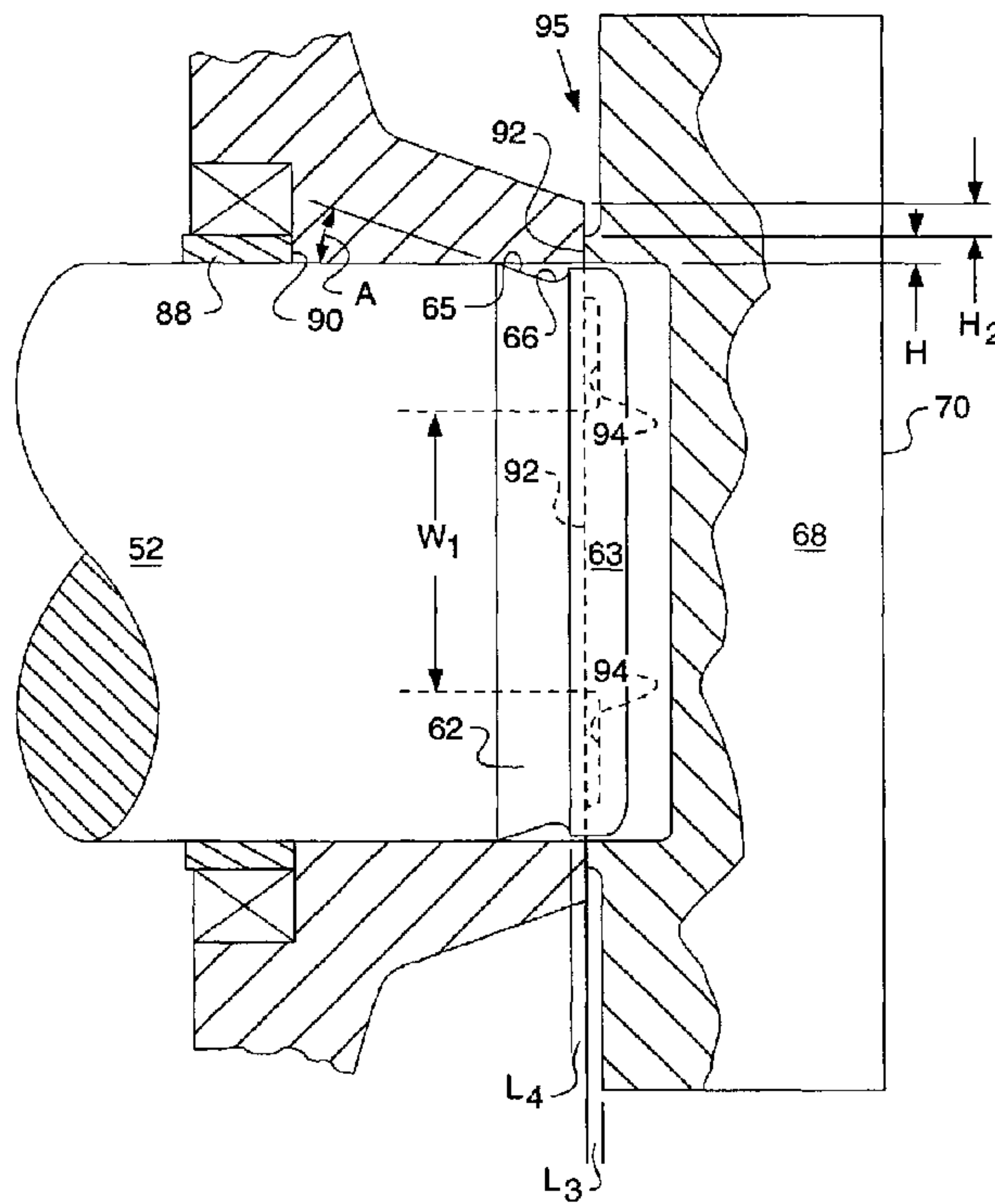




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(54) Titre : PROCÉDE ET APPAREIL POUR RETENIR UN JOINT DE CHAÎNE À CHENILLES  
 (54) Title: METHOD AND APPARATUS FOR RETAINING A TRACK CHAIN JOINT



(57) **Abrégé/Abstract:**

A method and apparatus of assembling a joint of an endless track chain (10) for track-type machines to prevent endplay in the joint (14) is disclosed. The joint (14) includes a pair of links (12) and a cylindrical pin (52). Each link (16) includes a outwardly offset outboard end collar (20) having a boss (50) extending outwardly therefrom and a bore (40) therethrough. Each boss (50) has an outer surface (44). The pin (58) includes opposite end portions (58). Each end portion (58) is pressed and non-rotatably mounted into respective one of the bores (44) of the outboard end collars (20). The method comprises the steps of forming an annular groove (62) about each of the end portions (58), placing a swage tool (67) against the outer side surface (44) of the boss (20) in axial alignment with the pin (52), and applying a sufficient force on the swage tool (67) to form at least one mechanically formed nodule (64) protruding from the outer side surface (38) into a respective ones of the grooves (62). The nodule (64) having a cross-sectional configuration substantially conforming to the groove (62).

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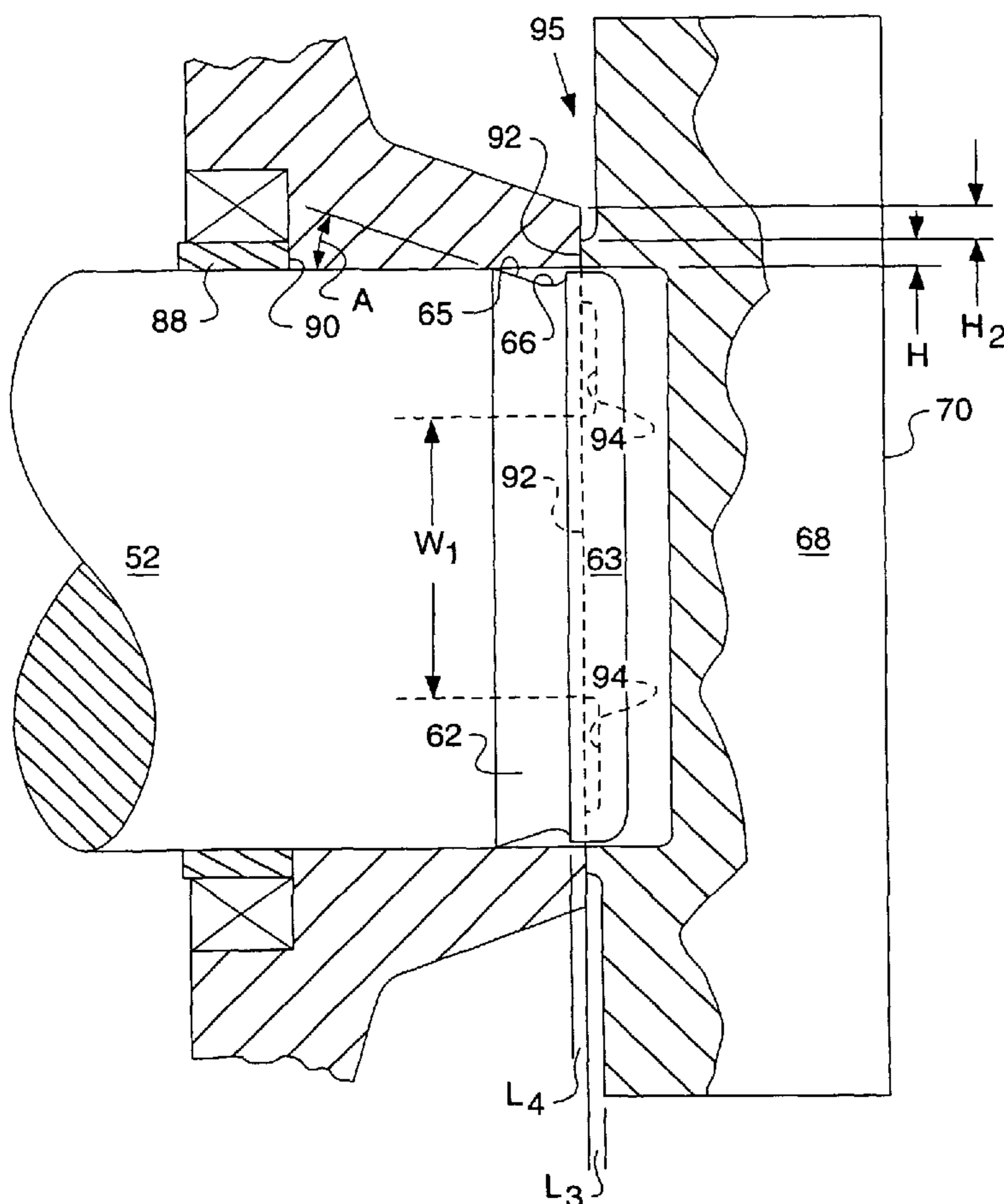
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(54) Title: METHOD AND APPARATUS FOR RETAINING A TRACK CHAIN JOINT



