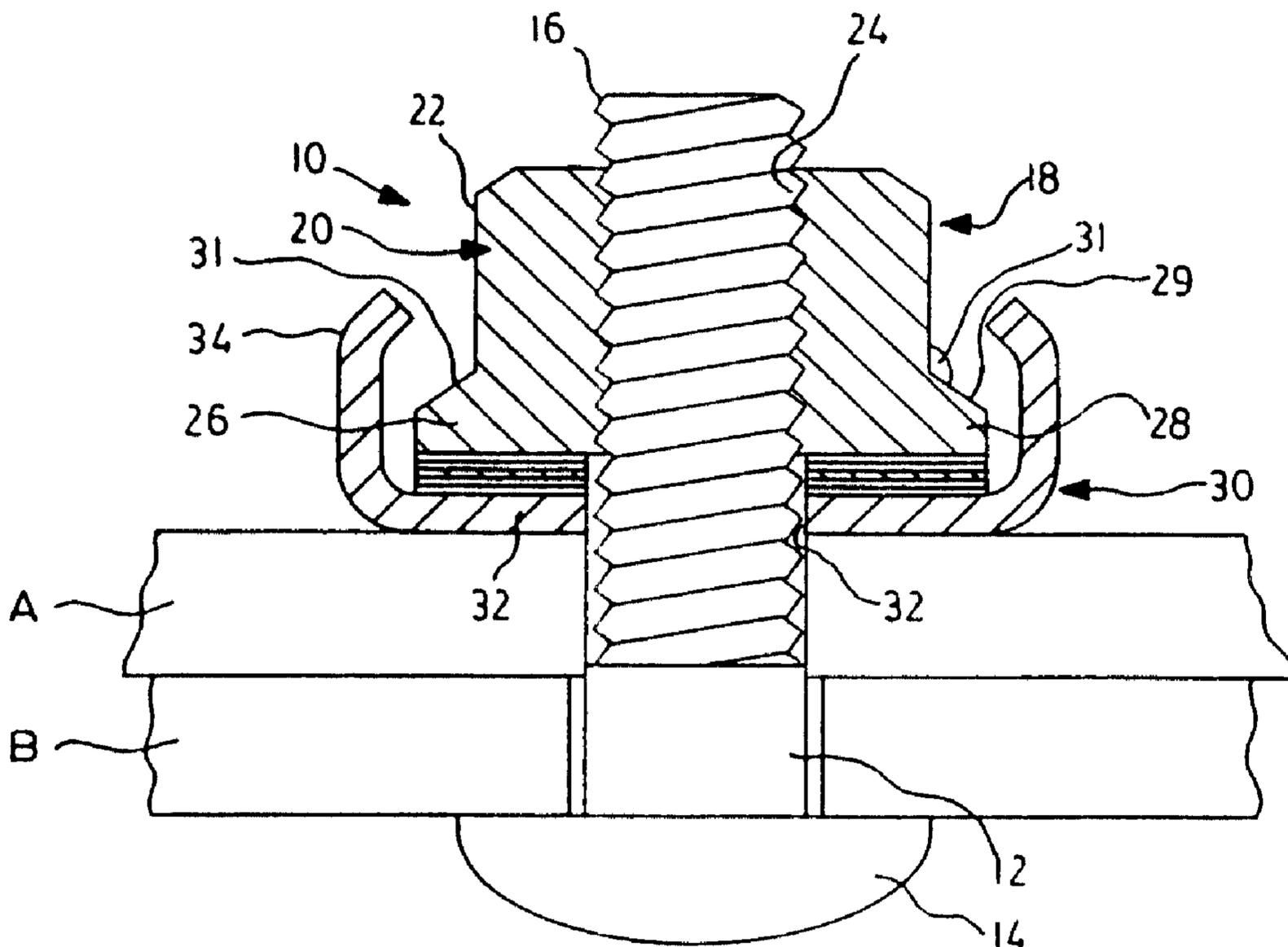




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(57) Abrégé/Abstract:

A fastener (10) has a body (20) and a cage (30) with cam surfaces (42, 44') formed on interengaging components (28, 33) to inhibit relative rotation. In one embodiment a washer (36) is interposed between said surfaces and has oppositely directed faces (38, 40) with cam surfaces formed on them. In a further embodiment, the underside of the cage has serrations formed on it.

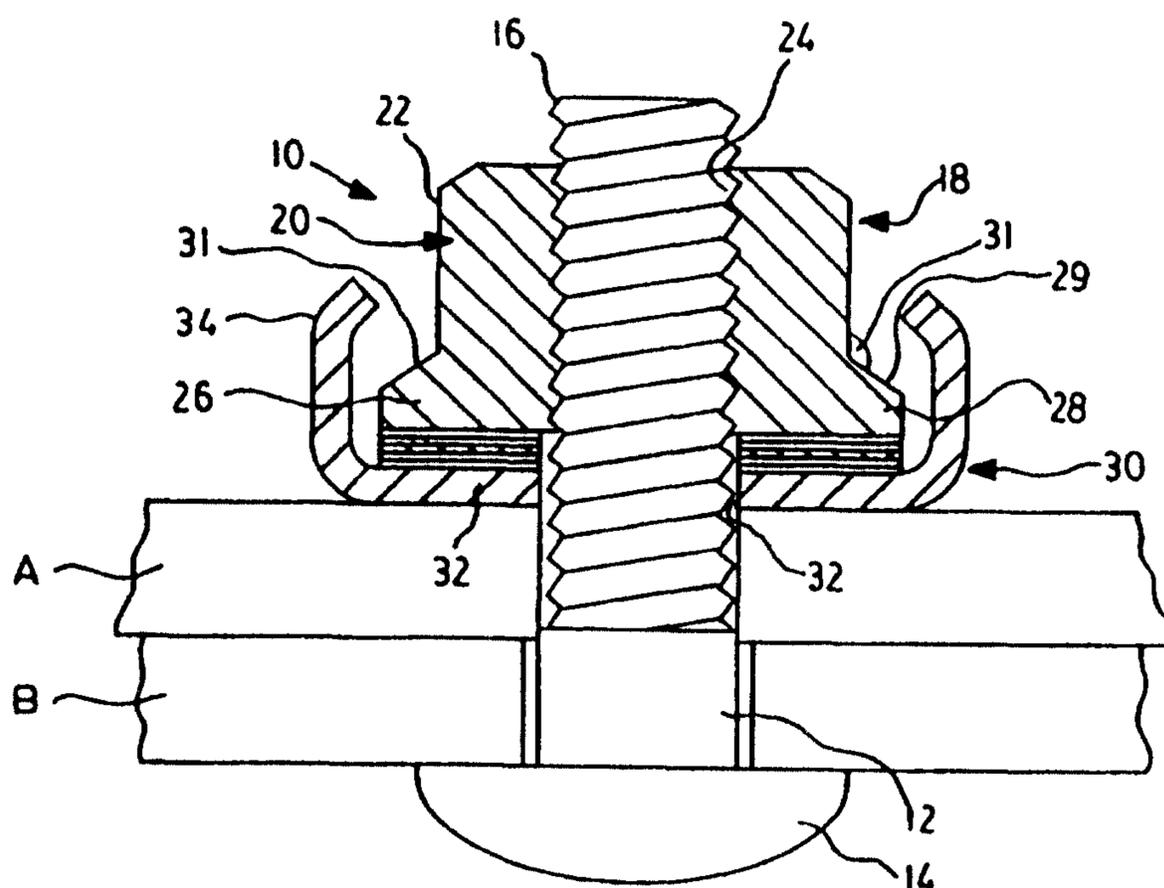
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<p>(21) International Application Number: PCT/CA99/00985</p> <p>(22) International Filing Date: 27 October 1999 (27.10.99)</p> <p>(30) Priority Data: 09/183,640 30 October 1998 (30.10.98) US</p> <p>(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application US 09/183,640 (CIP) Filed on 30 October 1998 (30.10.98)</p> <p>(71) Applicant (for all designated States except US): DUOCAM INC. [CA/CA]; 40 King Street West, Suite 3901, Toronto, Ontario M5H 3Y2 (CA).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): HEWGILL, John [US/US]; 1407 East 10th Avenue, Denver, CO 80218 (US).</p> <p>(74) Agents: ORANGE, John, R., S. et al.; Orange Chari Pillay, Toronto Dominion Bank Tower, Suite 3600, Toronto-Dominion Centre, P.O. Box 190, Toronto, Ontario M5K 1H6 (CA).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: FASTENER



