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(54) **Fracturing apparatus.**

(57) Material fracturing apparatus (10) comprises a shank (12) which has a fracturing tip (29) and which is pivoted about an axis (24) and is oscillated to and from by engagement of a drive (30) in a housing (21) with a drive transmitting portion (28) of the shank. The portion (28) is sealed to the housing by an annular seal (16) which is secured to the sealing surface (26) of the portion (28) at a position where a radius (33) from the axis (24) is perpendicular to the axis (26*b*) of the surface (26).

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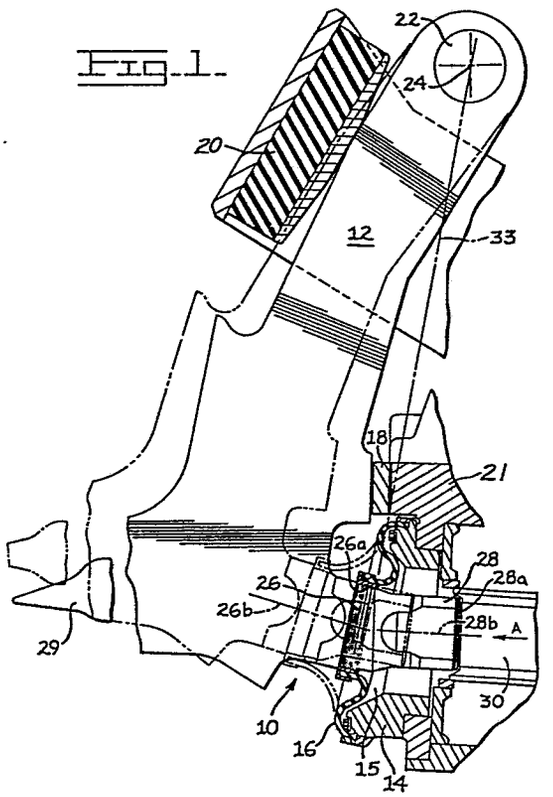
Fig. 1



CATERPILLAR TRACTOR CO. GJE 5081/173.

FRACTURING APPARATUS

The invention relates to apparatus for fracturing material by repeatedly delivering impact blows.

Numerous apparatus are available for fracturing rock formations and other materials in mining, excavation, and earthmoving in general. Fracturing materials by blasting with explosives can be an efficient technique, but may, under some circumstances, present an unacceptably high risk when used near population centre.

Mechanical impact apparatus such as jack hammers and/or crank driven impactors are known but are relatively slow and inefficient or constitute bulky devices which are not easily manipulated into limited access places.

U.S. Patent Specifications Nos. 3,868,145 and 3,922,017 illustrate two highly efficient, compact, manipulatable material fracturing apparatuses, each including a fracturing shank which is movable to and fro, mounted adjacent to a power drive housing. The shank, during operation, moves a short distance between a first impact receiving position and a second, material fracturing position where the fracturing shank is in penetrating contact with the fracturable material. In Specification No 3,868,145 the drive to the fracturing shank is transmitted through an impact

receiving portion of the shank which portion protrudes into the housing and is intermittently impacted by a rotatable eccentric.

In Specification No.3,922,017, the drive transmitting portion is provided by an intermediate hammer member which is pivoted to the fracturing shank and extends into the drive housing to transfer energy generated and stored within that housing to an impact receiving portion of the shank which is external to the housing.

In each of the aforementioned apparatus the intermediate portion which extends into the energy supply housing must be sealed to the housing to retain lubricant within the housing and to prevent foreign particle intrusion into the housing. Moreover the seal must be attached to the intermediate portion to avoid transporting foreign debris into the housing on the surface of that portion when it moves from its second to its first position. Sliding seals such as are commonly used in hydraulic cylinder applications as, for example illustrated in U.S. Patent Specification No 4,121,845 are thus not suitable for use in such material fracturing apparatus since they can permit transportation of foreign debris into the housing.

A type of boot seal, illustrated in U.S. Patent Specifications Nos 3,868,145 and 3,922,017, extends between the housing and the reciprocatable member which extends into the housing. However, while the impacting apparatuses described in these two specifications have, in general, fractured material in an efficient manner, the life of the boot seals has been erratic. A short boot seal life is highly undesirable since repair or replacement of such boot seal can be a time consuming process which must often be performed under field conditions. Moreover, during

such repair, the impact fracturing apparatus utilizing the boot seal must be shut down.

In accordance with the invention, in a fracturing apparatus for repeatedly delivering impact blows and comprising a fracturing shank which is pivotally mounted about an axis and which is repeatedly driven through a small angle by a drive within a housing; a drive transmitting portion carried by the fracturing shank and extending into the housing for transmitting motion from the drive to the fracturing shank, the drive transmitting portion having an annular sealing surface; and an annular seal having a radially inner terminating portion fixed and sealed to the sealing surface, a radially outer terminating portion fixed and sealed to the housing and an intermediate flexible portion interconnecting the inner and outer terminating portion; the axis of the sealing surface is substantially perpendicular to a radial line from the axis which radial line intersects both the axis and the junction of the flexible and inner terminating portions of the seal.