(57) Abstract: A method and apparatus of assembling a joint of an endless track chain (10) for track-type machines to prevent endplay in the joint (14) is disclosed. The joint (14) includes a pair of links (12) and a cylindrical pin (52). Each link (16) includes a outwardly offset outboard end collar (20) having a boss (50) extending outwardly therefrom and a bore (40) therethrough. Each boss (50) has an outer surface (44). The pin (52) includes opposite end portions (58). Each end portion (58) is pressed and non-rotatably mounted into respective one of the bores (40) of the outboard end collars (20). The method comprises the steps of forming an annular groove (62) about each of the end portions (58), placing a swage tool (67) against the outer side surface (44) of the boss (20) in axial alignment with the pin (52), and applying a sufficient force on the swage tool (67) to form at least one mechanically formed nodule (64) protruding from the outer side surface (38) into a respective one of the grooves (62). The nodule (64) having a cross-sectional configuration substantially conforming to the groove (62).

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DescriptionMETHOD AND APPARATUS FOR RETAINING A TRACK CHAIN JOINT5 Technical Field

This invention relates generally to a track chain for use on earthmoving machines, and more particularly to a method and apparatus for retaining the joints of the track chain.

10

Background Art

A track joint is usually held together by an interference fit between the ends of the track pins and their respective link bores into which the pin ends are tightly received. Even though a very high press force is used to press the links onto their respective pin ends, the links still have a tendency to move outwardly on the pin as a result of working forces exerted on the track during operation of the machine. This outward movement causes the joints to become loose or develop what is commonly referred to as end play.

Various methods have been tried to limit the amount of end play in track joints. Keeper assemblies, such as those disclosed in U.S. Patent No. 4,182,578 issued on 08 January 1980 and U.S. Patent No. 4,288,172 issued on 08 September 1981, both to Richard Livesay et al. And both assigned to the assignee hereof, have been successfully employed to reduce such end play movement. In order to accommodate

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manufacturing tolerances, joints utilizing such keepers must have a certain amount of clearance which produces a limited amount of built-in end play. As a result, these keepers reduce, but do not completely  
5 eliminate end play.

Another method of limiting end play is disclosed in U.S. Patent No. 3,831,257 issued on 27 August 1974, to Roger L. Boggs et al., which patent is also assigned to the assignee hereof, wherein  
10 welding about the ends of the track pin is used. In this method, retention is dependent on the strength of the weld. In practice, weld strength is difficult to control with any degree of consistency. If a weld is so weld that it breaks, all of its retention ability  
15 is lost.

More recently, the method and apparatus for retaining a track joint disclosed in U.S. Patent No. 5,201,171, issued on 13 April 1993, to Peter Anderton et al. And also assigned to the assignee hereof, has  
20 been successfully utilized. In such apparatus and method, an appropriate groove must be machined in the pin and material from the boss is displaced in the radial direction into the groove of the pin.

The solution to the above problems is  
25 hampered by another problem, which is inability to change dimensions of the track. One such dimension is the rail-to-rail width or gauge of the track. Like railroad track, the track links provide a pair of rail surfaces on which the wheels or rollers of the machine  
30 ride. The rail width or gauge for any particular

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machine is, for all practical purposes, permanently set and cannot be changed. This is because any change in rail gauge would require corresponding changes in the remaining components of the machine undercarriage and because the changed track would not be interchangeable with the track of existing machines.

The present invention is directed to overcoming the shortcomings of the prior attempts at providing a track joint with restricted end play.

10

#### Disclosure of the Invention

In one aspect of the present invention, there is provided a method of assembling a joint of an endless track chain for track type machines to prevent end play in the joint. The joint includes a pair of links and a cylindrical pin. Each link includes a laterally outwardly offset outboard end collar having a boss extending outwardly therefrom and a bore therethrough each boss having a side surface. The pin includes opposite end portions, each end portion being non-rotatably mounted into a respective one of the bores of the outboard end collars. The method comprising the steps of forming an annular groove about each of the end portions of the pin, placing a swage tool against the side surface of the boss in axial alignment with the pin, applying a sufficient force on the swage tool to form at least one mechanically formed nodule protruding from the side surface of the boss into respective one of the grooves of the pin,

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the nodule having a cross-sectional configuration substantially conforming to the groove.

In accordance with another aspect of the present invention, an apparatus for retaining the track joints of an endless track chain for a track-type machine is provided to prevent end play in the joints. Each joint includes a pair of links and a cylindrical pin. Each link has an outboard end collar with a pin boss extending outwardly therefrom and a bore therethrough. The pin boss has a side surface. Each pin has opposite end portions, each end portion being pressed and non-rotatably mounted into a respective one of the bores of the outboard end collars. The apparatus comprising an annular groove formed in each of the opposite end portions of the pin. Each groove is disposed within the bore at a location along the pin boss. At least one mechanically formed nodule protrudes from the side surface of the pin boss into respective ones of the pin grooves. Each nodule has a cross-sectional configuration substantially conforming to its groove and is formed from material that has been permanently extruded from the side surface of the pin boss into the groove.

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In accordance with still another aspect of the present invention, there is provided a method of assembling a joint of an endless track chain for track-type machines to prevent end play in the joint, the joint includes a pair of links and a cylindrical pin, each link includes a laterally outwardly offset outboard end collar having a boss extending outwardly therefrom and a bore therethrough, each boss having a outer side surface, and the pin includes opposite end portions, each end portion being non-rotatably mounted into a respective one of the bores of the outboard end collar, said method comprising the steps of: forming an annular frustoconical groove about each of the end portions of the pin; placing a swage tool against the outer side surface of the boss in axial alignment with the pin; applying a sufficient force in the axial direction on the swage tool to form at least one mechanically formed nodule protruding from the outer side surface of the boss into a respective one of the frustoconical grooves of the pin, the nodule having a cross-sectional configuration substantially conforming to the frustoconical groove.