(57) Abstract

A fastener (10) has a body (20) and a cage (30) with cam surfaces (42, 44') formed on interengaging components (28, 33) to inhibit relative rotation. In one embodiment a washer (36) is interposed between said surfaces and has oppositely directed faces (38, 40) with cam surfaces formed on them. In a further embodiment, the underside of the cage has serrations formed on it.

FASTENER

The present invention relates to fasteners.

It is well known to use threaded fasteners to secure components to one another. It is also well known to inhibit separation of the fasteners by providing a vibration resistant washer between the fastener and the component. Typically this would take the form of a spring washer inserted between a face of a nut and a component being clamped.

An alternative form of fastener is shown in U.S. Patent 5,626,449 to Hong Kong Disc Lock Company. In this type of fastener a washer is inserted between the nut and the component and opposed faces of the nut and washer are provided with cam surfaces. The cam surfaces effect axial movement between the washer and the nut upon relative rotation. By arranging for the cam surfaces to have an angle greater than the helix angle of the thread of the nut, unintentional removal of the nut is avoided.

An arrangement shown in U.S. Patent 5,203,656 utilizes a pair of cam surfaces by the provision of an intermediate member between a lower washer and a nut. This is referred to as a three-piece arrangement. However, a disadvantage of the arrangement shown in '656 patent is that a central pilot is used to retain the intermediate component on the nut. The pilot is swaged in situ which leads not only to expensive manufacture but also requires close control of the tolerances to ensure the necessary rotational and axial clearances are provided.

U.S. Patent 5,688,091 to McKinlay discloses a similar type of fastener to that of 5,626,449 in which a cage is used to retain a washer beneath the flared head of a nut. In this arrangement however a cam is provided between the nut and washer. The face between the washer and the cage is planar to provide a single pair of cam surfaces between the washer and nut. The adjacent planar surfaces between the washer and cage allow the washer to rotate as it is tightened. However, it has been found that this arrangement will rotate due to vibration to undo the fastener in the majority of applications.

It is an object to the present invention to obviate or mitigate the above disadvantages.

In general terms the present invention provides a fastener which has a body with an end face and a cage rotatably secured to the body with a planar face directed toward the end face. The sidewalls of the cage extend toward and over the lower portion of the body to permit rotation but inhibit axial separation. A washer is interposed between the body and the cage and has a pair of oppositely directed faces to overlie respective faces on the body and cage. Opposed pairs of faces are provided with complimentary cam surfaces so that relative rotation between the components of the fastener cause axial displacement of the components.

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which: -

Figure 1 is a perspective view of a fastener.

Figure 2 is a section through a fastener installed between a pair of components.

Figure 3 is an enlarged view of a portion of the fastener shown in Figure 1.

Figure 4 is a view on the line IV - IV of Figure 3.

Figure 5 is an exploded view of the components in an alternative embodiment of fastener.

Figure 6 is a view similar to Figure 5 of a third embodiment of fastener.

Figure 7 is a section of a further embodiment fastener.

Figure 8 is an enlarged exploded view of portions of the fastener shown in Figure 7.

Figure 9 is a section of a further embodiment of fastener.

Figure 10 is an embodiment similar to Figure 9 of an alternative fastener configuration.

Figure 11 is an embodiment of a fastener with a shearable shank.

Figure 12 is a perspective view of a tool used to apply and remove the fasteners shown in Figure 1.

Figure 13 is a developed view of the lower end of the tool of Figure 1 and fastener.

Figure 14 is a curve showing the relative performance of the fastener of Figure 7 in vibration testing.

Figure 15 is a sectional view of the fastener of Figure 2 utilised with a stud.

Figure 16 is a view similar to Figure 15 of an alternative embodiment of stud.

In reference to Figures 1 and 2, a fastener generally indicated 10 includes a bolt 12 having a head 14. The bolt 12 includes a threaded shank 16 on which is threaded a nut assembly 18.

The nut assembly includes a body of 20 having planar flats 22, typically arranged as sides of a hexagon, and an internal bore 24 having a thread form corresponding to the shank 16.

The lower end of the body 22 is flared to provide a skirt 26 with a generally planar end face 28.

Upper surface 29 of skirt 26 intersects the flats 22 at a radiused fillet 31 whose height alternates between high and low from flat to flat.

A cage 30 is positioned adjacent the end face 28 and has a bottom wall 32. The bottom wall 32 has an inwardly directed face 33 spaced from the end face 28. A central aperture 35 is provided to receive the bolt 12. A peripheral sidewall 34 extends axially toward and beyond the flared skirt 26.

The cage 30 is heat treated to provide two zones of different physical characteristics with the bottom wall 30 relatively hard and the sidewall 34 more ductile. The upper extremity of the sidewall 34 is locally deformed radially inward to overlie the sloped upper surface of the skirt 26 and limit relative axial movement between the cage 32 and the body 20. The local deformation which is facilitated by the ductility of the sidewall, is provided at six uniformly spaced locations indicated at 35 that provide circumferential abutments as well as radial retention between the cage 32 and body 20.

A washer 36 is interposed between cage 32 and body 20 and has a pair of oppositely directed faces 38, 40 directed toward the end face 28 and inwardly directed face 33 respectively. As can best be seen in Figure 3, pairs of opposed faces 28, 38 and 33, 40 are formed with complimentary cam surfaces indicated at 42, 42' and 44, 44' respectively.

Referring to Figures 2 and 3, the cam surfaces 42, 42' each includes a series of planar facets 46 inclined to a radial plane and uniformly distributed about the longitudinal axis of the bolt 12. The facets 46 are parallel to one another to provide full face contact. The facets 46 are interconnected by a generally axially extending ridge 48 to provide pairs of opposed toothed

surfaces that are parallel to one another. The inclination of the facets 46 is selected to be greater than the helix angle of the thread form 24 so that the axial movement induced by cooperation of the surfaces for a given rotation of the body relative to the fastener is greater than the axial displacement of the body 20 relative to the shank 16. The aggregate height of the ridges 48 for each set of cam surfaces 42, 42' is typically the 1.5 times pitch of the thread to achieve satisfactory locking. The height of each ridge 48 is determined by dividing the aggregate height by the number of facets. The number of facets is selected to be an integral multiple of the number of flats and for the cam surfaces 42, 42' 12 facets is found satisfactory. The height of the ridge 48 will then be 1.5 times the pitch divided by 12.