With this arrangement radial distortion of the seal, and particularly different radial distortion at different positions around the radially inner part of the seal, where the seal is most vulnerable to wear, is minimised, leading to long seal life. This is because the fracturing shank and drive transmitting portion only oscillate through a small angle so that the motion of the sealing surface and of the radially inner part of the seal approximates to straight line reciprocation along a tangent to a circle centred on the pivotal axis of the fracturing shank and this tangent is parallel to the axis of the seal. This advantage obtains not only when the drive transmitting portion is fixed to the fracturing shank, but also when

the drive transmitting portion is an intermediate hammer pivoted to the fracturing shank. In the latter case the drive transmitting portion has a composite oscillatory motion about both the pivotal axis of the fracturing shank and the axis of the pivotal connection between the drive transmitting portion and the fracturing shank. However the angular movement about the axes and their inevitable proximity ensures that the sealing portion of the drive transmitting portion effectively oscillates about the pivotal axis of the fracturing shank.

A further improvement in wear reduction at the vulnerable radially inner part of the seal may be achieved if the flexible portion of the seal extends away from the junction substantially parallel to the axis of the sealing surface. The radially inner edge of the flexible portion of the seal is then subjected to an axial push-pull upon movement of the drive transmitting portion and the wear-inducing bending of the seal occurs further outwards along the flexible portion where it is less locally restrained by the fixing to the sealing surface of the drive transmitting portion.

An example of apparatus according to the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1, is a side view, partly in section;

Figure 2 is an enlarged view of a portion of Figure 1;

Figure 3A is a front elevation of a portion of a seal;

Figure 3B is a transverse section through the seal illustrated in Figure 3A;

Figure 4 is a front elevation of a seal retaining ring; and,

Figure 5 is a rear elevation of a portion of a

shank assembly.

Figure 1 illustrates an impact fracturing apparatus 10 having an arcuately reciprocatable shank 12, a housing 14 having an interior 15 into which an impact receiving and drive transmitting portion 28 of the shank 12 is arcuately reciprocatable, and an annular seal 16 connected to the reciprocatable shank 12 and the housing 14 and having a longitudinal seal axis 16a (Figure 2). A pin 22 pivotally joins the shank 12 to a casing member 21, which also supports the housing 14, to constrain the reciprocation of the shank 12 along an arcuate path about a pivot axis 24 between a first, extreme impact receiving position (illustrated in full) and a second, extreme material fracturing position (illustrated in phantom). Arcuate reciprocation of the shank 12 to the right (as viewed in Figure 1) is limited by a stopping member 18 which abuts the shank 12 when it reaches its first extreme position. Likewise, a stopping member 20, which is disposed on the opposite side of the shank 12 and is preferably attached to a stationary casing member 21 (attachment not shown), abuts the shank 12 when it reaches the second, extreme material fracturing position.

The shank 12 includes a sealing portion 26 at an end of the portion 28, and a fracturing tip 29. As better illustrated in Figure 2, the shank's sealing portion 26 has a cylindrical sealing surface 26a with an axis 26b. The impact receiving portion 28 has a longitudinal axis 28b and an impact

receiving surface 28a which is engageable at intermittent times with a rotatable eccentric impacting member 30. A shank guide structure 31 includes two shank guides 32 (the one nearer the viewer having been removed to provide better visibility of the impact receiving portion 28) which are fixedly attached to the housing interior 15 and together transversely define an opening within which the impact receiving portion 28 is receivable. The shank guides 32 are arranged in closely spaced, transverse relation with the impact receiving portion 28 so as to direct the impact receiving surface 28a into an optimum impact receiving relationship with the impact member 30 and to resist transversely directed forces exerted on the shank 12 by the impacting member 30 and by the fracturable material. The shank guides 32 have an axial length 32a which is greater than the distance of e.g. 70 mm. separating the extreme reciprocation positions of the shank's impact receiving surface 28a as illustrated in Figure 1. The mechanism for intermittently engaging the impacting member 30 with the impact receiving surface 28a is better described in U.S. Patent Specification No. 3,868,145. The sealing surface's longitudinal axis 26b is perpendicular to a line 33 which extends radially from the pivot axis 24 to the sealing surface. As a result at this position, the longitudinal axis 26b remains perpendicular to the radial line 33 for all positions assumable by the shank 12 along its arcuate reciprocation path. The sealing surface's longitudinal axis 26b is inclined relative to the impact receiving portion's longitudinal axis 28b by an angle of approximately 10° by example.

The annular elastomeric seal 16 (best illustrated in Figures 3A and 3B) has a relatively rigid inner terminating portion 36 and a relatively rigid

outer terminating portion 38 which are respectively fixedly attached to the sealing surface 26a and the housing 14 so as to prevent debris intrusion into the housing's interior 15 and to prevent lubricant leakage out of the housing's interior 15. When the shank 12 assumes the position illustrated in Fig. 2 which is intermediate its extreme reciprocation positions, the seal apparatus 16 is unstrained symmetrically disposed about the longitudinal seal axis 16a, and the sealing surface's longitudinal axis 26b coincides with the seal's longitudinal axis 16a. The seal 16 includes an annular flexible portion 40 which is disposed between and joined to the relatively rigid terminating portions 36 and 38. A plurality (in this case two) of concentrically arranged interconnected convolutions 42 and 44 together constitute the flexible seal portion 40. The convolutions 42 and 44 have a convoluted centersurface 16b which appears as a centerline in Fig. 3B. It is to be understood that the centersurface 16b is the locus of points traced by the centerline illustrated in Fig. 3 as it is rotated about the longitudinal axis 16a. It is to be further understood that the centersurface 16b is an imaginary surface which is introduced for reference purposes only.

