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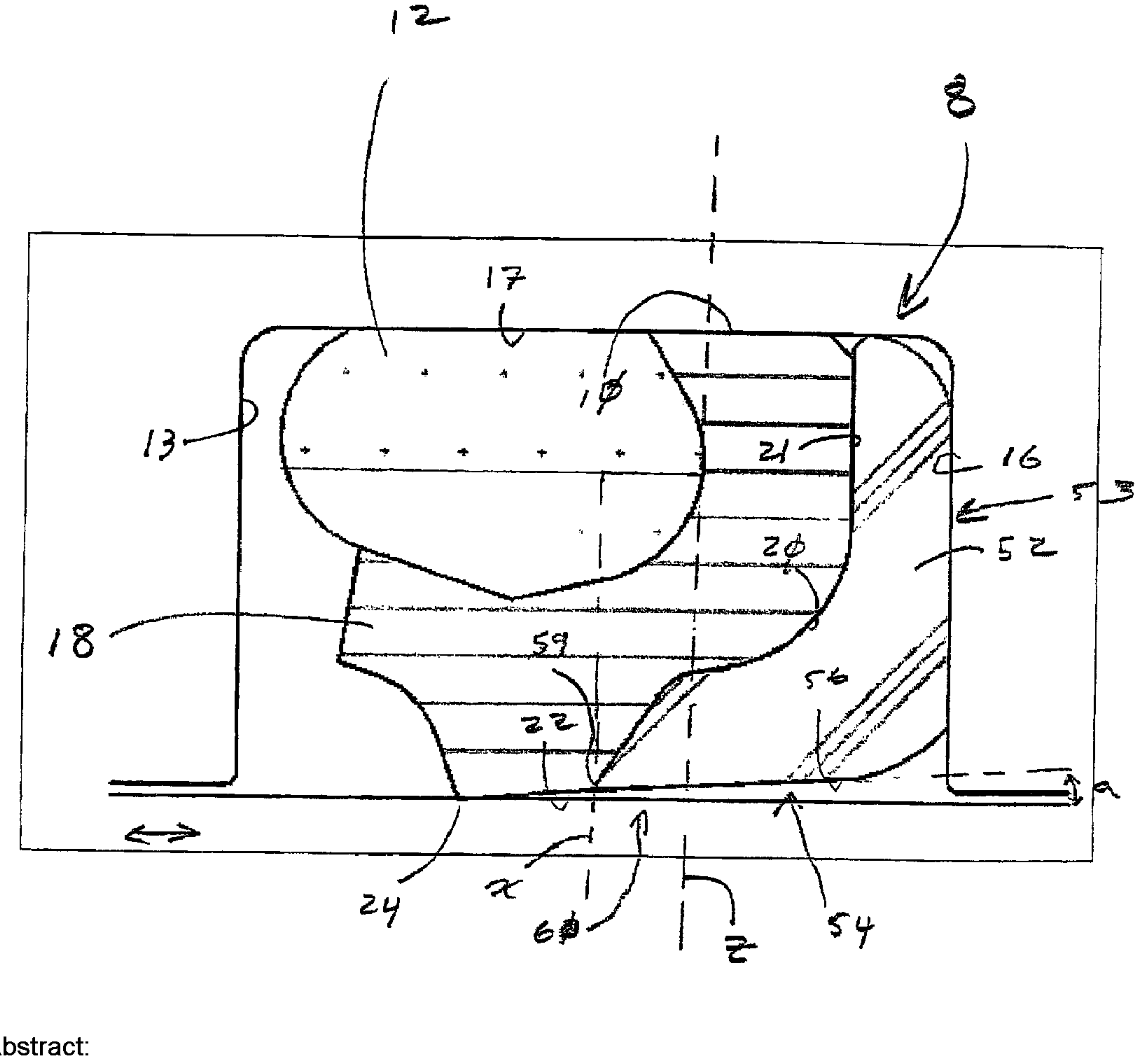
(54) Titre : JOINT DE TIGE ELASTOMERE ENERGISE A BAGUE D'APPUI INTEGREE
(54) Title: ELASTOMER ENERGIZED ROD SEAL WITH INTEGRATED BACKUP RING



(57) Abrégé/Abstract:
An annular seal for sealing between a static and a dynamic machine part such as between the cylinder head and the piston rod of a hydraulic cylinder, made of a resilient material and energized by a surrounding compression ring, such as an O-Ring, the annular

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(57) Abrégé(suite)/Abstract(continued):
seal being installed with the compression ring in a common, rectangular housing groove such that it separates the compression ring from the moving surface and the downstream wall of the housing groove, the outer diameter of the seal meets or exceeds that of the groove bottom.

ABSTRACT OF THE DISCLOSURE

An annular seal for sealing between a static and a dynamic machine part such as between the cylinder head and the piston rod of a hydraulic cylinder, made of a resilient material and energized by a surrounding compression ring, such as an O-Ring, the annular seal being installed with the compression ring in a common, rectangular housing groove such that it separates the compression ring from the moving surface and the downstream wall of the housing groove, the outer diameter of the seal meets or exceeds that of the groove bottom.