The cam surfaces 44, 44' also includes a series of parallel planar facets 50 similar to facets 46 of cam surface 42 but oppositely directed with respect to facets 46. The number of facets 50 is greater than the facets 46, but the aggregate height of ridges 52 that interconnect the facets 50 is similar. Accordingly, the height of each of the ridges 52 is less than that of ridge 48. The cam surfaces 42, 42' are therefore relatively coarse and the cam surfaces 44, 44' relatively fine. cam surfaces 44 will cooperate when subject to vibration to inhibit relative rotation between the cage 32 and washer 36. This allows the cams 42 to cooperate and prevent loosening of the nut 18.

In a typical embodiment, the 360° circle of coarse and fine cams will each have a total number divisible by the wrenching flats of the nut. For a hexagonal nut therefore, the coarse cam circle will typically consist of twelve cams, for diameters from ½ to 1-½ inches inclusive and the fine cam circle will consist of 18 cams.

The radial extent of the cams measured from the inner edge of the bore will range from 5 mm to 8 mm depending on the bolt diameter.

The nut assembly 18 is preassembled by inserting the washer 36 into the cage 32 and the body 20 placed on the washer 36. The sidewalls 34 are then radially displaced to overlap the upper surface 29 of flared skirt 26. The ductility of the sidewalls facilitates the displacement while permitting lower face to retain the hardened bearing surface. Preferably, the number of locations where the sidewalls are radially displaced will be similar to the number of

wrenching flats on the nut although this may be varied to be either greater or lesser depending on circumstances. Limited axial displacement is provided between the cage 32 and the body 20 allowing the cage 32 to rotate relative to body 22. It has been found that the greater height and added hoop strength available at the nut flange provides 30% more strength than a standard nut.

To fasten a pair of components indicated (A) and (B) in Figure 2, the bolt 12 is passed through an aligned aperture in the two components and the nut assembly 18 threaded onto the shank 16. As the lower face of the cage 32 engages the upper surface of component (A), the cam surfaces 42, 42' and 44, 42' are brought into engagement to rotate the washer 36 cage 32 and body 20 conjointly. The ridges 48 provide torque transmission between the body 22 washer 36 and cage 32 and because of the generally axial disposition of the ridges 48, relative axial separation is not induced.

The nut assembly 20 is tightened to the requisite torque to hold the two components (A) and (B) by the tool 60 shown in Figures 12 and 13.

Referring therefore to Figure 12, the tool 60 includes a cylindrical barrel 62 that may be connected to a conventional rotary drive and an internal socket 64. The socket has internal faces 66 corresponding to the flats 22 so as to be a snug fit over the body 20.

A rabbet 66 is formed at the lower end of the barrel 62 and is dimensioned to permit the lower end of barrel 62 to fit within the sidewalls 34 of the cage 30. The axial wall 68 of rabbet 66 has recesses 70 which correspond in size and spacing to the local deformations 35.

As shown in Figure 13, the lower end 72 of the faces 66 are staggered to alternate between "low" and "high" with the stagger corresponding to the change of height of the fillets 31. The height difference of the fillets is chosen to be greater than the axial extent of recesses 70 so that when a 'high' end 72 is engaged with an elevated fillet 31, the recess 70 does not engage the deformations 35.

In this position, as shown in Figure 13, the body 20 may rotate freely relative to the cage 30 and allow the nut to be tightened.

If in use the bolt 12 extends due to the axial loads placed upon it, relative rotation between cage 32 and body 22 will cause the ridges 52 to engage and the facets 46 of opposed faces to slide across one another. This induces an axial displacement between the faces, which is greater than the axial displacement provided by a corresponding rotation of the body 20 on the shank 16. As such a binding or interference is provided between the components and an unintentional separation is inhibited.

To remove the nut assembly 18, the tool 60 is used but with the "high" lower ends 72 aligned with the lower fillets 31. In this position, the recess 70 may engage the local deformations 35 and transmit torque to them. The body 20 and cage 32 may then be rotated conjointly and removed from the bolt. The recess 70 and deformation 35 will be brought into alignment, upon initial rotation of the body 20. Such rotation will be accommodated by relative movement of the cam surfaces, 42, 44.

An alternative embodiment is shown in Figure 5 in which like components will be identified by like reference numerals with a suffix (a) added for clarity. In the embodiment of Figure 5, the body 22 is formed with a conical protrusion 52 which passes through an enlarged bore 35a and cage 32a. The conical protrusion 52 has a pair of axial slots 54 that provide cleaning edges for the thread on the shank 16A. The conical protrusion permits centering of the component A on the fastener in the conventional manner.

A further embodiment is shown in Figure 6 in which like components will be identified with like reference numerals with a suffix "b" added for clarity. In the embodiments shown in Figure 6, a conical protrusion 52b is provided with slots 54b. The washer 36 is omitted to provide a two piece assembly with the cam surface 42b on the body 22b engaging with the cam surface 44b on the cage 32b.

In each of the embodiments of Figures 5 and 6 the axial slots 54b may be omitted if preferred.

The arrangement depicted in figures 1 to 3 is referred to as a three-piece arrangement because it includes the nut 22, washer 36 and cage 32. A two piece arrangement may also be produced, as shown in figures 7 and 8 wherein the washer 36 is eliminated so that the cam surface 42 of nut 22 and the cam surface 44 on inside bottom surface of the cage 32 engage. Each are produced with oppositely directed coarse cams which are complementary to each other.

In this case, the cage 30c has fine serrations 55, angled at 15° with respect to a radial plane on the outside bottom of the cage 30c. The serrations 55 are directed oppositely to the facets 46c that are located on the inside bottom of the cage 30c. The serrations 55 engage with the workpiece (A) and stop the cage 30c from moving, thus allowing the coarse cams to move up the incline and lock the nut 22. The effect of the serrations 55 may be seen from Figure 14. A pair of similar nut assemblies, one with serrations 55 and one without serrations, was tested on a Junker vibration testing machine. The tensile force was monitored over a period of time. As can be seen in Figure 14, the nut assembly without the serrations lost the tensile force in a relatively short time, indicating slippage of the nut on the bolt. By contrast, the nut assembly with serrations maintained the tensile load, indicating the effectiveness of the serrations in inhibiting rotation of the cage on the workpiece.

In each of the above embodiments a hexagonal body has been illustrated but it will be recognized that other forms of nut may be used such as barrel nuts with longitudinal grooves or other commonly available forms.

In a further embodiment, shown in figure 9, coarse cams are formed underneath the flange of a head of a bolt 56. The bolt 56 essentially replaces the nut 22 in the three-piece arrangement of figures 1 and 2 with a washer 36d interposed between the cam surface 42d and cage 32d arranged as described with respect to Figures 2 and 3 above. As with the nut 22, the flange bolt 56 can also be used in a 2-piece arrangement. In such an arrangement, coarse cams 42d would be located on the underside of the flange bolt 56 in order to engage oppositely directed coarse cams 44d that are located on the inside of the bottom surface of the cage.