The convolutions 42 and 44 respectively include an inner and an outer margin 46 and 48 which bound the flexible portion 40, interface with the inner and outer terminating portions 36 and 38 respectively, and have exemplary thicknesses perpendicular to the centersurface 16b of 4 mm and 3 mm, respectively. The inner margin 46 constitutes the effective inner edge of the flexible portion 40 and is disposed along the radial line 33. The inner convolution 42 has a smaller radius of curvature R_1 of 17.77 mm by example as measured from an axis of curvature O_1 to the

center surface 16b than does the outer convolution 44 whose radius of curvature R_2 of 23.69 mm by example is measured from an axis of curvature O_2 to the center surface 16b. The axes of curvature O_1 and O_2 (illustrated in Fig. 3B) are separated, or offset, by a distance which is designated generally by the reference letter O and, by example, equals 16.0 mm.

It is to be understood that the previously mentioned sizes and dimensions for the seal 16 correspond to a seal which utilizes an elastomer material commonly known in the trade as Hytrel. A suitable alternative seal material constitutes fabric reinforced neoprene rubber which varies in exemplary thickness from 7 mm at the inner margin 46 to 5 mm at the outer margin 48. The offset O of the radii of curvature by example equals 10.0 mm while the radii of curvature for the inner and outer convolutions 42 and 44, respectively, constitute 16.78 mm and 22.37 mm for such fabric reinforced neoprene seal material.

The inner and outer margins 46 and 48 respectively interface with and are connected to the inner and outer terminating portions 36 and 38. The thickness of seal 16 perpendicular to the center surface 16b varies from the inner margin 46 to its outer margin 48 with decreases from the inner margin's thickness being proportional to the radial distance H (illustrated in Fig. 3B) separating the center surface 16b at the inner margin 46 from the center surface 16b at the seal location in question. The seal's terminating portions 36 and 38 have thicker cross sections (as measured perpendicularly to the center surface) than the flexible portion 40 since the terminating portions 36 and 38 are actually joined to the relatively reciprocatable shank 12 and housing 14. The flexible seal portion 40 has isolation faces 50 and

52 which are equidistant from the convoluted centerfsurface 16b and are respectively exposed to the environment surrounding the impact apparatus 10 and that existing in the housing's interior 15.

The seal 16 further includes an annular connection member 54 of U-shaped cross section which is disposed about and vulcanized bonded to the inner terminating portion 36. The U-shaped connection member 54 is open along the axial end adjacent the inner margin 46 and is closed on the opposite axial end. The connection member 54 has a radially inwardly facing surface 56 which is threadably engageable with the sealing surface 26a. A plurality (two in the illustrated case) of openings 57 in the connecting member 54 are provided to receive a tightening tool used to relatively rotate and threadably engage the seal 16 and the sealing surface 26a with a predetermined torque. At least one cylindrical locking extension 58 protrudes from the connection member 54 and is deformable into a plurality of restraining slots 59 (best illustrated in Fig. 2) formed in the shank 12 to prevent relative rotation of the connection member 54 and the sealing surface 26a in a threadably disengaging direction.

A retainer ring 60, illustrated in Figs. 1, 2, and 4, is engagable with the seal's outer terminating portion 38 and is securable to the housing 14 by a plurality of threaded screw bolts 62. The retaining ring 60 is annular relative to the longitudinal seal axis 16a except in the vicinity of a vertical centerline therethrough where the retaining ring's radial thickness is reduced to permit disposition thereof between the seal's outer terminating portion 38 and the casing member 21. The retaining ring 60 and the outer terminating portion 38 are engageable along

cooperatively ramped interfacing surfaces 38a and 60a which are respectively disposed thereon. Tightening the screw bolts 62 displaces the retaining ring 60 axially relative to the outer terminating portion 38, increases the interference therebetween as a result of the cooperative inclination of the ramped surfaces 38a and 60a, compresses the seal's outer terminating portion 38. Optimum sealing of the seal's outer terminating portion 38 with the housing 14 and the retaining ring 60 obtains when the retaining ring 60 engages the housing 14. A securing bead 38b of the terminating portion 38 extends radially inwardly and is receivable in a circular notch 14a formed in the housing 14.

An enlarged view of the impact receiving portion 28 is illustrated in Fig. 5 as viewed from a vantage point A as indicated in Fig. 1. The impact receiving portion 28 has an outer periphery 28c which constitutes a four-sided figure whose corners have been rounded. The longest protrusion of the outer periphery 28c from the impact receiving portion's longitudinal axis 28b is the radius 28d which is smaller than the radius separating the sealing surface 26a from the sealing longitudinal axis 26b. Such size differential enables axial displacement of the seal 16 over the impact receiving portion's outer periphery 28c.