In accordance with yet another aspect of the present invention, there is provided a method of assembling a joint of an endless track chain for track-type machines to prevent end play in the joint, the joint including a pair of links and a cylindrical pin, each link including a laterally outwardly offset outboard end collar having a boss extending outwardly therefrom and a bore therethrough, each boss having a outer side surface, and said pin including opposite end portions, each end portion being pressed and non-rotatably mounted into a respective one of said bores of said outboard end collars, the method comprising the steps of: forming an annular frustoconical groove about each of the end portions of the pin; placing a swage tool against

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the outer side surface of the boss in axial alignment with the pin; applying a sufficient force on the swage tool to form at least one mechanically formed nodule extruded from the side surface of the boss into a respective one of the  
5 frustoconical grooves, the nodule having a cross-sectional configuration substantially conforming to the frustoconical groove.

In accordance with a further aspect of the present invention, there is provided an apparatus for retaining the  
10 track joints of an endless track chain for track-type machines to prevent end play in such joints, each joint including first and second pairs of links and a cylindrical pin, each link of the first pair of links having an inboard end collar with a first bore therethrough, and each link of  
15 the second pair of links having an outboard end collar with a pin boss extending outwardly therefrom and a second bore therethrough, the boss having a outer side surface, and the pin having opposite end portions, each end portion being pressed and non-rotatably mounted into a respective one of  
20 the second bores of the outboard end collars, the apparatus comprising: an annular frustoconical groove formed in each of the opposite end portions of the pin, each frustoconical groove being disposed within the bore at a location along the pin boss; and at least one mechanically formed nodule  
25 protruding from the outer side surface of the boss into respective ones of the pin frustoconical grooves, each nodule having a cross-sectional configuration substantially conforming to its frustoconical groove and being formed from material that has been permanently extruded from the side  
30 surface of the pin boss into the frustoconical groove.

In accordance with a further aspect of the present invention, there is provided an apparatus for mechanically connecting joints of an endless track chain for track-type



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machines to prevent end play in such joints, each joint including a track link and a cylindrical pin, each link having an inboard end collar with a first bore therethrough and an outboard end collar with a pin boss extending  
5 outwardly therefrom and a second bore therethrough, the boss having an outer side surface, the pin having an end portion being pressed and non-rotatably mounted into a respective second bore of the outboard end collar, the apparatus comprising: an annular frustoconical groove formed in the  
10 end portion of the pin, each frustoconical groove being disposed within the base at a location along the pin boss; a swage tool having a plurality of spaced swage segments contacting the outer side surface of the pin boss and being moveable in the axial direction to extrude a nodule from the  
15 side surface of the pin boss into the frustoconical groove, the nodule having a cross-sectional configuration conforming to the shape and cross-section of the frustoconical groove.

#### Brief Description of the Drawings

Fig. 1 is a plan view of a portion of an endless  
20 track chain embodying the present invention;

Fig. 2 is a transverse cross-sectional view taken along line 2-2 of Fig. 1 through a hinge joint;

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Fig. 3 is an exploded view showing a track link, a swage tool and a track pin of the present invention;

Fig. 4 is a fragmentary cross-sectional view of one of the joints shown in Fig. 2 and illustrating structure for mechanically interlocking the pin to the link;

Fig. 5 is a diagrammatic cross-sectional view of one of the joints showing the unswaged structure;

Fig. 6 is a diagrammatic cross-sectional view of one of the joints showing the swaged structure; and

Fig. 7 is an end view of a swaged joint taken along line 7-7 of Fig. 6 with the swage tool removed.

#### Best Mode for Carrying Out the Invention

Referring to the drawings, an endless track chain embodying the present invention is generally indicated at 10 in Fig. 1 for use on a track type machine (not shown). The track chain 10 is constructed from a plurality of link sets 12 which are articulately coupled in a transverse relation of the chain 10 by a plurality of hinge joints 14. Each link set 12 includes a pair of laterally spaced, longitudinally extending links, one being a right-hand link and the other being a left-hand link. As such links are mirror images of each other, both are referred to herein by reference numeral 16. Each link

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16 is provided with an inboard end collar, or boss, 18 and an opposite outboard end collar, or boss, 20. The inboard end collar 18 is laterally offset inwardly toward the center of the track chain 10, while the  
5 outboard end collar 20 is laterally offset outwardly therefrom. Link 16 further includes a longitudinally disposed rail surface 22. The rail surface 22 has a predetermined overall width "W" between an inner edge 24 and an outer edge 26. The rail surface 22 includes  
10 a full width central portion 28, a generally one-half width outboard portion 30 which extends along the outer edge 26 over the outboard end collar 20 and a generally one-half width inboard portion 32 which extends along the inner edge 24 over the inboard end  
15 collar 18. The distance between the inner edge 24 of one link in the link set 12 to the inner edge 24 of the other link defines a rail gauge width "G".

The inboard end collar 18 has a first bore 34 therethrough extending from an inner surface 36 of  
20 the inboard end collar to an outer surface 38 thereof. The inner surface 36 is offset inwardly from the inner edge 24 of the rail surface 22. The outer surface 38 is offset outwardly relative to the inboard portion 32 of the rail surface 22 so as to be disposed in a  
25 position substantially closer to the outer edge 26 of the rail surface 22 than to the inner edge 24 thereof. This offset positioning of the inner and outer surfaces 36,38, respectively, provide the first bore 34 with a predetermined bore length "L1" that is  
30 greater than one-half the width of the rail surface

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22. Preferably, the outer surface 38 is positioned within a range of from substantially greater than .50 times to less than 1.0 times the rail width "W" from the inner rail edge 24.

5           The outer end collar 20 has a second bore 40 therethrough extending from an inner surface 42 to an outer side surface 44 of the outer end collar 20. Each second bore 40 has a counterbore 46 adjacent the inner surface 42. Each counterbore 46 has a radial shoulder  
10 48 at the bottom thereof that is disposed outwardly from the inner surface 42. It should be appreciated that the offsetting relationship of the end collars 18,20 permits the outboard end collar 20 of one link set to overlap the inboard end collar 18 of an  
15 adjoining link set in the track chain. As shown in the drawings, the outboard side surface 44 of the outboard end collar 20 is provided on a pin boss 50. The outer surface 44 is offset laterally a substantial distance from the outer edge 26 of the rail surface 22 to  
20 provide the second bore 40 with a predetermined bore length "L<sub>2</sub>" that is at least as great as the overall width "W" of the rail surface 22.

          The joint 14 includes a cylindrical pin 52, a rotatable tubular bushing 54 and a pair of hardened  
25 sleeve bearings 56. The pin 52 has opposite end portions 58, each of which is pressed and non-rotatably mounted into a respective one of the second bores 40 of the outboard end collars 20 of each link 16 in a link set 12.