The arrangement shown in Figure 9 may also be utilized with other forms of bolt head such as domed heads or socket headed bolts. Thus is shown in Figure 10, a cage 32e is retained on a domed body 56e with local deformations 34e. The body 56e has a socket 58 formed at a central location to receive a hexagonal wrench key.

A washer 36e is interposed between the cage 32d and underside of body 56e to provide a pair of cam surfaces 42e, 44e as described above.

The fasteners shown above may also be used with other fastening systems such as tension control bolting systems shown in Figure 11. With such a system, the shank 16f is formed with a splined tip 78 and torque applied between the tip 78 and nut 22f to tighten the nut on the bolt 12f. As illustrated in Figure 11, the nut assembly 18f has a form similar to that shown in Figure 2 above and therefore acts as a self-locking assembly. Upon application of the design torque to the nut 22f, the tip 78 shears from the shank 16f to inhibit further tightening. Subsequent removal can be accomplished as noted above.

The use of the nut assembly 18f inhibits rotation of the nut 22f under vibration and therefore maintains the loading on the bolt 12f. To ensure accurate loading of the bolt 12f it is desirable that the area of the abutting nut and washer is 50% or less than the area of the end face 32f of cage 30f. This may readily be attained using the cam surfaces and lubrication provided between the cam surfaces to reduce frictional resistance during tightening.

In a typical application for a $\frac{3}{4}$ inch (19mm) bolt diameter the end face 32f has an outside diameter of approximately 47-mm and a bolt hole clearance of approximately 24 mm. The annulus in contact with the object is therefore 23 mm wide.

In this embodiment, the cam surfaces 42f, 44f have a radial extent of approximately 6 mm. and so the ratio of areas is approximately 40% of the end face 32f.

The nut assembly of Figure 1 though 7 may also be used advantageously with studs secured in a blind hole. As shown in Figure 15, a nut assembly 10g, similar to that shown in Figures 1 to 4, is threaded on a stud 12g. The stud 12g has a pair of threads 24g at opposite ends

80,82, which may be of opposite hand, or the same hand, or of different form to suit the particular applications. One end, 80, is received in a blind bore 84 in a support structure 86. The bore 84 is threaded with a complementary thread to the 80 so that the stud may be threaded in.

The stud is installed by threading the nut assembly 10g onto the opposite end and driving the stud 12g into the blind bore 84. The nut 10g is then torqued against the components A, B to be held on the support structure 86. The nut assembly 10g will then hold the stud 12g under tension and retain it in the bore 84.

The arrangement of stud shown in Figure 15 is particularly beneficial when used with a tension control splined tip similar to that shown in Figure 11. Referring to Figure 16, the splined tip 78 is formed on the end 80h and can be used to drive the stud 12h into the blind bore 84h and subsequently controls the torque applied to the nut assembly 10h. The nut assembly of the embodiment of Figure 7 may also be used with the stud arrangement show in Figures 15 and 16 with serrations 55 providing the enchanced retention of the nut assembly.

It will be seen therefore that a simple yet effective fastener has been described that provides the requisite resistance to vibration and at the same time is relatively easy to manufacture.

Claims:

1. A fastener comprising a body with a thread formed thereon, said body having an end face, a cage rotatably secured to said body and having a radial face directed toward said end face and side walls extending toward and overlying a portion of said body to inhibit axial separation, and a flat washer interposed between said body and said cage, said washer having an inner periphery and an outer periphery with a pair of oppositely directed radial faces extending between said inner and outer peripheries, one of said faces being directed toward said end face of said body and the other of said faces being directed toward said radial face of said cage, opposed pairs of said faces abutting over substantially the entire radial extent thereof upon initial engagement, said faces having complementary cam surfaces formed thereon between said inner periphery and said outer periphery to induce relative axial movement upon rotation between said faces, said cam surfaces including a plurality of inclined facets having an angle of inclination greater than the helix angle of said thread.
2. A fastener according to claim 1 wherein said body has a flared skirt adjacent said radial face and said side walls overlap said skirt.
3. A fastener according to claim 1 wherein said body is a nut having planar flanks to permit torque transmission thereto.
4. A fastener according to claim 3 wherein selected ones of said flanks have an abutment to inhibit movement of a tool axially along said flanks toward said cage.
5. A fastener according to claim 1 wherein said facets are interconnected by ridges to provide a torque-transmitting abutment between said faces.
6. A fastener according to claim 1 wherein said cam surfaces associated with respective ones of said opposed pairs of faces are different.
7. A fastener according to claim 1 wherein said facets associated with one of said pairs of surfaces are of different length to facets associated with the other of said pairs of surfaces.
8. A fastener according to claim 1 wherein said body has a plurality of flats formed thereon to define a polygonal body and the number of said facets is an integral multiple of the number of flats.

9. A fastener according to claim 1 wherein said body has a threaded shank depending therefrom.
10. A fastener according to claim 1 wherein said facets are inclined at an angle up to 1.5 times that of said helix angle of said thread.
11. A fastener comprising a body having an end face, a cage rotatably mounted on said body and having a radial face directed toward said end face and sidewalls extending toward and overlying a portion of said body, to inhibit axial separation, said opposed faces having complementary cam surfaces formed thereon to induce relative movement upon rotation between said faces, said cage having a surface oppositely directed to said radial face and having a plurality of asymmetric serrations formed thereon and extending substantially continuously across said surface, each of said serrations having an inclined facet and a generally axial end face and being oppositely directed to said cam surface.
12. A fastener according to claim 11 wherein said facets are disposed at 15 degrees to a radial plane.
13. A fastener assembly for securing a pair of components to one another, said fastener assembly including a bolt having a head with a first end face directed toward one of said components and a threaded shank depending from said head, a nut having a body and a second end face directed toward another of said components, said body being threaded to receive said shank, a cage secured to one of said head and said body and having a radial face extending across a respective one of said end faces, and a flat washer interposed between said cage and said end face, said washer having an inner periphery and an outer periphery with a pair of oppositely directed radial faces extending between said inner periphery and said outer periphery, and one of said face being directed toward said one end face and the other of said faces being directed toward said radial face of said cage, opposed pairs of said faces lying in a plane generally perpendicular to a longitudinal axis of said body and abutting over substantially the entire radial extent thereof upon initial engagement, said faces having complementary cam surfaces formed thereon to induce relative axial movement upon rotation between said faces, said cam surfaces including a plurality of inclined facets having an angle of inclination greater than the helix angle of said threaded shank.

14. A fastener assembly according to claim 13 wherein said shank has a splined tip at the opposite end to said head, said tip being severable upon application of a predetermined torque to said nut.
15. A fastener assembly according to claim 13 wherein said one end face is a said nut.
16. A fastener assembly according to claim 13 wherein said one end face is a said head.
17. A fastener assembly according to claim 16 wherein said head is polygonal.
18. A fastener assembly according to claim 16 wherein said head is domed.
19. A fastener according to claim 13 wherein said facets are inclined at an angle up to 1.5 times that of said helix angle of said thread.