Canting the axis of the shank's sealing portion 26 relative to the axis of the shank's impact receiving portion 28, and utilizing the seal geometry previously described results in greatly reduced strain levels in the seal 16 which are substantially equal at the points of maximum strain. Of particular importance in this respect are the tapered thickness which is a function of the radial distance H, the convolutions' different radii of curvature R_1 and R_2, and the offset distance O between the axes of curvature.

The seal 16 may be removed from the apparatus 10 by extracting the screw bolts 62, removing the retaining ring 60, disengaging the deformed areas of the locking extension 58 from the locking slots 59, and rotating the seal 16 and integral connection member 54 to unscrew them from the sealing surface 26a. After moving the stopping member 20 to an unobstructing position, the shank 12 is arcuately displaced to a convenient position where the impact receiving portion 28 is disengaged from the shank guides 32 and is resident outside the housing's interior 15. The seal 16 is then axially displaced along the outer periphery 28c of the impact receiving member 28 until it passes the impact receiving surface 28a and can be removed to a remote location. Assembly of the seal 16 is accomplished in the opposite order.

During shank reciprocation, the cross section of the flexible seal portion 40 flexes between an "S-shape" and a nearly straight line as illustrated in Figure 1. However, throughout the seal flexure the edges of the flexible portion 40 running into the terminating portions 36 and 38 remain substantially cylindrical i.e. extend generally parallel to the axis 26b. The respective orientation of the convolutions 42 and 44 toward and away from the housing 14 cause fracturable material and other debris exposed to the isolation face 50 to be expelled therefrom during seal flexure and thus avoid potentially debilitating, seal immobilizing debris accumulation on the isolation face 50. The U-shaped cross section of the connection member 54 shields the vulcanized bond from direct impingement by fracturable material during shank reciprocation and maximizes the bonding area between the seal material (preferably Hytrel) and the connection member 54 (preferably carbon steel) for the purpose of

reducing the stress (and thus increasing the life) imposed thereon during shank reciprocation.

While the seal 16 has been illustrated as providing sealing between an arcuately reciprocatable shank 12 with an integral impact receiving portion 28, it is to be understood that the seal 16 may be used with equal facility with the intermediate hammer member described in U.S. Patent Specification No.3,922,017, after suitable modification to that apparatus.

CLAIMS.

1. Fracturing apparatus (10) for repeatedly delivering impact blows, the apparatus comprising a fracturing shank (12) which is pivotally mounted about an axis (24) and which is repeatedly driven through a small angle by a drive (30) within a housing (14); a drive transmitting portion (28) carried by the fracturing shank and extending into the housing for transmitting motion from the drive to the fracturing shank, the drive transmitting portion having an annular sealing surface (26a); and an annular seal (16) having a radially inner terminating portion (36) fixed and sealed to the sealing surface, a radially outer terminating portion (38) fixed and sealed to the housing and an intermediate flexible portion (40) interconnecting the inner and outer terminating portions; characterised in that the axis (26b) of the sealing surface is substantially perpendicular to a radial line (33) from the axis (24) which radial line intersects both the axis (26b) and the junction (46) of the flexible and inner terminating portions of the seal.

2. Apparatus according to claim 1, wherein the flexible portion (40) of the seal extends away from the junction (46) substantially parallel to the axis (26b) of the sealing surface.

3. Apparatus according to claim 1 or claim 2, wherein the drive transmitting portion (28) is fixed to the

fracturing shank (12) and is guided in a guide structure (31) as it moves to and fro with the fracturing shank.

4. Apparatus according to any one of the preceding claims, wherein the inner terminating portion (36) is held in an annular connection member (54) which is screwed onto the sealing surface (26a).

5. Apparatus according to claim 4, wherein the drive transmitting portion (28) has restraining slots (59) for receiving at least one deformed portion (58) of the connection member (54) to prevent unscrewing of the connection member.

6. Apparatus according to any one of the preceding claims, wherein the outer terminating portion (38) has a protruding securing bead (38b) which is received in an annular securing notch (14a) in the housing (14).

7. Apparatus according to any one of the preceding claims, further including a retainer ring (60) for clamping the outer terminating portion (38) to the housing (14).

8. Apparatus according to claim 7, wherein means (62) are provided for drawing the retaining ring axially onto the housing to secure the outer terminating portion (38), and wherein the retaining ring (60) and the outer terminating portion (38) have engaging surfaces (38a, 60a) which are cooperatively inclined to the axis of the retaining ring to provide a required clamping pressure.

9. Apparatus according to any one of the preceding claims, wherein the flexible portion (40) is sinuously convoluted from the inner (36) to the outer (38) terminating portion.

10. Apparatus according to claim 9, wherein the thickness of the flexible portion (40) decreases from the inner (36) to the outer (38) terminating portion

substantially proportionally to the radial spacing (H) of the centre surface (16b) of the flexible portion from the junction (46) between the flexible portion (40) and the inner terminating portion (36).

11. Apparatus according to claim 9 or claim 10, wherein there are two convolutions (42, 44), the concave sides of which face in opposite axial directions, and the curvature of the convolutions (42) nearer to the inner terminating portion is greater than that of the other convolutions (44).