Jeff Baehl

ELASTOMER ENERGIZED ROD SEAL WITH INTEGRATED BACKUP RING

BACKGROUND OF THE INVENTION

1. Field of the invention.

The present invention relates to an improved sealing element which includes an energizer element, a seal element, and an integrated backup ring with controlled flex.

2. Description of the related art.

Seal elements are commonly utilized in machines having parts which move relative to each other and which include fluid which is to be retained in a specific portion of the machine. Seal elements may additionally be utilized between static members of machines in situations in which a fluid is to be kept within a certain portion of the machine. One of the machine parts typically includes a gland which is designed to house the sealing element. Examples of such seals include the annular seals utilized in hydraulic mechanisms to seal between the piston and the cylinder of the hydraulic mechanism. In these configurations, the gland may be formed in the piston or the cylinder of the hydraulic element.

Prior seal elements have included plastic sealing surfaces which cover the entire sealing surface of the seal. These plastic seal elements were in some cases made from polytetrafluoroethylene (PTFE), urethanes, or elastomers.

Many known sealing arrangements utilize a three piece configuration with an energizer/seal element/ backup ring being first placed in the gland and a second separate sealing element then being placed adjacent the energizer/seal element and a third separate backup ring placed against the seal element.

Configurations of this type are problematic in that they are difficult to install. Three piece configurations are additionally problematic as the additional seal parts create additional gap tolerance concerns. Additionally, standard backup rings are rectangular in cross section and only protect the seal ring from the gap created by the groove body and the moving element (which can also be referred to as a moving body, the moving element/body including a moving surface). During operation under pressure, the entire backup ring is forced down on the rod significantly contributing to friction. Further, proper film control may be lost by such uncontrolled movement.

What is needed in the art is a seal arrangement having improved leakage control, reduced friction, and increased lifetime for sealing environments adapted for reciprocation, rotary, oscillating, and static uses.

What is also needed in the art is a seal arrangement which allows a portion of the seal to contact the surface to be sealed and which is able to create controlled and non-linear load patterns at the point of seal element and backup ring contact.

SUMMARY OF THE INVENTION

The present invention is directed to overcome the above-mentioned shortcomings in the art, and provide a sealing apparatus with the unique construction that tends to prohibit seal rotation during operation with superior fluid film control. The present invention is in three parts. First is that of an elastomer energizer, which may be in the shape of a square ring, o-ring, or an other custom design for energizing the seal system. Second is that of a seal element or ring having a particular geometry and composition. Third is an backup ring (reinforcing ring) having a particular shape, structural material, and engineered flex. The flex of the backup ring is particularly designed to occur under various conditions, thereby increasing sealing and protecting the seal ring, and at other times releasing from the sealing surface to reduce and/or eliminate friction.

The geometric layout of the backup ring element ensures firm contact between the seal and groove bottom, independently of the seal pressure and radial position of the moving part, and concentrates contact forces against the moving part by means of an engineered flex of the backup ring. In the installed state, the backup ring has a radial height exceeding that of the housing groove. Further, the influence of the compression ring or energizer is balanced out by positioning the seal apex near or particularly in front of the axial position of the center of the energizer. The seal apex itself is defined, in one form of the invention, by an inlet angle upstream of the apex of preferably more than 30° to the moving part, and a downstream slip angle of greater than 5° preferably greater than 7°.

The invention of the backup ring utilizes a flexible area under the rear portion of the annular seal to support the seal, preventing damage from the gap between the groove body and the moving element. This area will also support the seal element and minimize the deflection of the seal element down stream, and against the moving body to provide better fluid film control. This function also minimizes radial loading on the moving element as pressure increases. The axial length of the support area may be dependent on the position of the energizer ring. The backup ring for enhanced performance should pass under five percent to ninety-five percent (5% to 95%) of the energizer ring and in an alternate embodiment twenty percent to forty percent (20% to 40%) of the energizer ring. For optimum performance in an alternate embodiment, the backup ring should pass under twenty-seven percent to thirty-three percent (27% to 33%) of the energizer ring.

Depending upon the geometry of the seal, the sealed pressure produces a net torque on the angular seal, which works to force the assembly down upon the moving part, or alternatively to improve contact with the groove bottom. The direction and relative magnitude of this improvement can be approximated by the ratio of radial groove height divided by the axial distance from the seal apex to where the seal meets the groove bottom. When the ratio exceeds one, seal contact with the groove bottom is improved with pressure, and in the present invention this ratio exceed 1.25.

Flexibility to allow radial displacement of the moving part is determined by the radial height of the sealing element, defined as that portion of the seal element which lies downstream of the radial line going through the downstream end position of the energizer. In the present invention, a line can be drawn downstream from the point where this line intersects the moving surface forming an angle with the moving surface of at least 7° without contacting the solid part of the seal.