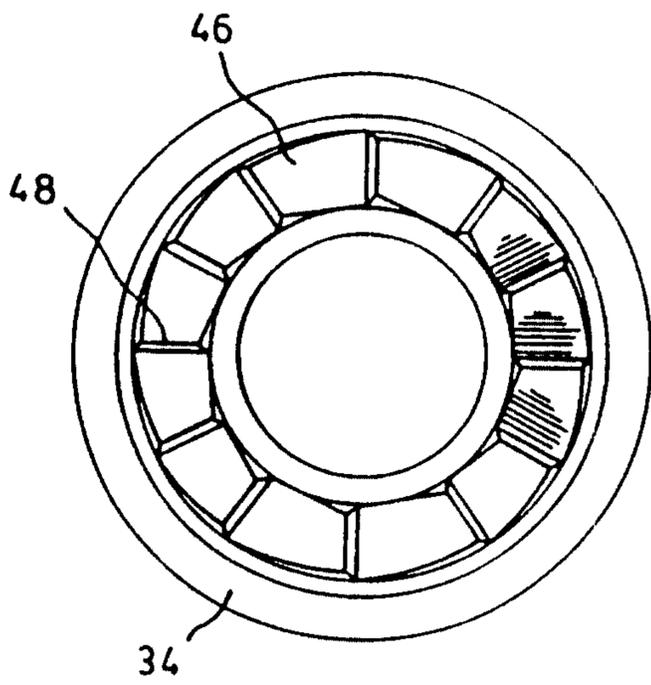


FIG. 4

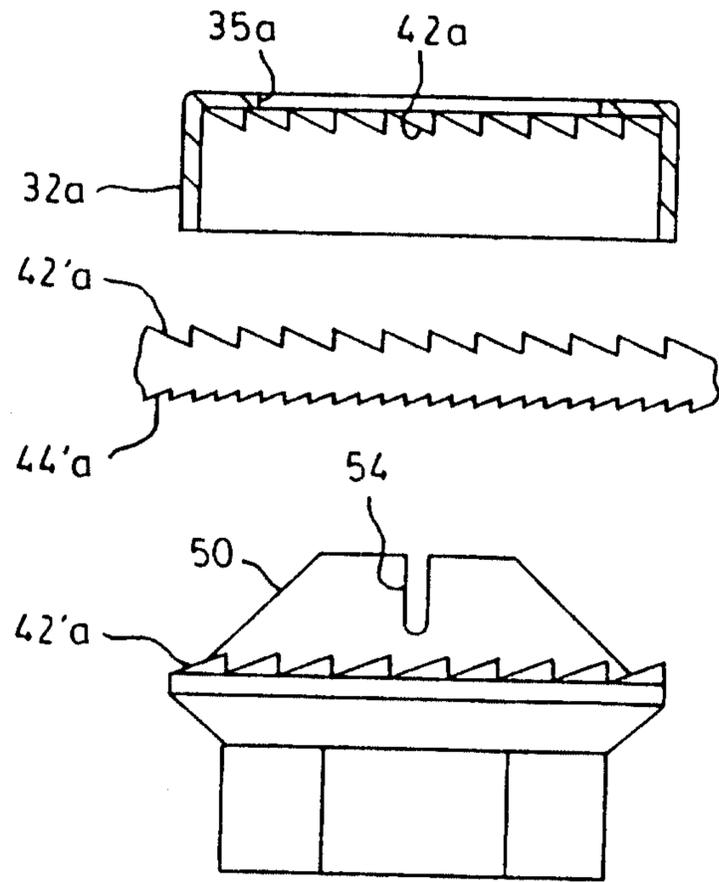


FIG. 5

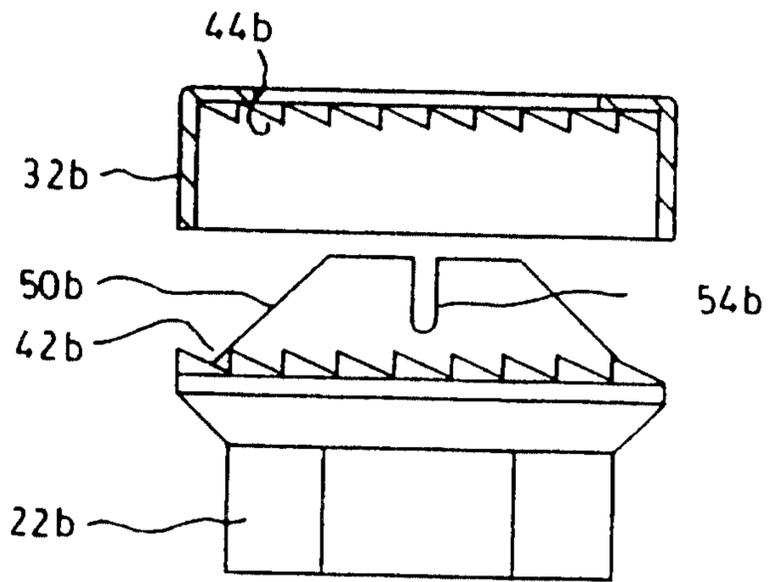


FIG. 6

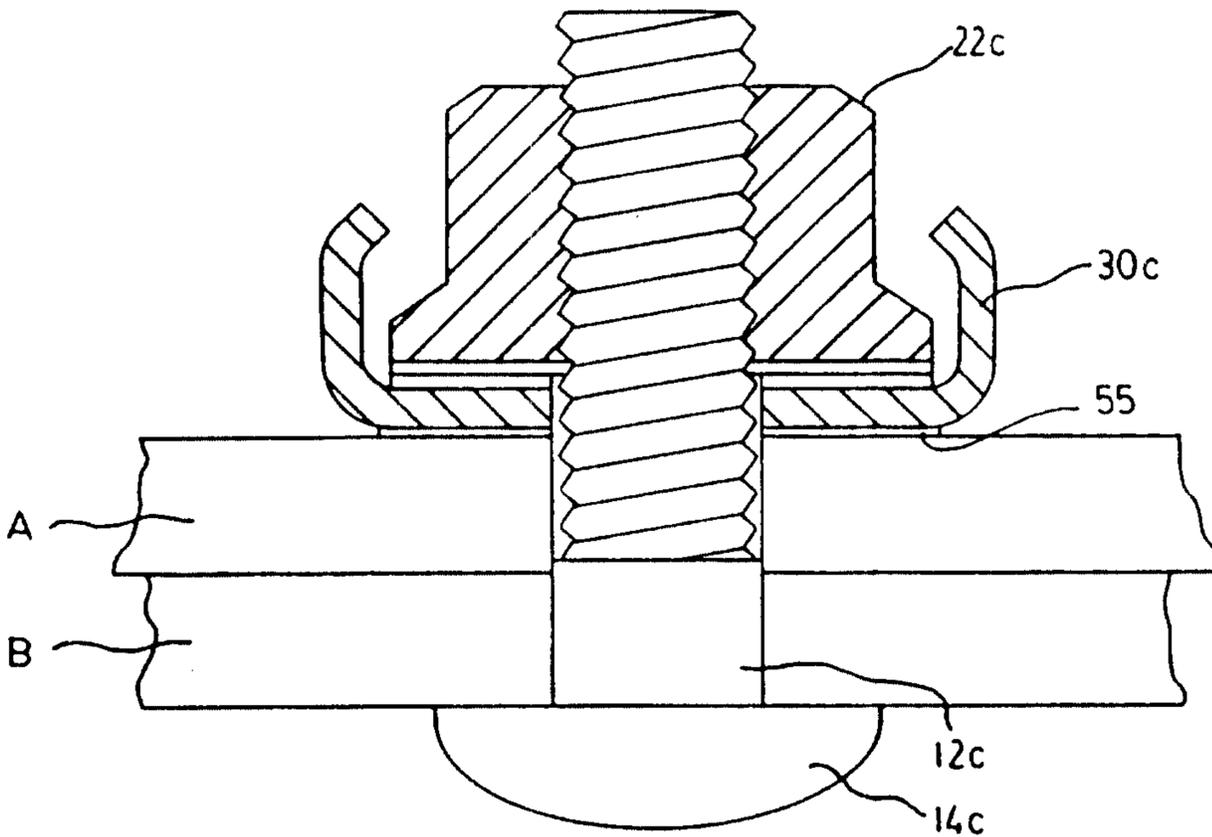