Fig. 1

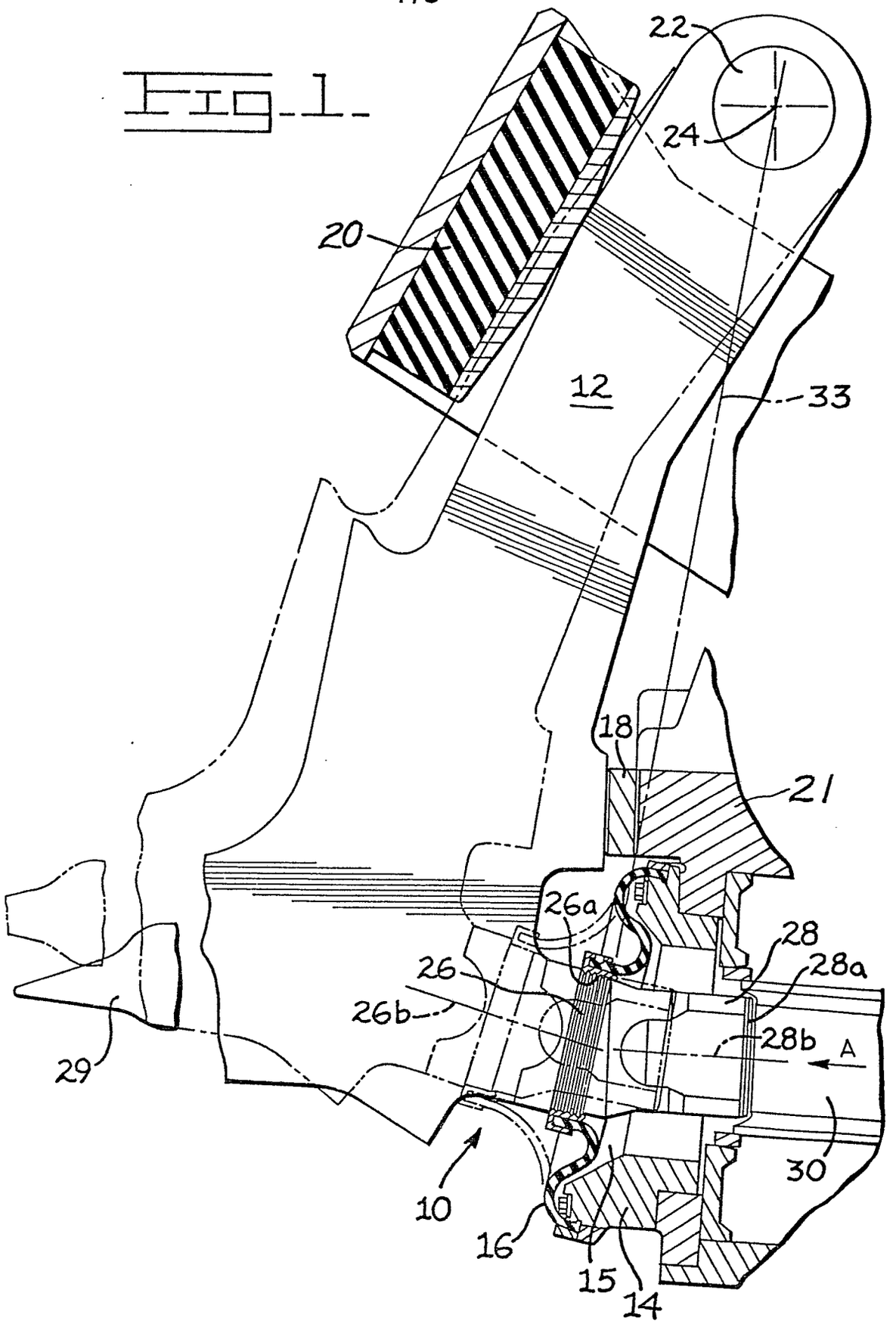


Fig-2-

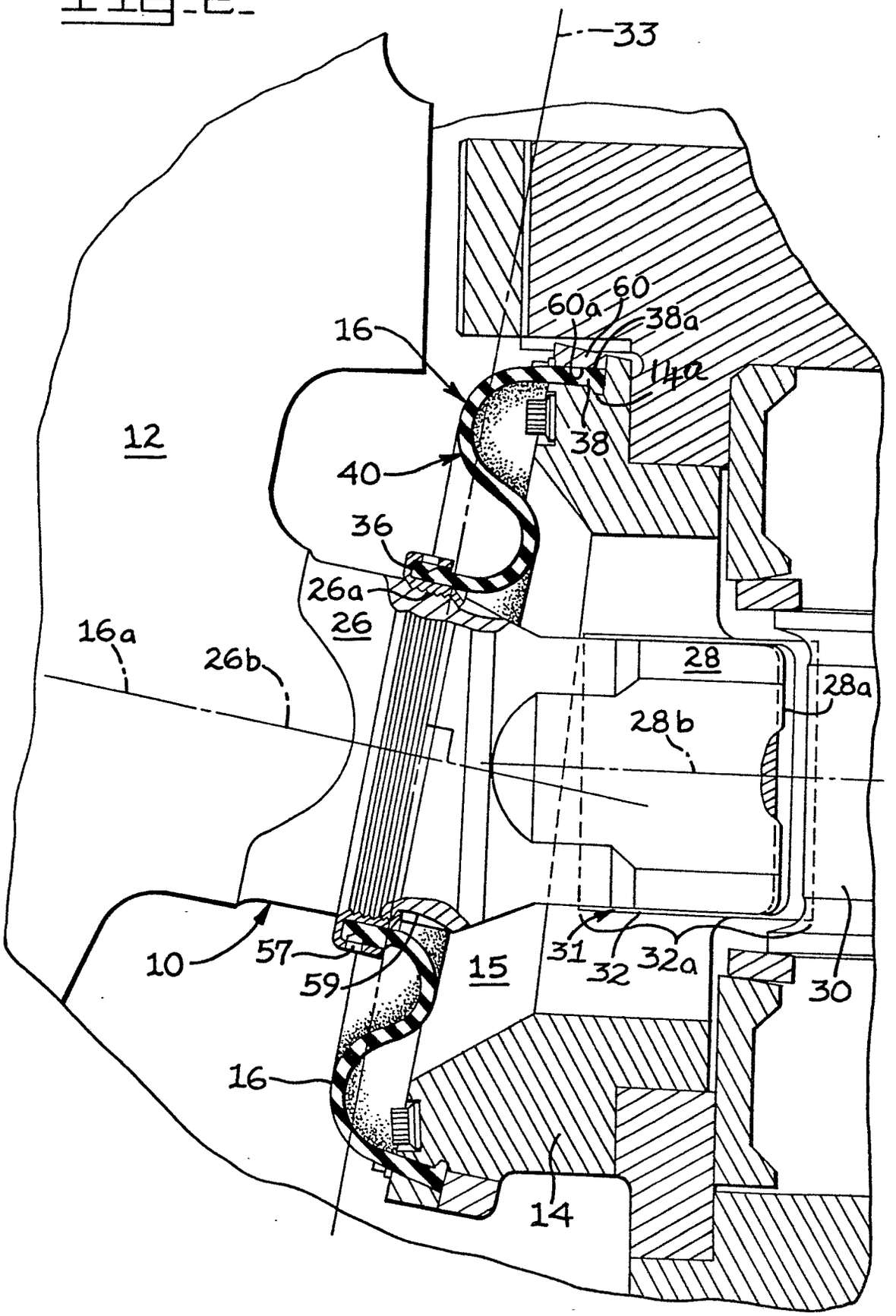

33
60a
60
38a
14a
16
12
38
40
36
26a
26
16a
26b
28
28a
28b
10
57
59
15
31
32
32a
30
16
14