The backup ring includes a clearance on the inner diameter with the moving element. This allows the flexible area of the support ring to deform and make contact therewith at a desired pressure level. The stress taken up in the deflection of the support ring is eliminated from the additive friction resulting from increased contact area and stresses of the annular ring. The radial clearance of the most up-stream edge should be from 0 to 0.050 inches (0.25 mm). Further, in another form of the invention, the angle of the inner diameter surface of the backup ring should be minimized to be between 0 to 10 degrees, so that when unpressurized, hoop stress within the backup ring and/ or backup ring flex area will lift the area from the moving surface, thereby reducing friction and supporting transmission of a fluid film.

In a broad aspect, the present invention provides an annular seal arrangement for sealing between a static machine part and a dynamic machine part, such as between a cylinder head and a piston rod of a hydraulic cylinder, said annular seal arrangement comprising: a compression ring; and a seal element made of a resilient material and energized and surrounded by said compression ring, the seal element being installed with the compression ring in a common, rectangular housing groove defined by the static machine part, the seal element separating the compression ring from a moving surface of the dynamic machine part and a downstream wall of the housing groove, the outer diameter of the seal element having a radial extent which is one of greater than and equal to a radial extent of a groove bottom of the housing groove before the annular seal arrangement is installed in the housing groove.

In the seal arrangement of the present invention the radial extent of the outer diameter of the seal element preferably exceeds the radial extent of the groove bottom by between 0 and 1.50 mm before the annular seal arrangement is installed in the housing groove. A radial height of the seal element is preferably one of greater than and equal to a radial height of the housing groove before the annular seal arrangement is installed in the housing groove.

Preferably, the radial height of the seal element exceeds the radial height of the housing groove by between 0 and 25% before the annular seal arrangement is installed in the housing groove.

Preferably, the seal element is laid out with a seal apex defined by an upstream seal angle of more than 15° and a downstream slip angle of more than 2°, the seal apex being formed by one of the intersection of the upstream seal angle and the downstream slip angle, a flat shape with a width of no more than 1 mm, and a convex shape with a width of no more than 1 mm. Preferably, a position of the seal apex is axially located near a center of the compression ring when the annular seal arrangement is installed in the housing groove.

The seal element may be laid out with a seal apex defined by an upstream seal angle of more than 40° and a downstream slip angle of more than 10°, the seal apex being formed by one of the intersection of the upstream seal angle and the downstream slip angle, a flat shape with a width of no more than 1 mm, and a convex shape with a width of no more than 0.75 mm.

The seal element may be laid out with a seal apex defined by an upstream seal angle between 45 and 50°, and a downstream slip angle between 12 and 17°.

In the seal arrangement of the present invention the seal element is laid out such that the ratio: Radial groove height / axial distance from a seal apex to where the seal element meets the groove bottom, exceeds 1.25.

The seal element may be laid out such that the ratio: Radial groove height / axial distance from a seal apex to where the seal element meets the groove bottom, exceeds 1.75.

Moreover, the seal element may be laid out such that a straight line can be drawn from a seal apex through a body of the seal element to a radial line defining a downstream wall of the seal element, and that a first said radial line forms an angle with the moving surface of at least 40°.

The seal element may be laid out such that a straight line can be drawn from a seal apex through a body of the seal element to a radial line defining a downstream wall of the seal element, and that a first said radial line forms an angle with the moving surface of at least 50°.

In the seal arrangement of the present invention, from a radial line going through a downstream end position of the compression ring a line can preferably be drawn downstream from a point where the radial line intersects the moving surface, forming an angle with the moving surface of at least 7° without contacting the seal element.

Moreover, in one embodiment from a radial line going through a downstream end position of the compression ring, a line can be drawn downstream from a point where the radial line intersects the moving surface, forming an angle with the moving surface of at least 14° without contacting the seal element.

In another embodiment, from a radial line going through a downstream end position of the compression ring, a line can be drawn downstream from a point where the radial line intersects the moving surface, forming an angle with the moving surface of at least 18 and not more than 24° without contacting the seal element.

Preferably, the present invention further includes a support ring positioned adjacent the seal element, in which the outer diameter of the support ring meets or radially exceeds the groove bottom.

The present invention may include a support ring positioned adjacent the seal element, in which the outer diameter of the support ring radially exceeds the groove bottom by between 0 and 0.75 mm.

A support ring positioned adjacent the seal element of the present invention may hvae a radial height of the support ring being equal to or less than a depth of the housing groove.

In one embodiment of the present invention a support ring positioned adjacent the seal element, may have an internal diameter of the support ring exceeds the moving surface by 0 to 0.5 mm.

In another embodiment a support ring positioned adjacent the seal element may have an inner surface of the support ring with an angle away from the moving surface greater than 1° but less than 5°.

In the seal arrangement of the present invention the compression ring may be an O-ring.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a sectional view of one embodiment of an annular seal formed in accordance with the teachings of the present invention;

Fig. 2 is a sectional view of another embodiment of an annular seal formed in accordance with the teachings of the present invention; and

Fig. 3 is a sectional view of yet another embodiment of an annular seal formed in accordance with the teachings of the present invention.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates one preferred embodiment of the invention, in one form, and such exemplification is not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and particularly to Fig. 1, there is shown a seal 8 in accordance with the teachings of the current invention. The annular configuration of seal 8 illustrated in Fig. 1 is not meant to be limiting in any way as the seal structure taught by the current invention may be utilized in seals of differing configuration, such as linear or elliptical seals, for example and can be utilized in reciprocation, rotary, oscillating, and static configurations. Annular seal 8, as shown, generally seals between two concentric members with annular seal 8 being held in place by a gland 13 (which can be variously referred to as a groove channel or a housing groove) contained within either of the concentric members.