FIG. 7

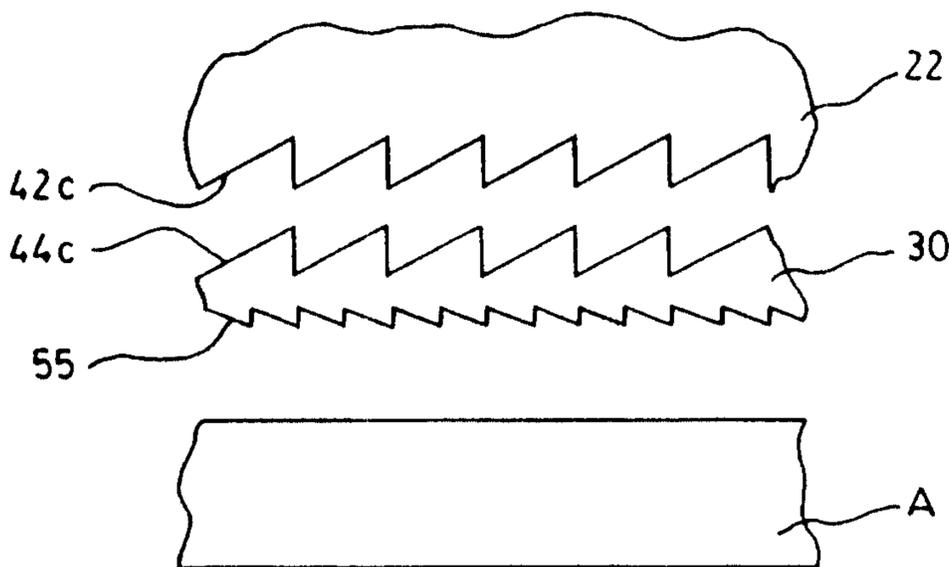


FIG. 8

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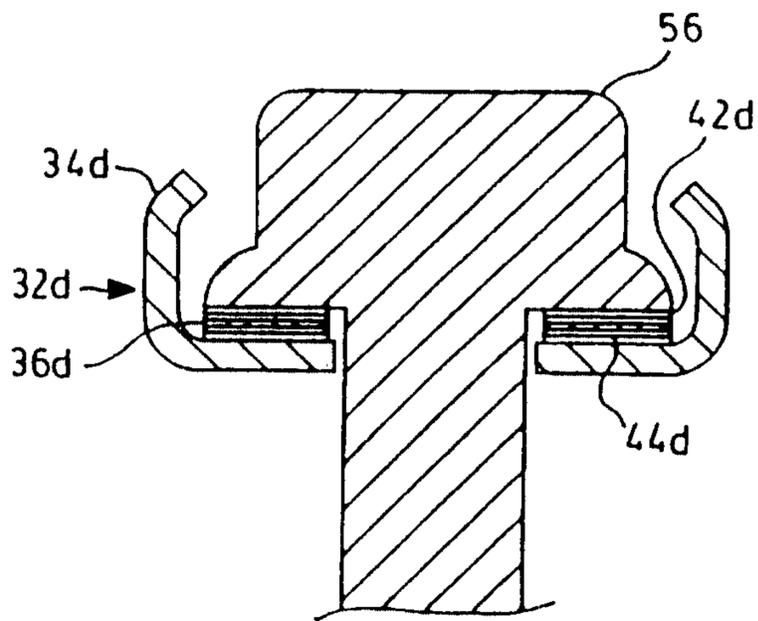