Fig-3-A

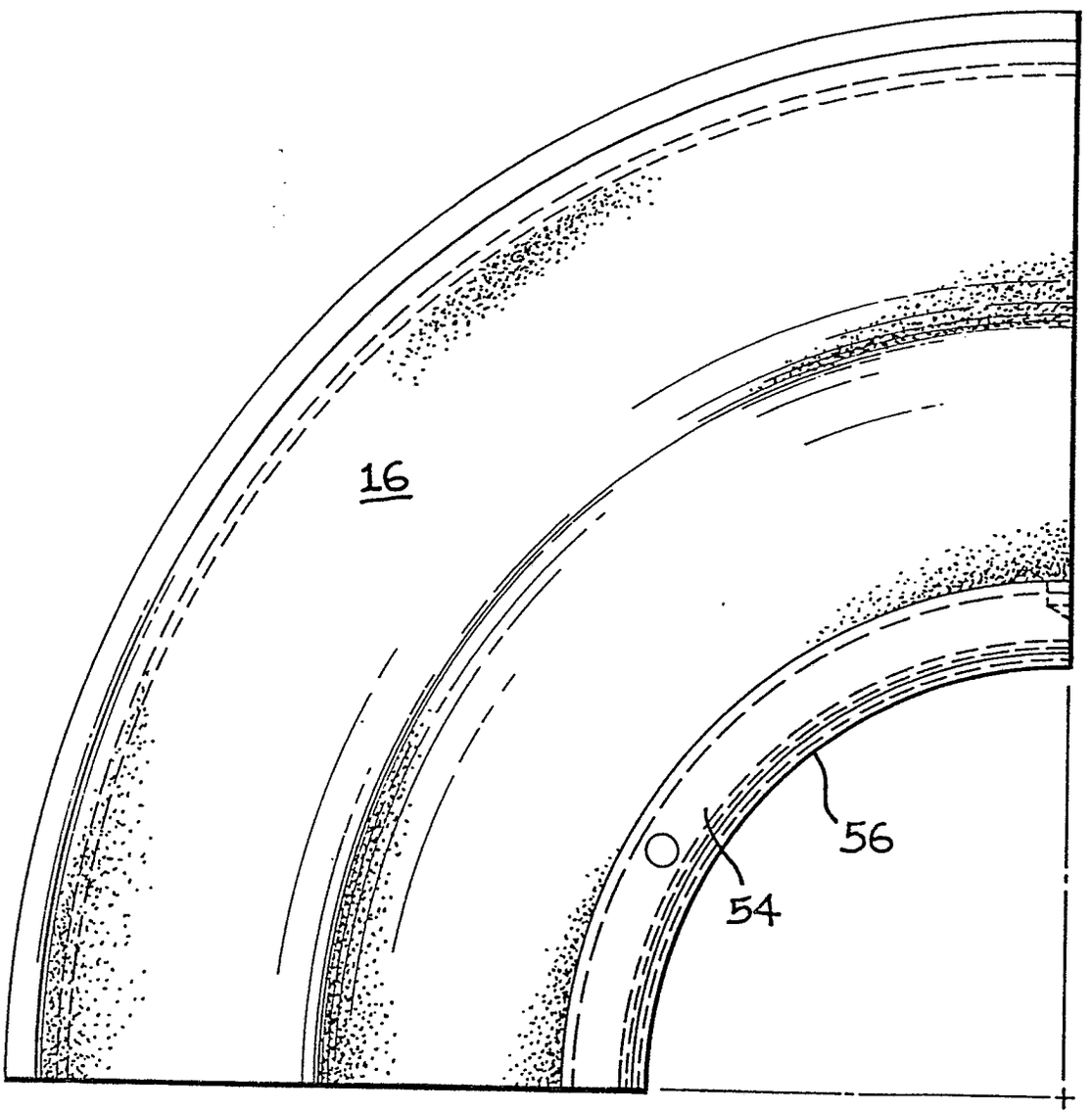