As explained above, the sealing geometry utilizes an energizer/seal element 12 having a semicircular or rectangular surface which is designed to be first inserted into the gland.

Elastomeric energizer 12 may be made of known materials, methods, shapes, and sizes including but not limited to, square, O, and custom shapes.

Seal element 18 includes a top surface 10 that is sized in length sufficient to interfere with the groove channel and prevent seal element rotation toward the dynamic surface. The further contact of energizer 12 in the embodiment of Fig. 1

occurs at line Z, a theoretical line, dropped through seal element 18 tangent to the furthest edge, the furthest nearest edge of the energizer 12.

A seal element backup ring or support ring 52 is shown disposed between seal element 18 and gland wall 16. In the present invention, backup ring 52 includes an upstanding, in radial direction portion 53 and a horizontal, in axial direction portion 54, forming in cross section a substantial L-shape. Horizontal portion 54 at its most distal surface, forms an edge or point 59, through which an imaginary line X is dropped, as shown on Figs. 1-3.

A main feature of the new backup ring 52 includes the use of a flexible area or portion 60, which is oriented under the rear portion of seal element 18 to support seal element 18 and prevent seal damage (e.g. extrusion) into the gap between the groove body and moving element. Area 60 also supports the seal element and minimizes deflection of the seal element downstream and against the moving body providing better fluid control. This function of area 60 minimized radial loading on the moving element as pressure increases.

In one aspect of the invention, the axial length of the flexible area 60 is dependent on the position of energizer ring 12. As shown in Figs. 1-3, flexible area 60 as bounded lines X and Z, is oriented under energizer 12. The distance between lines X and Z should be approximately twenty to forty percent (20% to 40) of the maximal axial length of energizer 12. The length of flexible area 60 preferably may lie within the range of twenty seven to thirty three percent (27% to 33%) of the maximal axial length of energizer 12. Other percentages of overlap between backup ring 52 and energizer 12 may alternatively be utilized based on the particular operating conditions or requirements necessary for seal system 8.

Other percentages of overlap may be necessary depending on the construction materials of backup ring 52. Construction materials for backup ring 52 range from elastomeric in nature to structural plastics, to composites to metals and alloys such as bronze, including but not limited to, polytetrafluoroethylene (PTFE), polyurethane, high modulus plastics, structural thermal sets, polyamides, PPS, and various combination of such materials. Material selection may be dependent on the sealing application and environment.

A feature of the seal element 18 is that of a smooth radius corner 20, which makes a smooth transition from the rear half of the surface 22, which initially begins at seal apex 24 to side surface 21.

As shown in Fig. 1, the bottom surface 22 includes a smooth radius corner 20. Such smooth radius without any steps, chamfers, or sharp edges is called fully blended, which assists in fluid film control under dynamic motion. The size, distance, and geometry of corner 20 may assist control of flexible portion 60 and, during pressurization, help to first cause backup ring 52 to be locked into place with sidewall 16. Additional loading of corner 20 into backup ring 52 would then tend to cause flexible area 60 to flex and move into contact with the moving element. No particular requirement of a smooth or fully blended surface is necessitated in connection with seal element side surface 21 and alternate embodiment 52' as shown in Fig. 2 has a non-blended curve. In this embodiment, side surface contacts gland wall 16.

The embodiment of Fig. 3 shows a seal system 8 with a back up ring 52', radially longer than the average depth of the seal gland, thereby extending back past back surface 17 (which can be referred to as the groove bottom).

Preferably, backup ring 52 in any of its forms will have a clearance on the inner diameter surface 56 with the moving element. Most preferably, tip edge 59 will also have a clearance. This permits flexible area 60 of backup ring 52 to deform and make contact at a desired pressure level with the moving element. The stress taken up in the deflection of backup ring 52 is eliminated from the additive friction resulting from increased contact area and stresses of seal ring 12. Preferably, the radial clearance of the tip edge 59 should be withing the range of 0 to 0.050 inches (0.25 mm) .

Another geometrical feature of seal element 18 and backup ring 52 is that of the bottom surface 22, and 56 having an angle, in comparison with an opposite horizontal line of between zero to 10°, which is referenced as angle A. Preferably, angle A is greater than or equal to 5°, Most preferable is that bottom surface 22 has an angle of 7°. Such angle prevents a shear effect from occurring and keeps fluid in laminar flow against element 18 and backup ring 52. The angle A has been found to provide better fluid film control.

Construction materials from seal element 18 range from elastomeric in nature to structural plastic, including but not limited to, polytetrafluoroethylene (PTFE), polyurethane, high modulus plastics, structural thermal sets, polyamides, PPS, and various combination of such materials may be utilized for the element 18.