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Referring more particularly to Figs. 3-6 the joint 14 further includes a mechanical interlocking structure 60 for locking the pin 52 to the outboard end collar 20 to eliminate end play by preventing any axial movement of the links 16 along the pin 52. The mechanical interlocking structure 60 comprises a circumferentially disposed groove 62 formed about each of the ends 58 of the pin 52 and at least one mechanically formed nodule 64, which is formed by extruding the outer surface 44 of the pin boss 50 into a respective one of the grooves 62. The groove 62 is formed by a frustoconical surface 65 connected to a radius 66. The frustoconical surface 65 is tapered toward the pin 52 end and the radius 66 is located outwardly of the frustoconical surface 65. The frustoconical surface is tapered to have an angle "A" of 15° degrees or less to provide a lead-in taper for the pin 52 or it is pressed into the link. The mechanically formed nodules 64 are preferably formed by a swage tool 66 axially pushing on the outer surface 44 of the boss 50. The pin 52 diameter outwardly of the groove 62 defines a pin land 63 that is reduced in size relative to the diameter inwardly of the groove 62. The reduced pin land 63 diameter provides clearance between the second link bore 40 to prevent scoring of the second link bore 40 during disassembly of the components. During disassembly the pin 52 and the link 16 must be separated and the reduced diameter will prevent scoring by the swaged module.

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The swage tool 67 includes a base 68 suitable to withstand high forces. The base 68 has a first surface 70 and a second surface 72 having a counterbore 73 for receiving the end 58 of the pin 52.

5 The counterbore of the swage tool 67 has an inside diameter sized for receiving the load 63 of the pin 62. The diametrical clearance between the counterbore 73 and the pin land 63 is in the range of 0-3 mm. A plurality of swage segments 74 extend from the second

10 surface 72 for contact with the outer surface 44 of the boss 50. The swage segments 74 have a swage area 75 defined by a predetermined length  $L_3$ , width  $W_2$ , and height  $H$  and the cross-section area of the groove 62 should be equal to or less than the swage area 75 of

15 the swage segments 74. The outer surface 44 of the pin boss has a height of  $H_2$ . In the present embodiment four swage segments are shown however any number can be used without departing from the scope of the invention. The application of a sufficient force on

20 the swage tool 67 will result in the swage segments 74 extruding metal from the outer surface 44 of the boss 50 into the groove 62. The shape and cross-section of the groove 62 is shaped and sized to control filling of the groove 62 by the nodule 64 and also retention

25 between the pin 52 and the link 16.

The tubular bushing 54 is provided with a pin bore 76, which is sized to freely rotatably mount the bushing 54 about the pin 52. Bushing 54 has a pair of opposite end faces 78 and is of a size to extend

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between and be freely rotatable relative to the inboard end collars 18.

The pair of hardened sleeve bearings 56 have a inner face 80 and an outer face 82. The sleeve bearings 56 are adapted to be press fitted in the bores 34 of the inboard end collar 18. It should be understood by those skilled in the art that such sleeve bearings 56 must have a certain minimum length that is sufficient to support the loads imposed upon the joint 14 during operation, as dictated by the weight and power of the machine on which the track chain 10 is placed. As can be seen, the first bores 34 are substantially larger than the second bores 40 in order to receive the sleeve bearings 56.

A first pair of seals 84 are provided for sealing between the bushing 54 and the inboard end collar 18 and a second pair of seals 86 provide sealing between the inboard end collar 18 and the outboard end collar 20.

A set of four thrust rings 88 is disposed internally of each of the seals 84,86. The thrust rings 88 are provided to maintain a predetermined minimum axial spacing for the seals 84,86 to prevent the seals from being crushed during assembly or operation.

Referring to Figs. 5-7, each of the thrust rings 88 includes a side surface 90, which interacts with the link 16 to limit compression. The side surface 90 has a predetermined surface area. Each of the swage segments have an end surface 92 having a

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predetermined surface area. The predetermined surface areas are added together to determine the total surface area of the swage segments. In order to prevent imbedding of the thrust ring into the link the total surface area of the segments relative to the surface area of the ring must have a ratio of less than 1.0. The end surface 92 of the swage segments 74 is perpendicular to the axial direction of the pin and link boss and is flat.

10 The outboard end collar 20 of the link 16 extends axially outwardly to overlap the groove 62 a predetermined length "L<sub>4</sub>". The minimum predetermined length of overlap is about .5 mm and the maximum length of overlap is about 3 mm. The predetermined length of overlap must be maintained to fill the groove 62 with the proper swaged module 64. If the overlap is too small or large the groove will not be filled by the swaging operation.

20 The height "H" of the swage segments 74 of the swage tool 67 relative to the Height H<sub>2</sub> of the outer surface 44 of the pin boss 50 is equal to half or less relative to the height of the outer surface. The swage segments 74 contact only the inner half of the outer surface 44 of the pin boss because the outer half is needed to contain the swaged material module to force the module into the pin groove 62. The swage tool 67 having spaced segments 74 includes a surface 94 between the spaced segments 74. As the swage tool is axially moved to swage the module 64 into the groove 62 the surface 94 contacts the link boss

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surface 44 to limit the penetration of the segments to prevent excessive swaging as link material varies in hardness from one link to another.

Referring to Fig. 7 the link boss surface 44 is shown as having a plurality of swaged pocket areas 96 each having a predetermined circumferential width W2. All the circumferential widths are added together to have a total circumferential width. The total circumferential width should be less than 60% of the circumference of the pin 52. This totaled circumferential width is limited so that the track joint can be rebuilt and reswaged or extruded at least once.

#### 15 Industrial Applicability

The endless track chain 10 constructed in accordance with the teachings of the present of the present invention provides a structure which maintain structural integrity or load carrying capacity of the track chain to eliminate reduce end play and maintain the rail gauge dimension.

The mechanical interlocking structure 60 is provided to eliminate endplay in the joint 14. The interlock 60 includes the grooves 62 about the end portions 58 of the pin 52. Once the track chain 10 is assembled in a conventional manner with a track press, a suitable swage tool 67 is placed on each of the outer surfaces 44 provided on the bosses 50 of the outboard end collars 20 and in axial alignment with the pin 52. A suitable force is then applied to the

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swage tool 67 by means of a press or the like to extrude metal from the outer surface 44 of the pin boss 50 into the grooves 62 about the pin 52. The mechanically formed nodule 64 is formed by metal protruding from the outer surface 44 of the pin boss 50 into the groove 62. The nodule 64 has a cross-sectional configuration substantially conforming to the shape of the groove 62. The groove 62 is formed by a frustoconical 65 connected to a radius 66. In operation, the nodule 64 prevents any axial movement of the pin 52 in the second bore 40 in the outboard end collar 20, thus ensuring that the joint 14 remains tight without any end play.

To disassemble the track joint for repair, a force is applied to spraed the links apart or push the pin from the links. The applied force will shear the module to allow for the pin to be removed. The pin land is smaller in size than the rest of the pin to provide clearance. This clearance will prevent scoring of the bore of the pin boss.

In view of the forgoing, it is readily apparent that the present invention provides a method and apparatus for mechanically joining the track pin to the track link to eliminate endplay in the track chain to improve the joint in the track chain.

Other aspects, objects and advantages of this invention can be obtained from a study of the drawings, the disclosure and the appended claims.