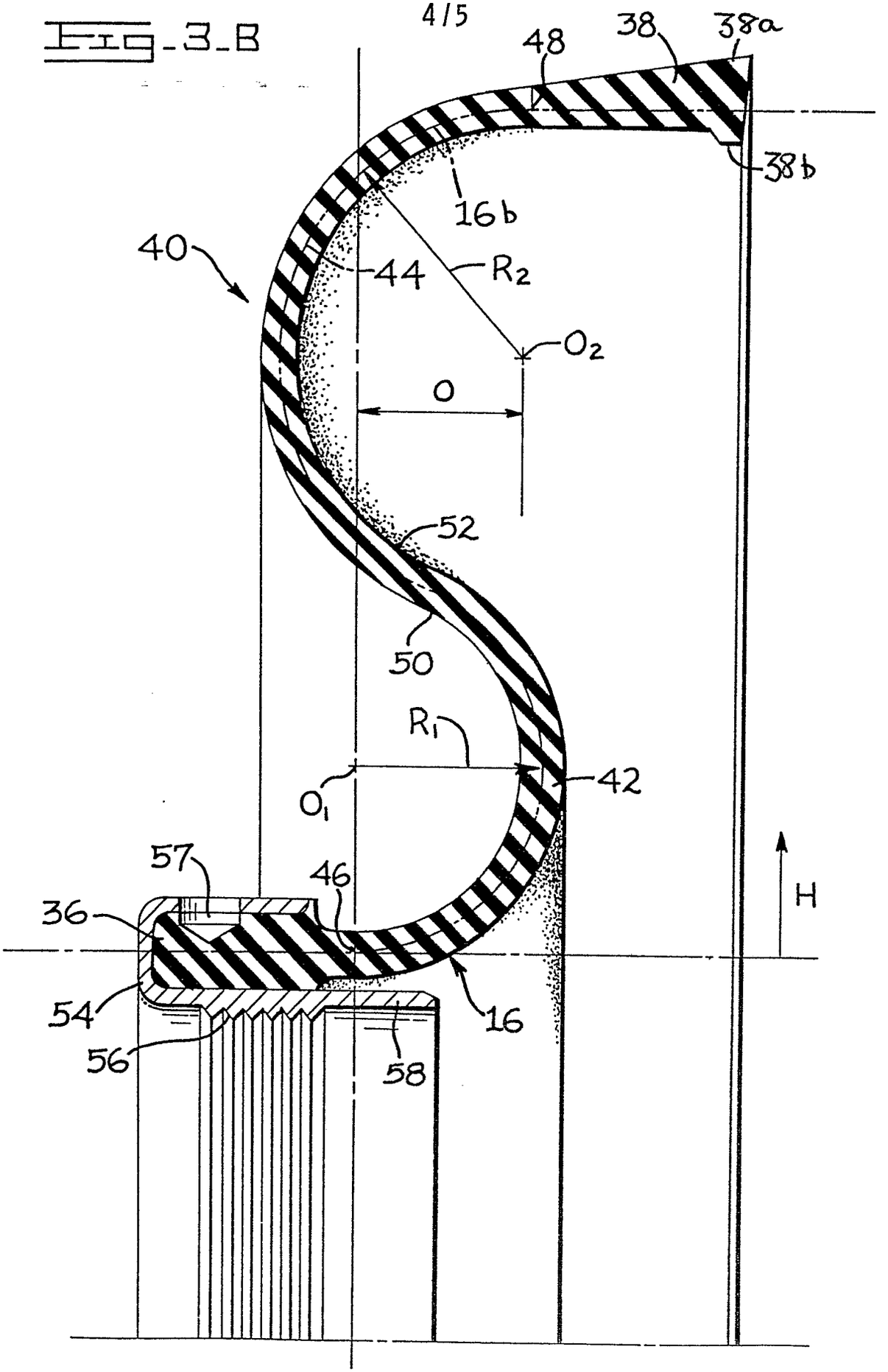