Additionally, seal element 18 may be bonded with energizer 12, as known in the art, with adhesive or alternate types of connection materials or methods.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

WHAT IS CLAIMED IS:

1. An annular seal arrangement for sealing between a static machine part and a dynamic machine part, such as between a cylinder head and a piston rod of a hydraulic cylinder, said annular seal arrangement comprising:

a compression ring; and

a seal element made of a resilient material and energized and surrounded by said compression ring, the seal element being installed with the compression ring in a common, rectangular housing groove defined by the static machine part, the seal element separating the compression ring from a moving surface of the dynamic machine part and a downstream wall of the housing groove, the outer diameter of the seal element having a radial extent which is one of greater than and equal to a radial extent of a groove bottom of the housing groove before the annular seal arrangement is installed in the housing groove.

2. The seal arrangement of Claim 1 in which the radial extent of the outer diameter of the seal element exceeds the radial extent of the groove bottom by between 0 and 1.50 mm before the annular seal arrangement is installed in the housing groove.

3. The seal arrangement of Claim 1 in which a radial height of the seal element is one of greater than and equal to a radial height of the housing groove before the annular seal arrangement is installed in the housing groove.

4. The seal arrangement of Claim 1 in which the radial height of the seal element exceeds the radial height of the housing groove by between 0 and 25% before the annular seal arrangement is installed in the housing groove.

5. The seal arrangement of Claim 1 in which the seal element is laid out with a seal apex defined by an upstream seal angle of more than 15° and a downstream slip angle of more than 2°, the seal apex being formed by one of the intersection

of the upstream seal angle and the downstream slip angle, a flat shape with a width of no more than 1 mm, and a convex shape with a width of no more than 1 mm.

6. The seal arrangement of Claim 1 in which the seal element is laid out with a seal apex defined by an upstream seal angle of more than 40° and a downstream slip angle of more than 10°, the seal apex being formed by one of the intersection of the upstream seal angle and the downstream slip angle, a flat shape with a width of no more than 1 mm, and a convex shape with a width of no more than 0.75 mm.

7. The seal arrangement of Claim 1 in which the seal element is laid out with a seal apex defined by an upstream seal angle between 45 and 50°, and a downstream slip angle between 12 and 17°.

8. The seal arrangement of Claim 5 in which a position of the seal apex is axially located near a center of the compression ring when the annular seal arrangement is installed in the housing groove.

9. The seal arrangement of Claim 1 in which the seal element is laid out such that the ratio: Radial groove height / axial distance from a seal apex to where the seal element meets the groove bottom, exceeds 1.25.

10. The seal arrangement of Claim 1 in which the seal element is laid out such that the ratio: Radial groove height / axial distance from a seal apex to where the seal element meets the groove bottom, exceeds 1.75.

11. The seal arrangement of Claim 1 in which the seal element is laid out such that a straight line can be drawn from a seal apex through a body of the seal element to a radial line defining a downstream wall of the seal element, and that a first said radial line forms an angle with the moving surface of at least 40°.

12. The seal arrangement of Claim 1 in which the seal element is laid out such that a straight line can be drawn from a seal apex through a body of the seal element to a radial line defining a downstream wall of the seal element, and that a first said radial line forms an angle with the moving surface of at least 50°.

13. The seal arrangement of Claim 1 in which from a radial line going through a downstream end position of the compression ring a line can be drawn downstream from a point where the radial line intersects the moving surface, forming an angle with the moving surface of at least 7° without contacting the seal element.

14. The seal arrangement of Claim 1 in which from a radial line going through a downstream end position of the compression ring, a line can be drawn downstream from a point where the radial line intersects the moving surface, forming an angle with the moving surface of at least 14° without contacting the seal element.

15. The seal arrangement of Claim 1 in which from a radial line going through a downstream end position of the compression ring, a line can be drawn downstream from a point where the radial line intersects the moving surface, forming an angle with the moving surface of at least 18 and not more than 24° without contacting the seal element.

16. The seal arrangement of Claim 1, further including a support ring positioned adjacent the seal element, in which the outer diameter of the support ring meets or radially exceeds the groove bottom.

17. The seal arrangement of Claim 1, further including a support ring positioned adjacent the seal element, in which the outer diameter of the support ring radially exceeds the groove bottom by between 0 and 0.75 mm.

18. The seal arrangement of Claim 1, further including a support ring positioned adjacent the seal element, a radial height of the support ring being equal to or less than a depth of the housing groove.

19. The seal arrangement of Claim 1, further including a support ring positioned adjacent the seal element, in which an internal diameter of the support ring exceeds the moving surface by 0 to 0.5 mm.

20. The seal arrangement of Claim 1, further including a support ring positioned adjacent the seal element, an inner surface of the support ring having an angle away from the moving surface greater than 1° but less than 5°.