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CLAIMS:

1. A method of assembling a joint of an endless track chain for track-type machines to prevent  
5 end play in the joint, the joint includes a pair of links and a cylindrical pin, each link includes a laterally outwardly offset outboard end collar having a boss extending outwardly therefrom and a bore therethrough, each boss having a outer side surface,  
10 and the pin includes opposite end portions, each end portion being non-rotatably mounted into a respective one of the bores of the outboard end collar, said method comprising the steps of:

forming an annular frustoconical groove  
15 about each of the end portions of the pin;  
placing a swage tool against the outer side surface of the boss in axial alignment with the pin;  
applying a sufficient force in the axial direction on the swage tool to form at least one  
20 mechanically formed nodule protruding from the outer side surface of the boss into a respective one of the frustoconical grooves of the pin, the nodule having a cross-sectional configuration substantially conforming to the frustoconical groove.

25

2. A method of assembling a joint of an endless track chain for track-type machines to prevent  
end play in the joint, the joint including a pair of links and a cylindrical pin, each link including a  
30 laterally outwardly offset outboard end collar having

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a boss extending outwardly therefrom and a bore therethrough, each boss having a outer side surface, and said pin including opposite end portions, each end portion being pressed and non-rotatably mounted into a  
5 respective one of said bores of said outboard end collars, the method comprising the steps of:

forming an annular frustoconical groove about each of the end portions of the pin;

placing a swage tool against the outer side  
10 surface of the boss in axial alignment with the pin;

applying a sufficient force on the swage tool to form at least one mechanically formed nodule extruded from the side surface of the boss into a respective one of the frustoconical grooves, the  
15 nodule having a cross-sectional configuration substantially conforming to the frustoconical groove.

3. An apparatus for retaining the track joints of an endless track chain for track-type  
20 machines to prevent end play in such joints, each joint including first and second pairs of links and a cylindrical pin, each link of the first pair of links having an inboard end collar with a first bore therethrough, and each link of the second pair of  
25 links having an outboard end collar with a pin boss extending outwardly therefrom and a second bore therethrough, the boss having a outer side surface, and the pin having opposite end portions, each end portion being pressed and non-rotatably mounted into a

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respective one of the second bores of the outboard end collars, the apparatus comprising;

an annular frustoconical groove formed in each of the opposite end portions of the pin, each  
5 frustoconical groove being disposed within the bore at a location along the pin boss; and

at least one mechanically formed nodule protruding from the outer side surface of the boss into respective ones of the pin frustoconical grooves,  
10 each nodule having a cross-sectional configuration substantially conforming to its frustoconical groove and being formed from material that has been permanently extruded from the side surface of the pin boss into the frustoconical groove.

15

4. The apparatus of claim 3 wherein the groove is formed from the frustoconical surface and a radius connected to the frustoconical surface.

20

5. The apparatus of claim 4 wherein the frustoconical surface tapers 15 degrees toward the pin end.

6. The apparatus of claim 5 wherein the  
25 radius is located outwardly of the frustoconical surface.

7. An apparatus for mechanically connecting joints of an endless track chain for track-type  
30 machines to prevent end play in such joints, each

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joint including a track link and a cylindrical pin,  
each link having an inboard end collar with a first  
bore therethrough and an outboard end collar with a  
pin boss extending outwardly therefrom and a second  
5 bore therethrough, the boss having an outer side  
surface, the pin having an end portion being pressed  
and non-rotatably mounted into a respective second  
bore of the outboard end collar, the apparatus  
comprising:

10 an annular frustoconical groove formed in  
the end portion of the pin, each frustoconical groove  
being disposed within the base at a location along the  
pin boss;

a swage tool having a plurality of spaced  
15 swage segments contacting the outer side surface of  
the pin boss and being moveable in the axial direction  
to extrude a nodule from the side surface of the pin  
boss into the frustoconical groove, the nodule having  
a cross-sectional configuration conforming to the  
20 shape and cross-section of the frustoconical groove.

8. The apparatus of claim 7, including an  
annular thrust ring positioned with the bore of the  
pin boss around the pin, the thrust ring having a side  
25 surface having a predetermined surface area.

9. The apparatus of claim 8, wherein each  
swage segment has a flat side surface, perpendicular  
to the axial direction and, having a surface area, the  
30 surface area being added together to having a total

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surface area, the total surface area of the swage segments relative to the surface area of the thrust ring in a ratio of less than 1.0.

5           10. The apparatus of claim 9, wherein the side surface of the pin boss has a predetermined height and the swage segments contact the lower half of the predetermined height to extrude material into the frustoconical groove.

10

11. The apparatus of claim 10, wherein the swaged area in the side surface of the pin boss is less than 60% of the circular circumference of the pin.

15

12. The apparatus of claim 7, wherein the frustoconical groove has a taper of less than 15 degrees.

20

13. The apparatus of claim 11, wherein the pin boss overlaps the frustoconical groove a minimum of .05 mm and a maximum of 3 mm.

14. The apparatus of claim 13, wherein the swage segments have an inner surface having a predetermined diameter.

25

15. The apparatus of claim 14, wherein the pin diameter outwardly of the groove defines a pin land reduced in size relative to the diameter inwardly

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of the groove, the inner surface diameter of the swage segments and the outer diameter of the pin land has a diametrical clearance in the range of 0 mm to 3 mm.

5           16. The apparatus of claim 15, wherein the swage tool includes a surface between the spaced segments that contact the pin boss to limit axial movement to prevent excessive swaging of the pin boss.

