effect of making the sealing of the rims more secure as they are urged into their seatings.

It should be noted that the seals are subjected not only to axial reciprocating displacements but there is also an angular displacement component due to the fact that the drive rods are coupled to eccentrics and their upper ends will therefore also be given a lateral displacement corresponding to their vertical displacement. The seals will tend to resist lateral displacement, however so that the transverse forces imposed will largely appear as angular displacements of the drive rods at the seals. Such displacements can be accommodated without difficulty because of the considerable radial extent of the seal between the edge portions even though, of course, the lateral displacements generating these movements are relatively large.

As they reciprocate, the drive rods will accordingly have a slight rocking motion about a centre in the region of their seals and as a result the diaphragm attached to the lower end of each drive rod is given a lateral displacement also. This can have a beneficial effect in that the seating faces on the casing contacted by the diaphragms are subjected to a wiping action that helps to avoid the collection of foreign matter on these faces which might otherwise impair the sealing effect.

A variety of materials can be used for the seals depending on the requirements of the fluid to be pumped, including polypropylene, RP rubber, silicone rubber or natural rubber, but preferred materials for many purposes will be polyurethane or nitrile rubber. The hardness of the material must be chosen so that it is not so soft that its shape is unstable under the pressure forces acting upon it, as this might affect the pump performance and could also give rise to undesirably large tension forces in the material, but on the other hand it must not be so hard that the deformations induce stresses that shorten its working life unduly. It appears that a Shore hardness greater than 50 and less than 100 is required, and a Shore hardness of 75 is preferred.

CLAIMS

1. A flexible seal for application between members one of which reciprocates relative the other, comprising an annular element formed of resilient material which is stable as to its pre-established configuration, said element having inner and outer edge portions which are relatively thicker than an intermediate integrally connected web portion between said edge portions and said pre-established configuration providing that said inner and outer edge portions are axially offset, one relative the other.

2. A seal according to claim 1 wherein said seal, in cross section, has a conical configuration and said inner and outer edge portions are concentric.

3. A seal according to claim 2 wherein the half cone angle of said configuration is substantially 75°.

4. A seal according to any one of claims 1 to 3 wherein the inner and outer edge portions are relatively nested axially of each other.

5. A seal according to claim 4 wherein only a minor end portion of said inner edge portion of said element nests axially within the boundary defined by said outer edge portion.

6. A seal according to claim 5 wherein said inner and outer edge portions are axially elongated.

7. A seal according to any one of the preceding claims wherein curved profile transition regions connect said web portion to the inner and outer edge portions respectively, said transition regions providing a progressive change of thickness between the portions they connect.

8. A seal according to claim 7 wherein each transition region has a radial extent not substantially less than the readial extent of its associated edge portion.

9. A seal according to claim 7 or claim 8 wherein the inner edge portion has a wedge-like profile tapering towards its associated transition region.

10. A flexible seal for use with a member relatively axially displaceable in a mounting, the seal comprising respective inner and outer edge portions for sealing engagement with the member and the mounting respectively, and an integrally connected intermediate web portion between said edge portions, end regions of the seal radial cross-section forming said edge portions being each substantially deeper than said intermediate cross-section regions forming said web portion, transition regions of said cross-section connecting said intermediate region with said end regions and blending smoothly with their connected regions, each transition region having a curved profile providing a progressive change of depth of the cross-section between the regions they connect.

11. A seal according to any one of the preceding claims wherein the Shore hardness of the seal is greater than 50 and less than 100.

12. A seal according to any one of the preceding claims in combination with a reciprocating member and a housing for said reciprocating member wherein said inner and outer edge portions of said seal are clamped to said reciprocating member and said housing respectively, and said web portion is placed in compression in the originally installed position of

said seal.

13. A combination according to claim 12 wherein the means clamping the outer edge portion of said seal and the means clamping its inner edge portion are so arranged as to leave a clearance between the seal and their radial extremities nearer the web portion.

14. A combination according to claim 12 or claim 13 so arranged that during the movement of said reciprocating member, the material of said seal is maintained under compression or is only momentarily placed in tension at the limits of said movement.

15. A pair of seals according to any one of claims 1 to 11 in a diaphragm pump including a pair of diaphragm-carrying drive rods mounted for out-of-phase reciprocation in a housing, means for sealingly securing the outer edge portion of each said seal to the housing and the inner edge portion of each said seal to a respective drive rod, said seals being constructed and arranged to be initially placed in compression and to be maintained substantially continuously in compression during the reciprocation of said drive rods.

16. A flexible seal constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.

17. A diaphragm-type pump provided with at least one flexible seal according to claim 16.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1979. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.