FIG. 9

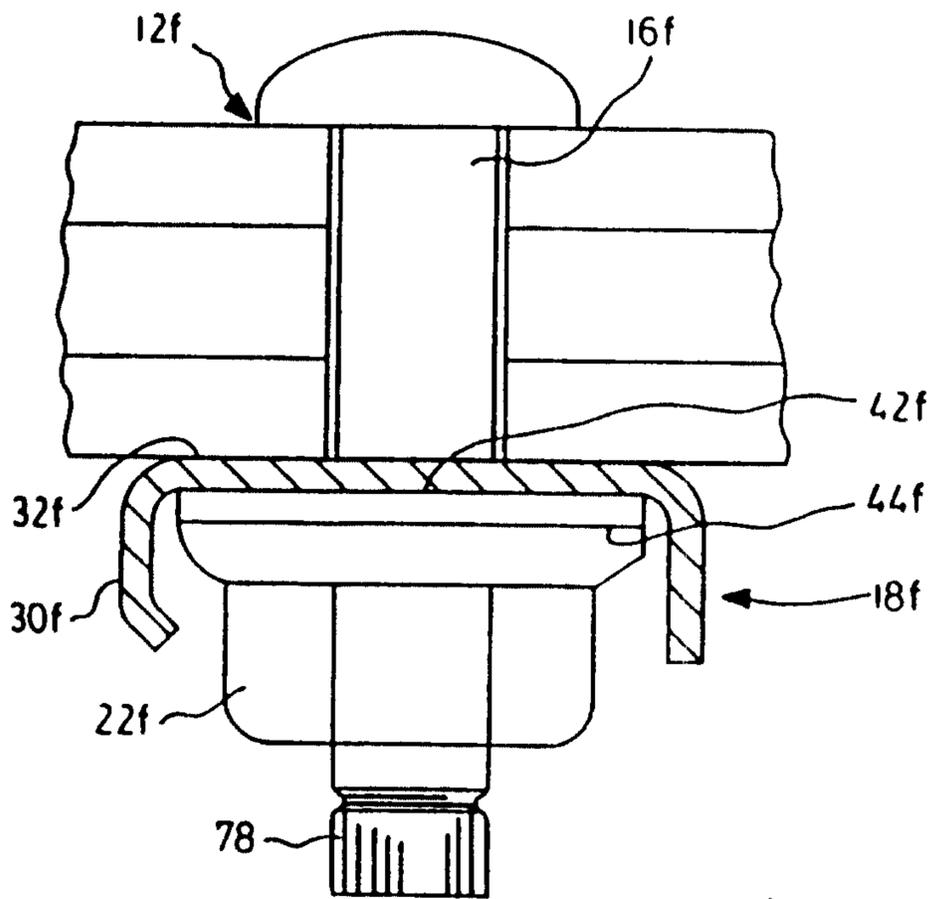


FIG. 11

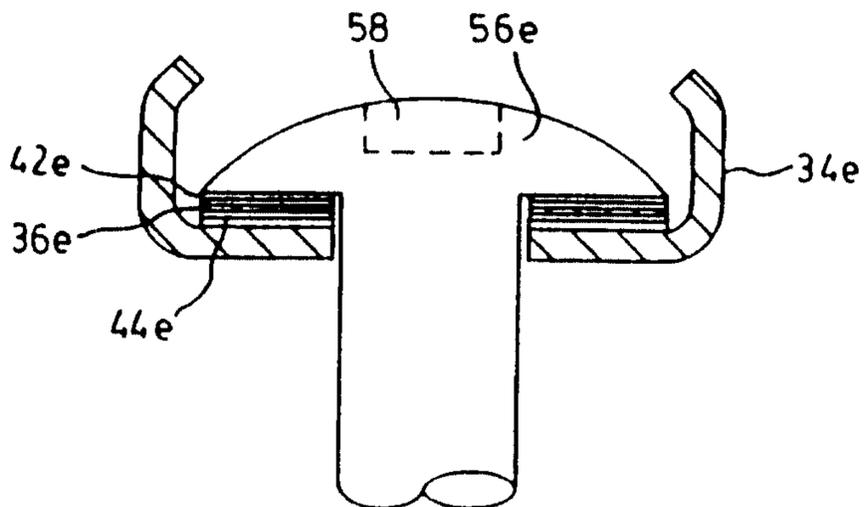


FIG. 10

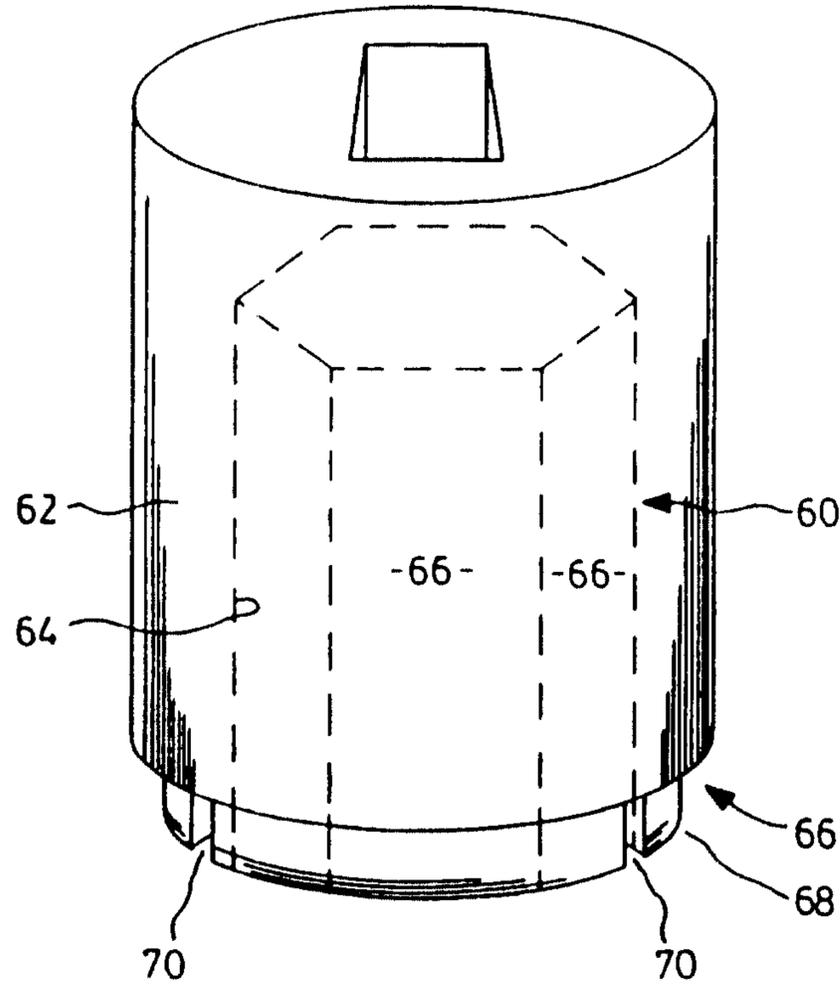


FIG. 12