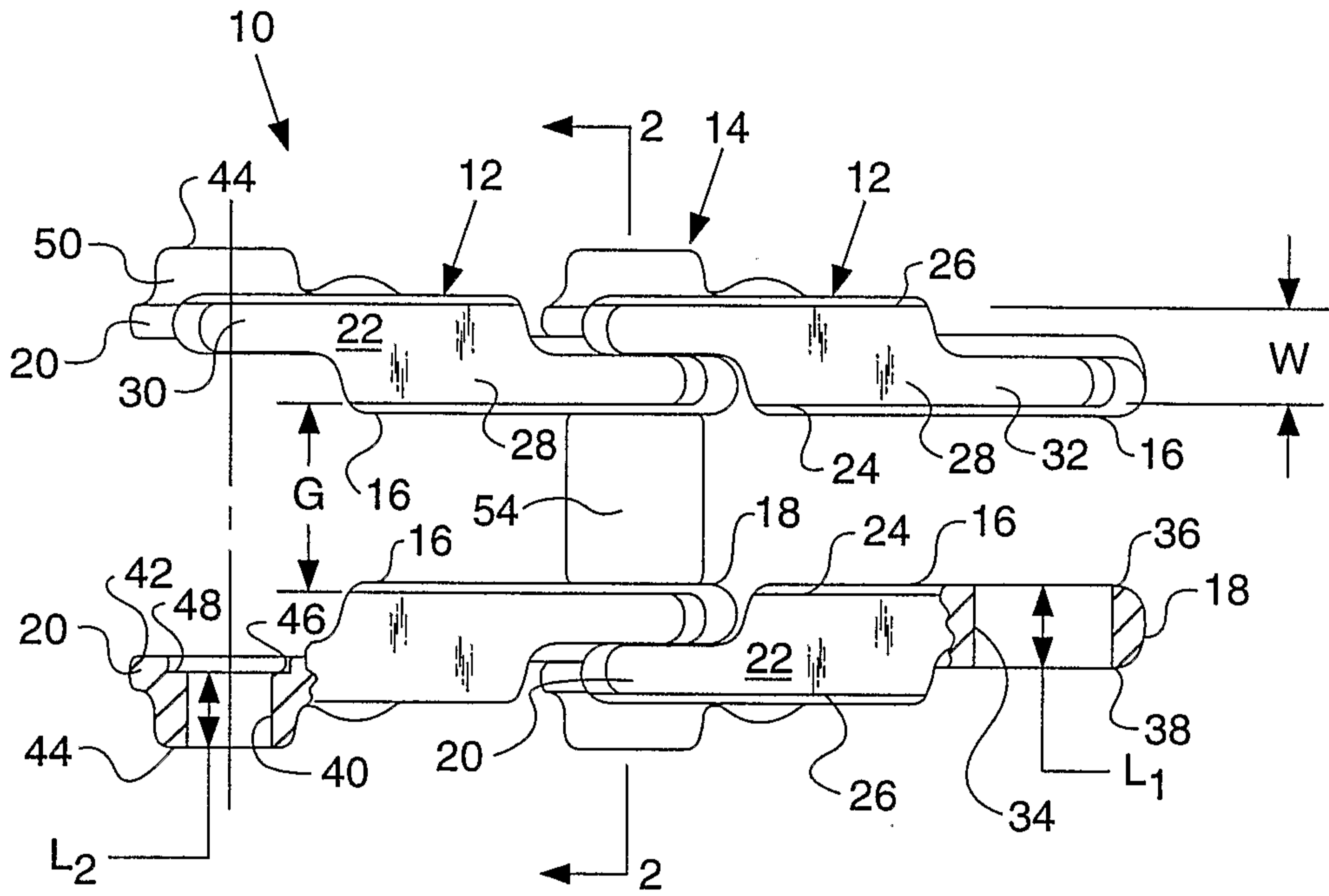
10           17. The apparatus of claim 16, wherein the diameter of the pin land is smaller in size than the inner diameter of the bore of the pin boss to prevent scoring of the pin boss during disassembly.