21. The seal arrangement of Claim 1 wherein the compression ring is an O-ring.

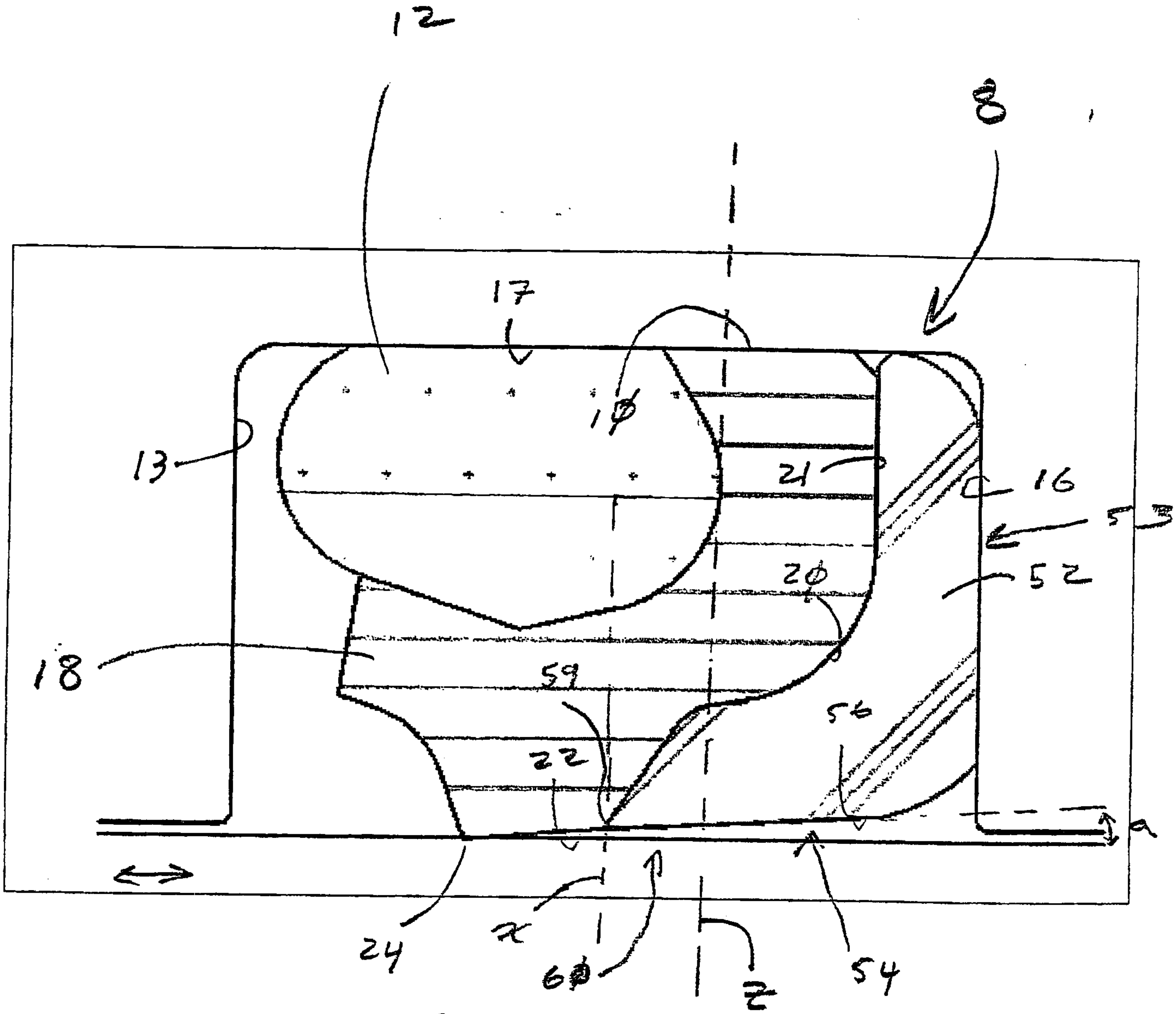