Fig-3-B



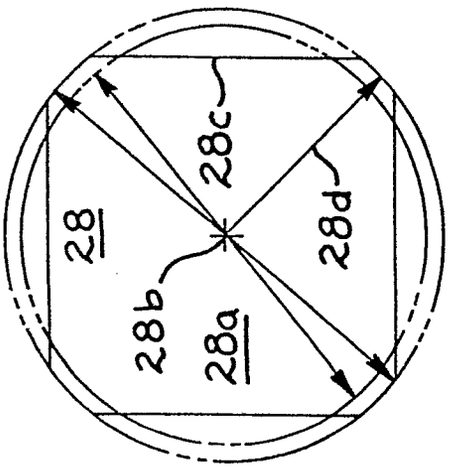


Fig-5-

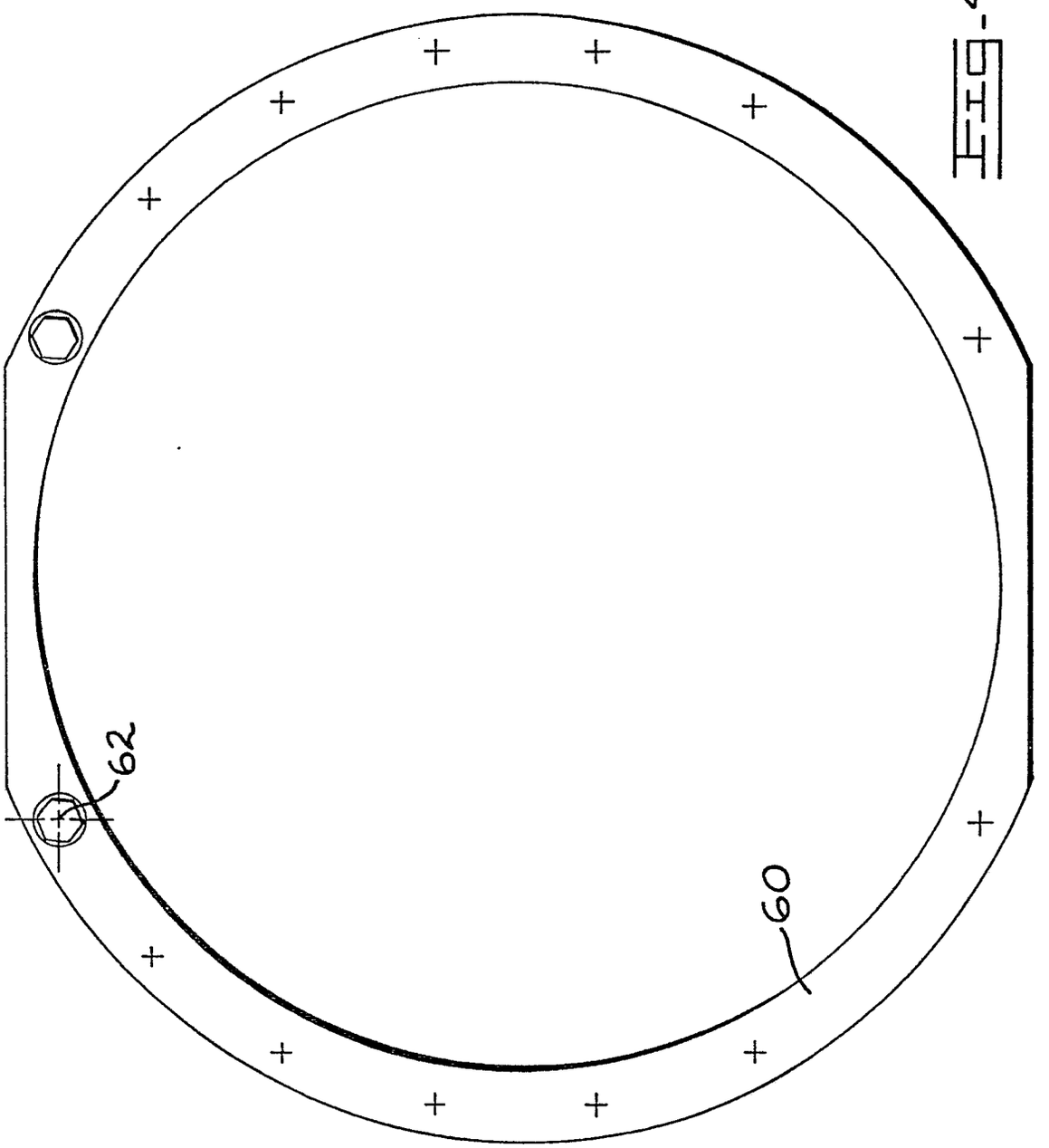


Fig-4-

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 81 30 5806.2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	WO - A1 - 80/01188 (LIVESAY) * fig. 3 *	1-3	E 21 D 9/10
Y	US - A - 3 770 322 (COBB et al.) * fig. 23 *	1-3	
A	US - A - 3 381 987 (HUSEN) * fig. 2 *	1,2,4, 7-11	
A	US - A - 3 611 816 (WEDEKIND et al.) * fig. 6 *	1,2,4, 7-11	

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

E 21 C 27/28
E 21 C 27/46
E 21 D 9/10

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same category
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	28-04-1982	ZAPP