SMART & BIGGAR  
OTTAWA, CANADA

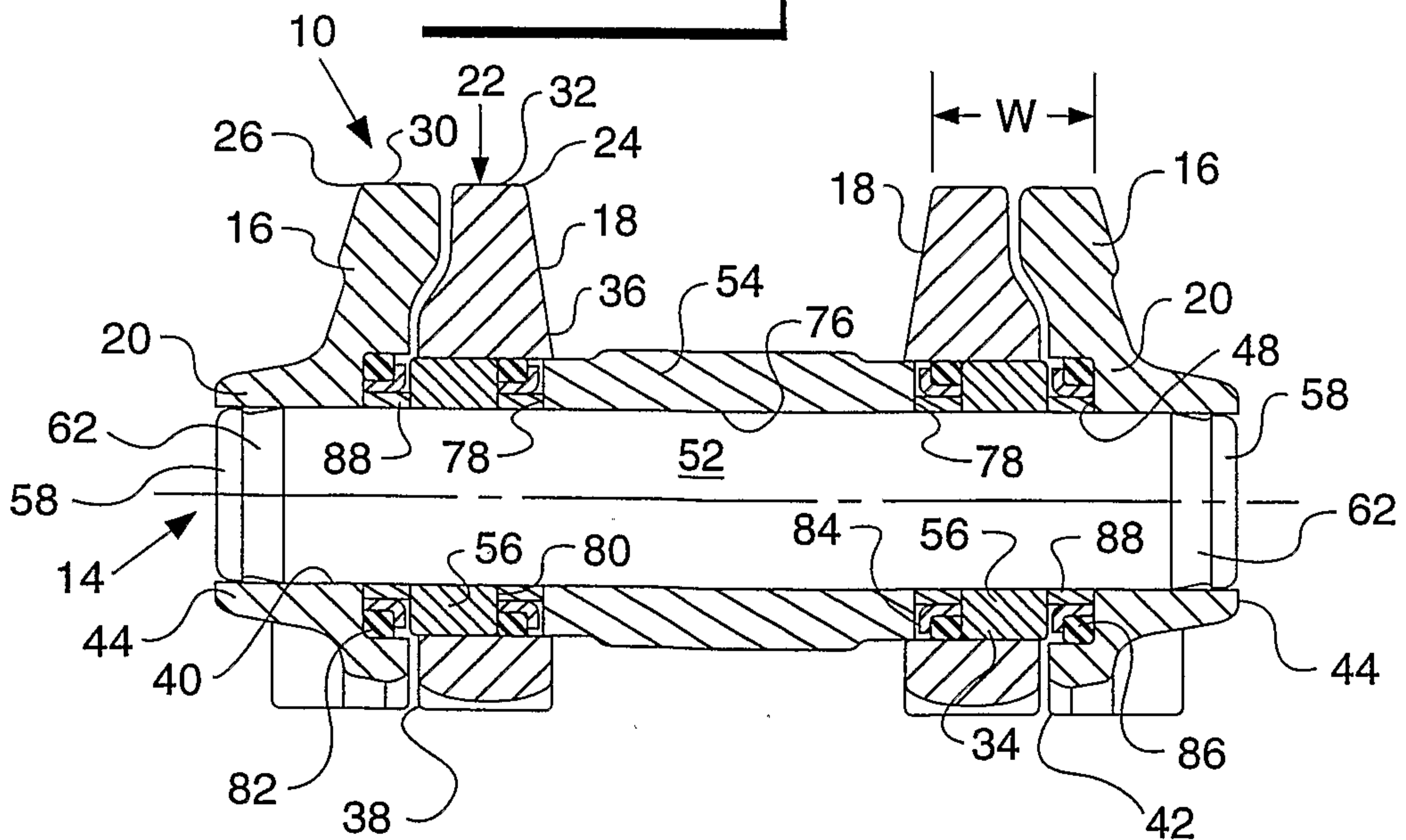
PATENT AGENTS



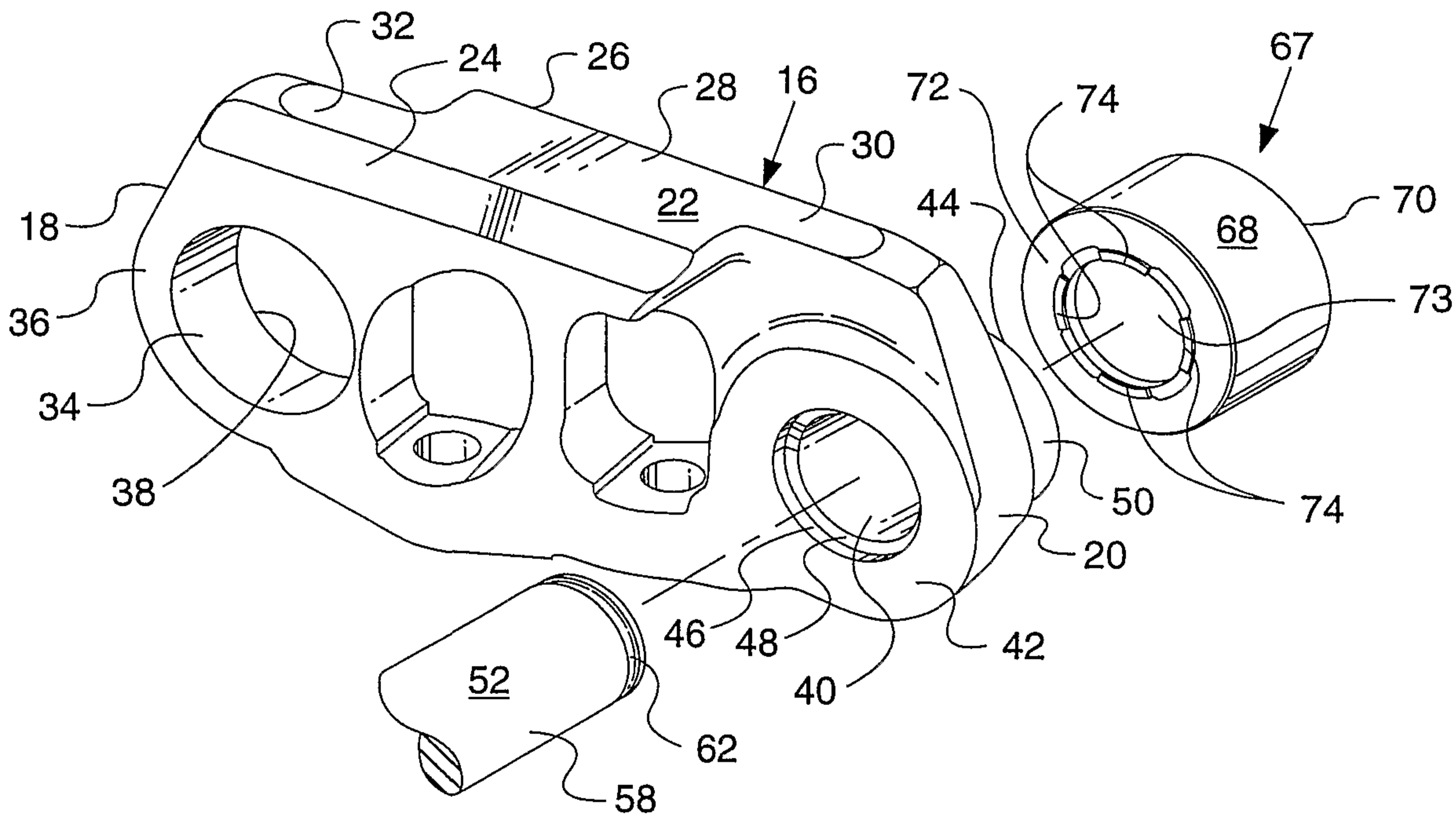
**FIG. 1**



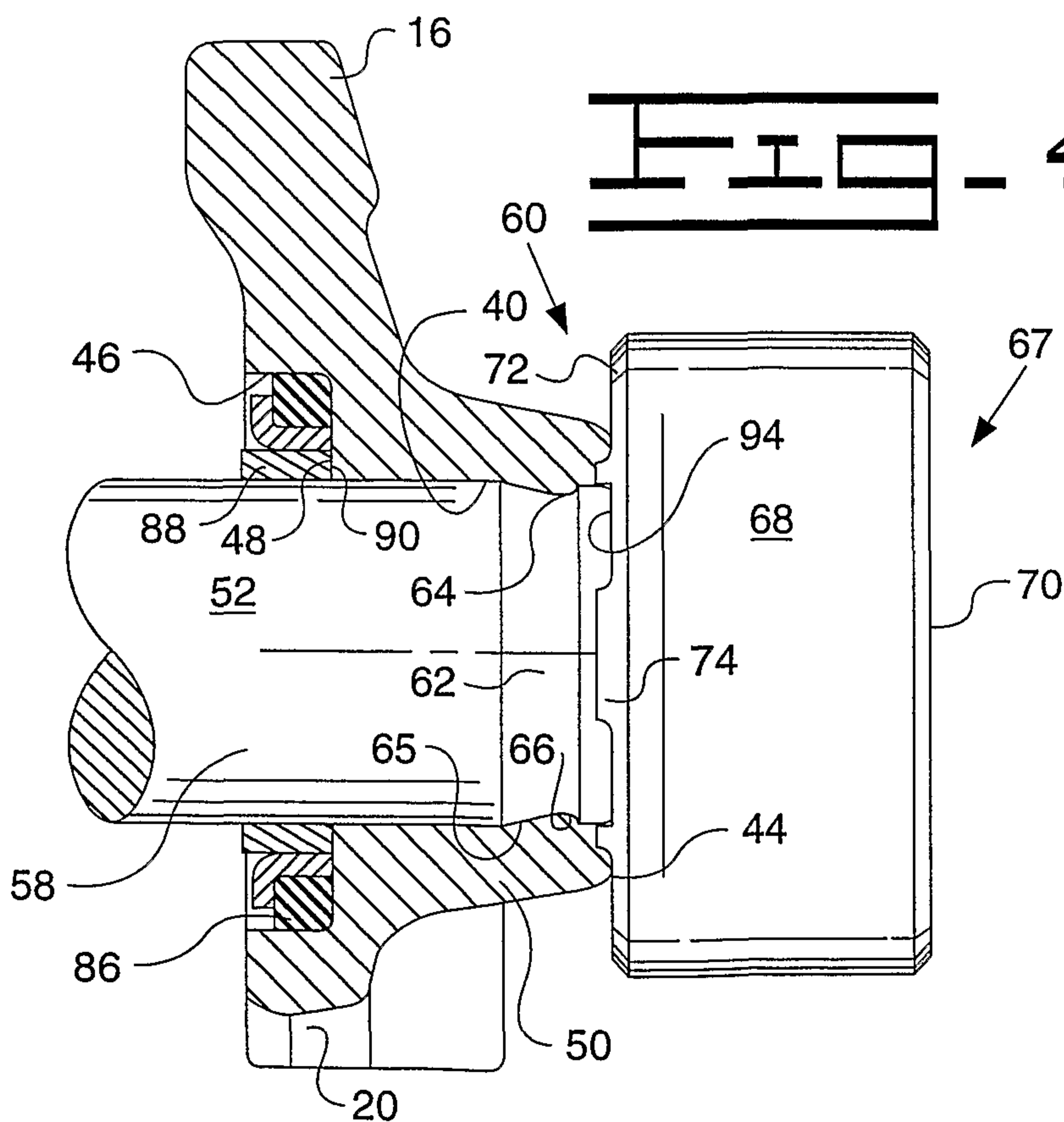