Fig. 1

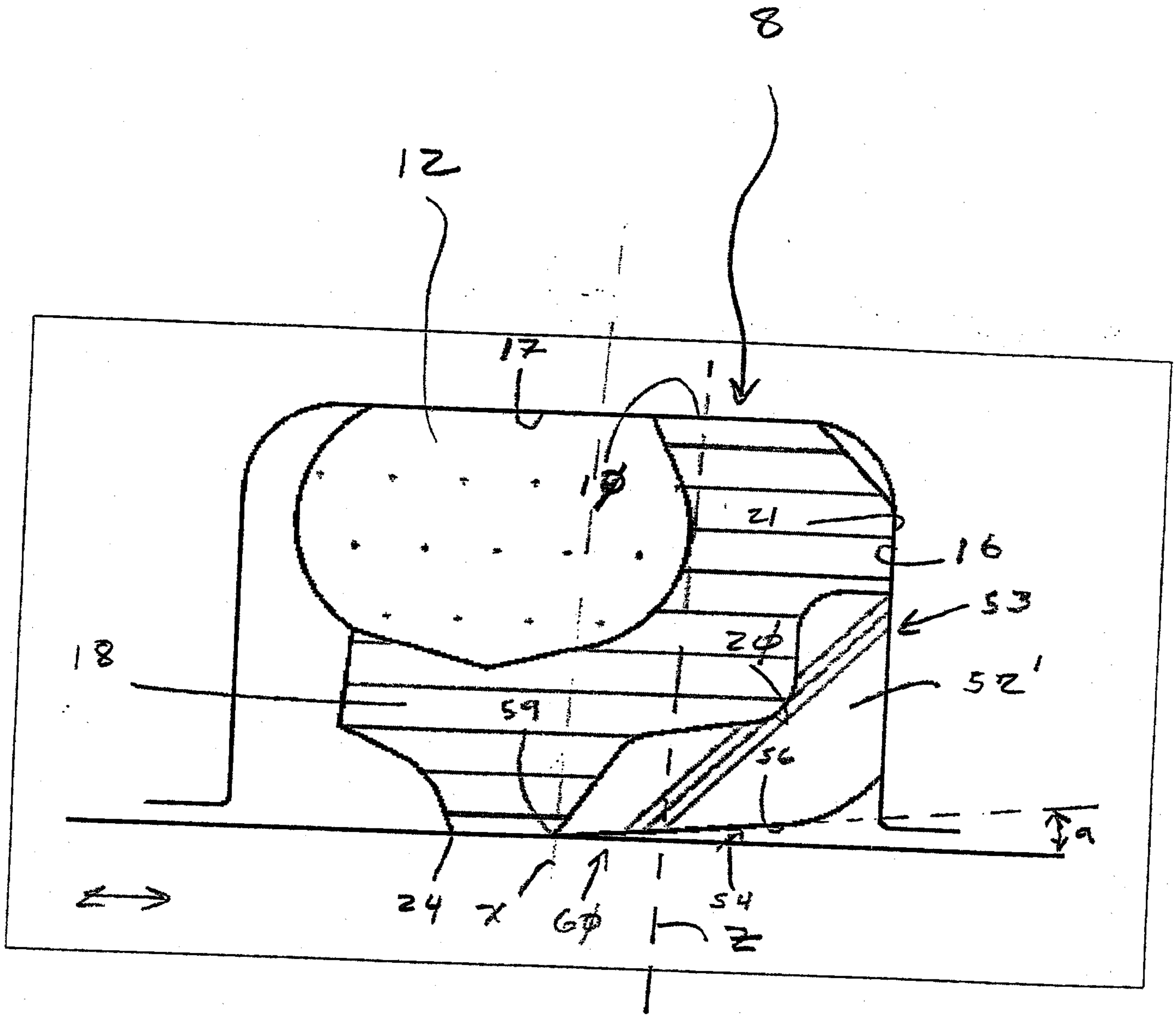


Fig. 2

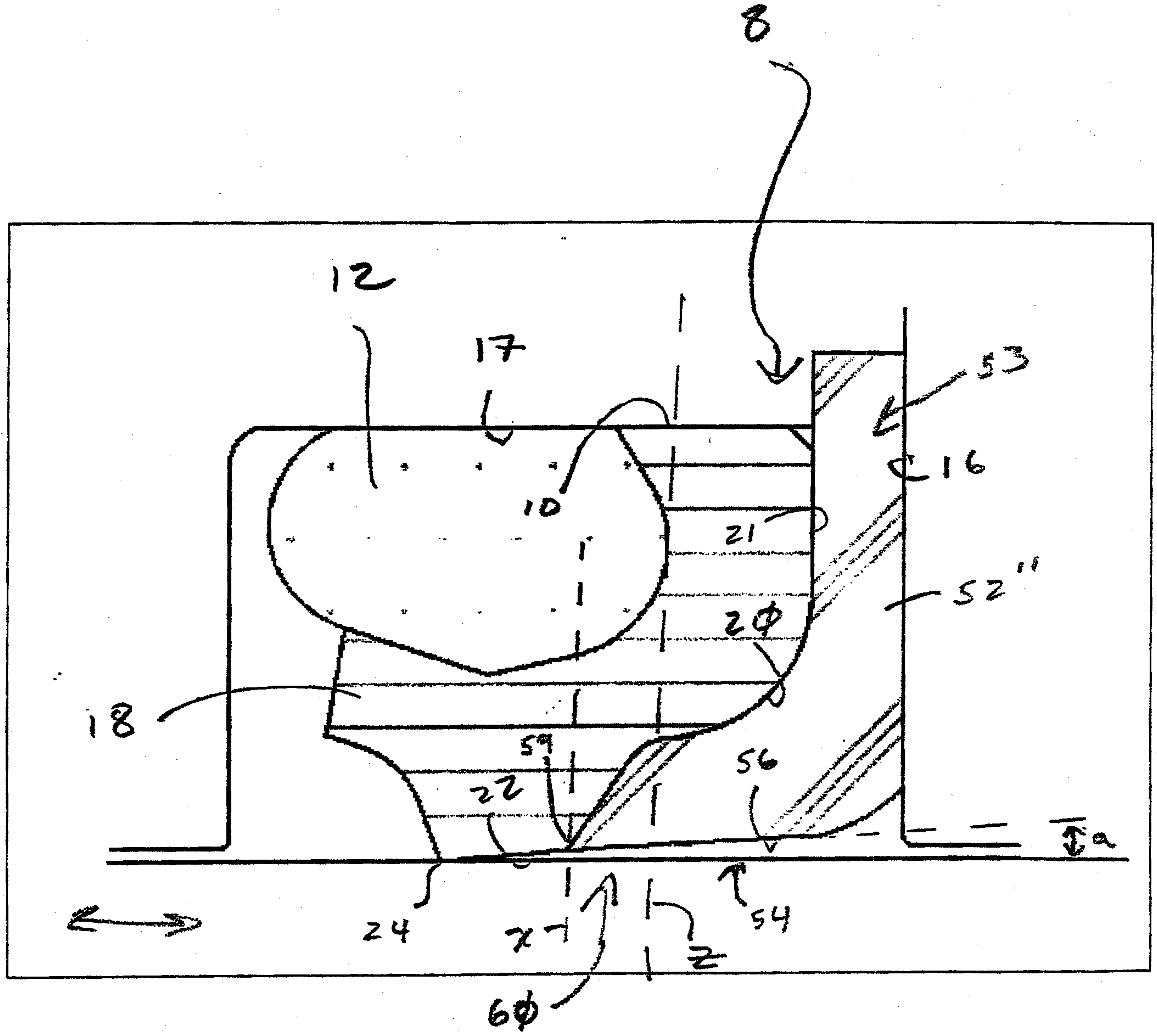