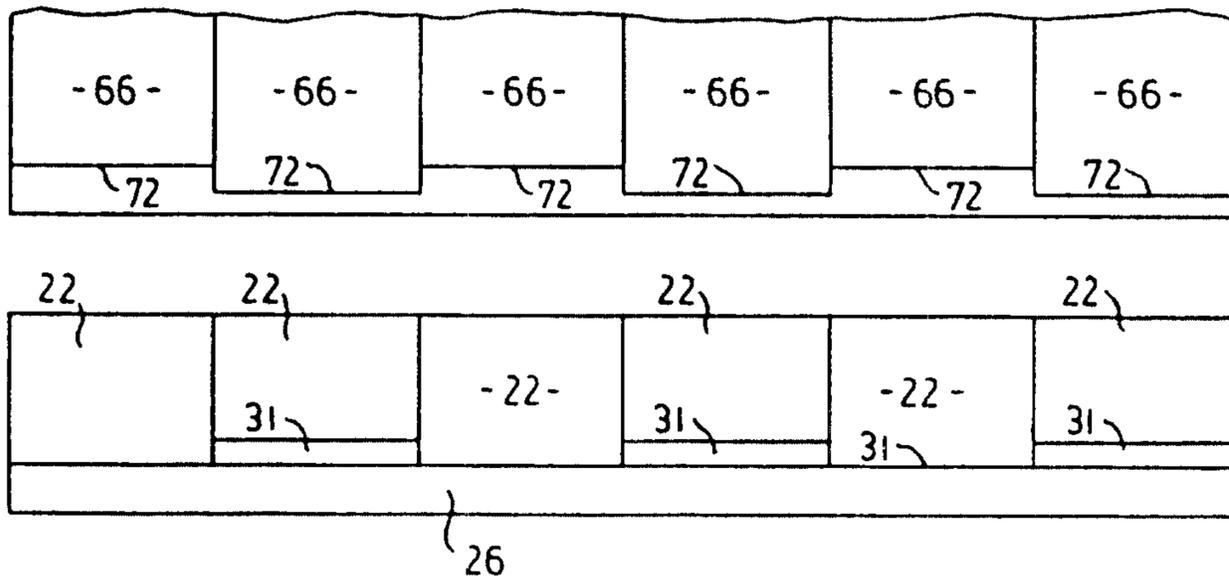


FIG. 13

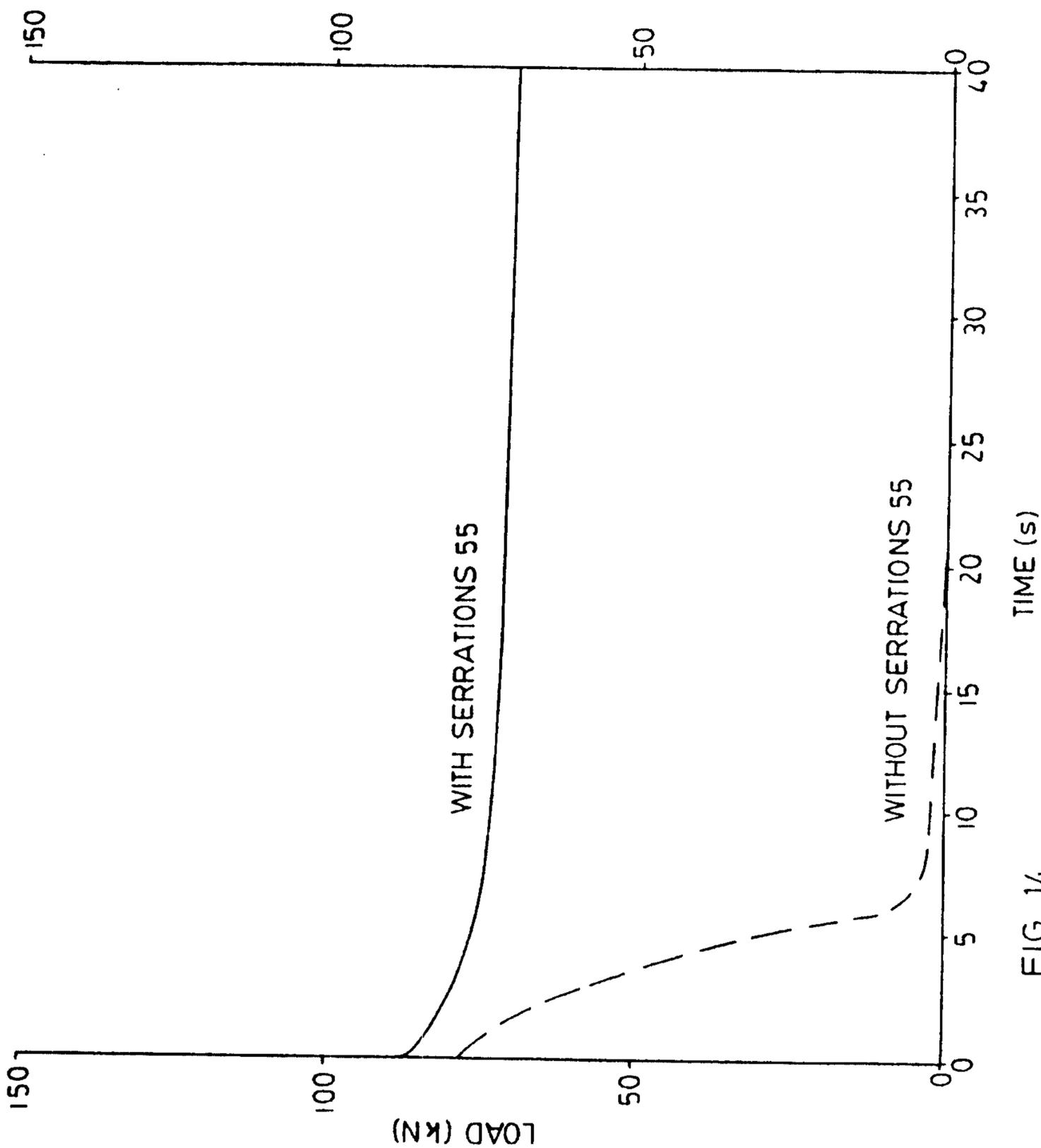


FIG. 14

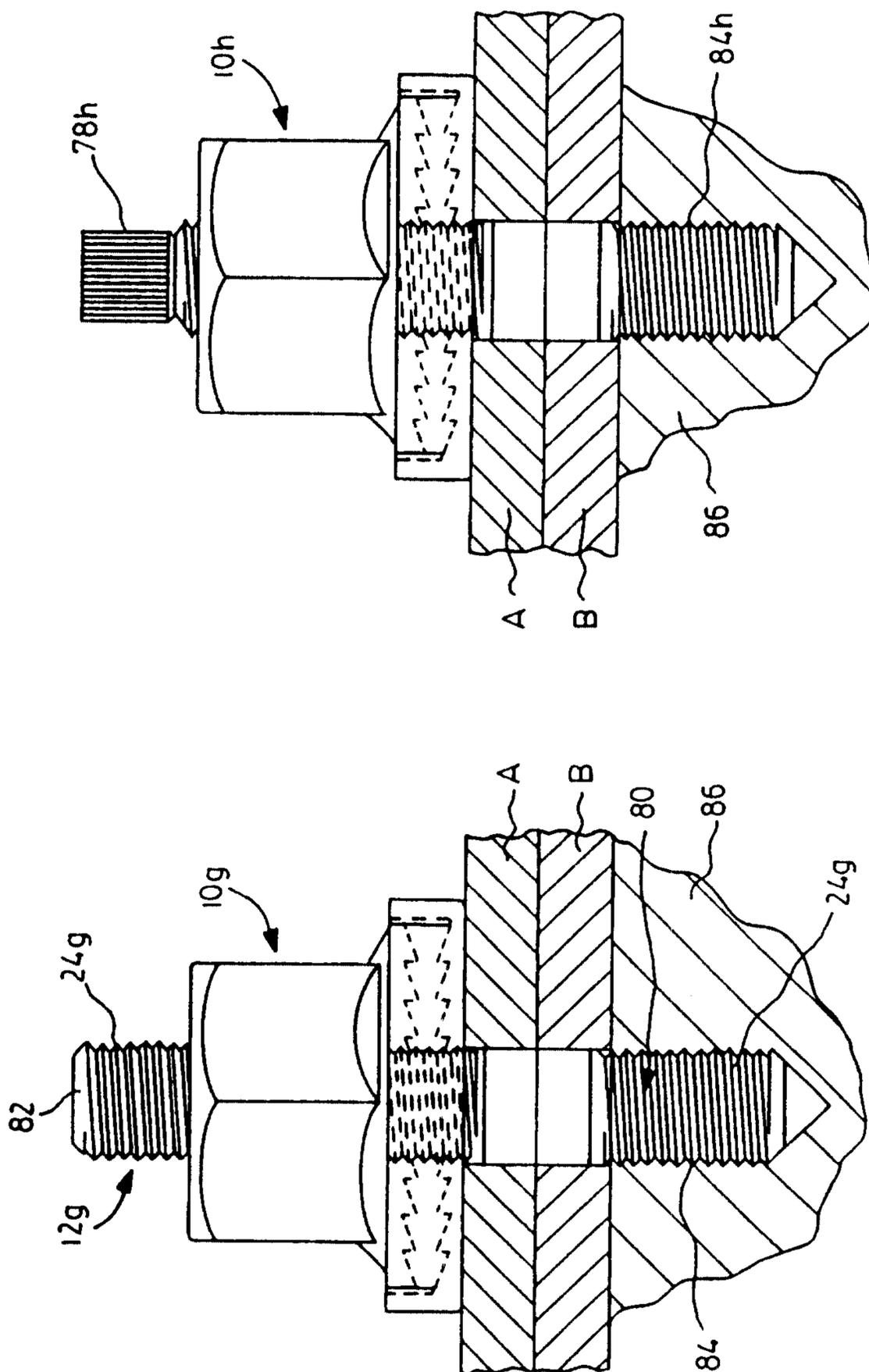


FIG. 16

FIG. 15