**FIG. 2**



**FIG. 3.**



**FIG. 4.**



**FIG. 5.**

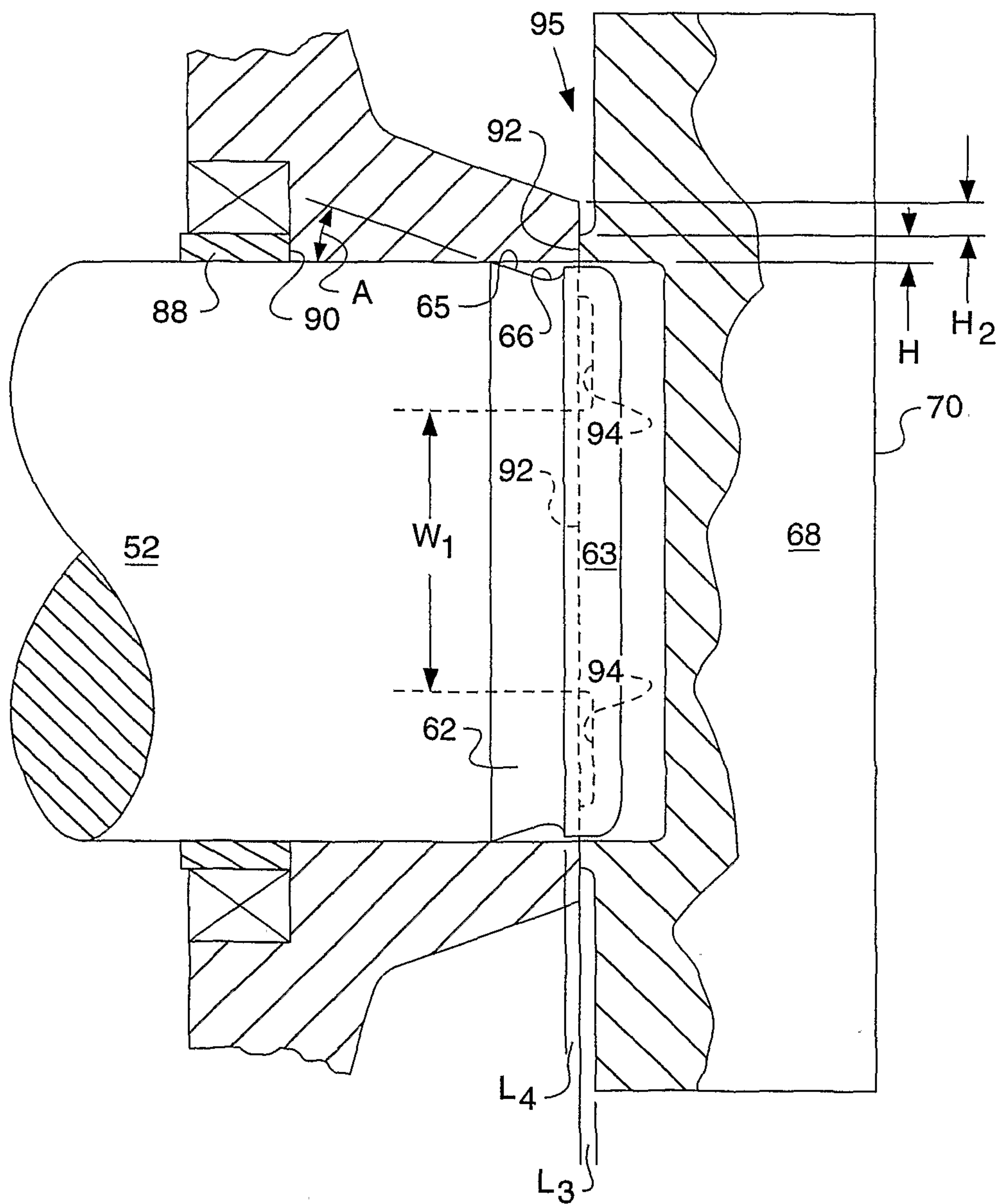


FIG. 7-

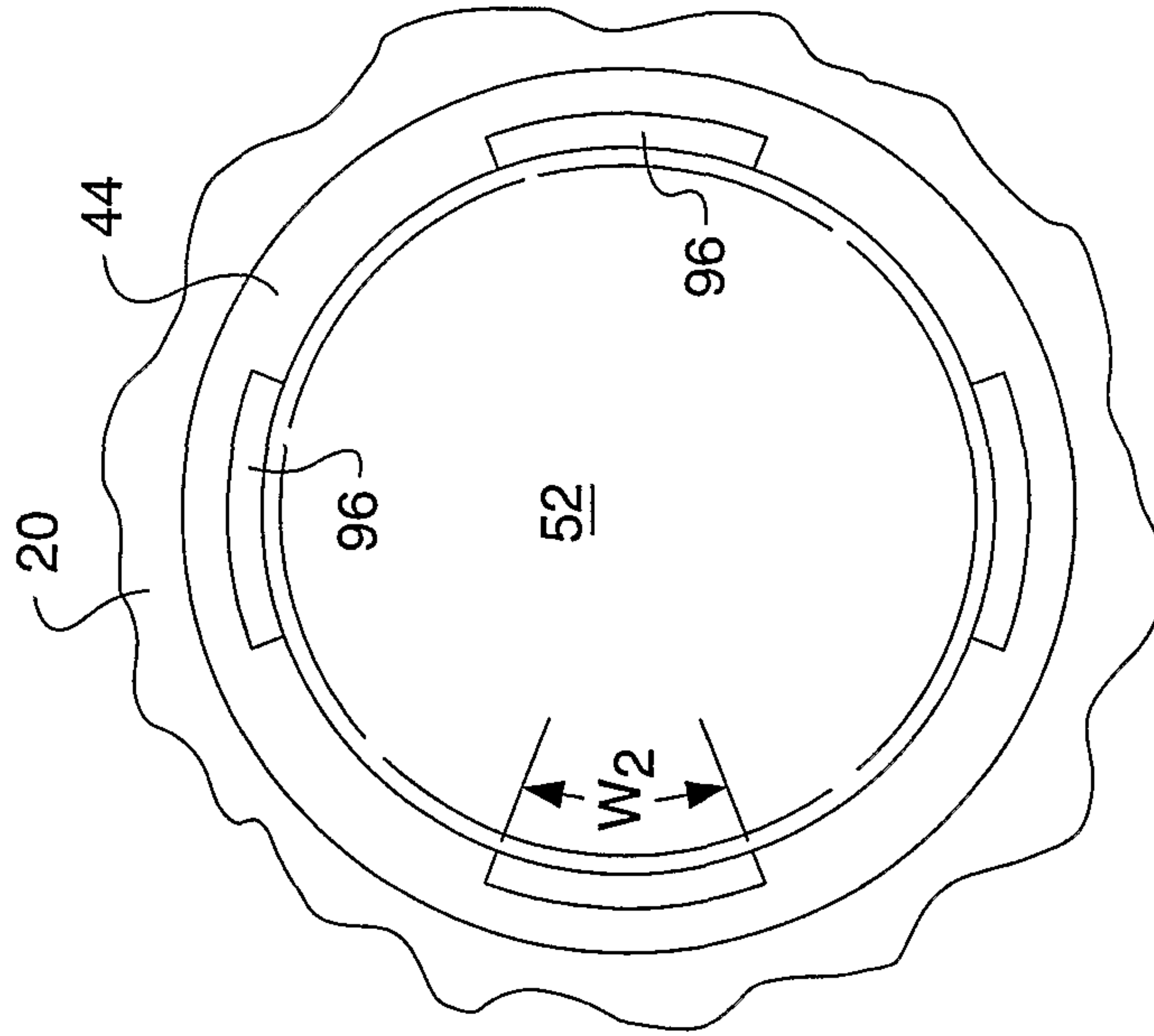


FIG. 8-