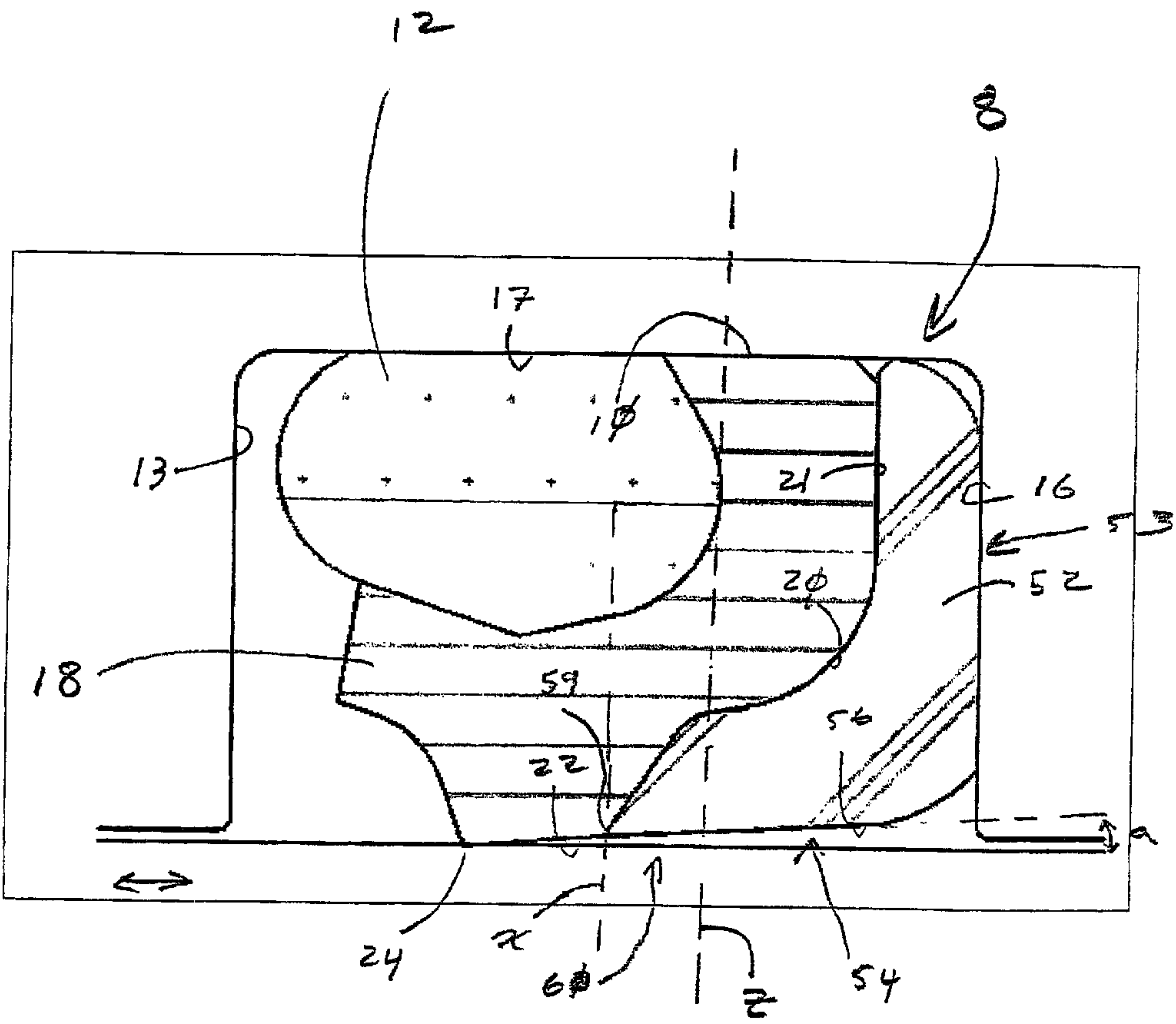


Fig. 3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