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(54) **SHEET METAL JOINING APPARATUS WITH A DIE ASSEMBLY**

(57) A metal joining apparatus (31) is provided. In another aspect, a single piece die guard (51) includes an integral die shield section (71) and an integral retainer section (73) wherein a die anvil (161, 461, 561) can be removed. A further aspect employs a workpiece-facing surface of a die guard having a generally uniform height at both a die shield section and a retainer section with a separately insertable anvil and/or die body (163). A method of assembling a die assembly includes inserting a die blade (121, 321, 421, 521) sub-assembly into one end of a bore of a die guard, and inserting at least a portion of a die having an anvil into an opposite end of the same bore in the die guard. Yet another aspect discloses an apparatus and a method of assembling a die assembly wherein a laterally enlarged flange (167, 467, 567) of a die is removeably trapped between a backside of a die guard and an actuator frame (33) to which the die guard is removeably secured, with a workpiece-clinching anvil projecting from the die within the die guard.

EP 3 769 859 A1

Description

BACKGOUND AND SUMMARY

[0001] The present disclosure relates generally to a joining apparatus and more particularly to a metal-working die assembly.

[0002] It is well known to employ a punch and die assembly to create a clinch joint within sheet metal workpieces located therebetween. Furthermore, many conventional die assemblies are mounted onto separate die retainers or holders in order to secure the die assemblies to a frame of an actuator tool. Examples of such die assemblies and separate holders are disclosed in the following U.S. patents invented by Sawdon which are commonly owned with the present application: 7,694,399 entitled "Sheet Fastening Apparatus and Method" which issued on April 13, 2010; 6,430,795 entitled "Composite Urethane Stripper for Metal Joining Apparatus" which issued on August 13, 2002; and 5,860,315 entitled "Device for Securing Tools" which issued on January 19, 1999. While these devices were significant improvements in the industry, the separate external shield of the die assembly in addition to the distinct holder sometimes causes extraneously redundant components and also can add undesired extra height to the combination which may render fastening access difficult when certain workpiece shapes are encountered.

[0003] Figures 12 - 14 of commonly owned U.S. Patent No. 5,479,687 entitled "Apparatus for Joining Sheets of Material" which issued to Sawdon on January 2, 1996, shows a die retainer integral with an outer sleeve. However, the anvil cannot be removed for replacement due to wear during use.

[0004] In accordance with the present invention, a metal joining apparatus is provided. In another aspect, a single piece die guard includes an integral die shield section and an integral retainer section wherein a die anvil can be removed. A further aspect employs a workpiece-facing surface of a die guard having a generally uniform height at both a die shield section and a retainer section with a separately insertable anvil and/or die body. A method of assembling a die assembly includes inserting a die blade sub-assembly into one end of a bore of a die guard, and inserting at least a portion of a die having an anvil into an opposite end of the same bore in the die guard. Yet another aspect discloses an apparatus and a method of assembling a die assembly wherein a laterally enlarged flange of a die is removeably trapped between a backside of a die guard and an actuator frame to which the die guard is removeably secured, with a workpiece-clinching anvil projecting from the die within the die guard.

[0005] The present apparatus and method are advantageous over traditional devices. For example, the integral shield and retainer sections reduce separate parts while providing a low height profile to more easily access workpieces. Furthermore, the present design makes assembly and disassembly of the die blades and the anvil much easier. Moreover, fewer parts and multifunctionality are beneficially achieved with the present apparatus. Additional advantages and features of the present apparatus and method can be ascertained from the following description and appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Figure 1 is a perspective view showing the present joining apparatus acting upon workpieces;

Figure 2 is a side-elevational view showing the present joining apparatus acting upon the workpieces;

Figure 3 is a fragmentary perspective view showing a first embodiment of the present joining apparatus;

Figure 4 is a cross-sectional view, taken along line 4 - 4 of Figure 2, showing the first embodiment joining apparatus acting upon the workpieces;

Figure 5 is an enlarged cross-sectional view like that of Figure 4 showing the first embodiment joining apparatus acting upon the workpieces;

Figure 6 is a perspective view showing the first embodiment joining apparatus;

Figure 7 is a top elevational view showing the first embodiment joining apparatus;

Figure 8 is a side-elevational view showing the first embodiment joining apparatus;

Figure 9 is a cross-sectional view, taken along 9 - 9 of Figure 7, showing the first embodiment joining apparatus;

Figures 10 - 16 are a series of perspective views showing assembly steps of the first embodiment joining apparatus;

Figure 17 is a perspective view showing a second embodiment of the present joining apparatus;

Figure 18 is a perspective view showing a third embodiment of the present joining apparatus;

Figure 19 is a perspective view showing a fourth embodiment of the present joining apparatus;

Figures 20 and 21 are perspective views showing a fifth embodiment of the present joining apparatus, in different die assembly orientations; and

Figure 22 is a side-elevational view showing the fifth embodiment joining apparatus.

DETAILED DESCRIPTION

[0007] A joining apparatus 31 is illustrated in Figures 1 - 5 and includes a metallic C-frame 33 with an actuator 35. Actuator 35 is pneumatically or hydraulically powered. Alternately, it may be electromagnetically powered such as with an electric motor which drives an associated output transmission spindle. A longitudinally elongated punch 37 and laterally surrounding stripper 39 are linearly advanced and retracted by activation of actuator 35. Op-

erator graspable handles 41 are coupled to a middle section of frame 33 and an eyelet 43 attached to an upper section of frame 33 is suspended from a vertically oriented cable having its opposite end attached to a manufacturing plant ceiling or associated overhead fixture. Thus, the operator can manually move frame 33 between various areas to be joined on sheet metal or extruded workpieces 45. Alternately, an articulating robot may be coupled to the middle section of frame 33 for automated movement thereof.

[0008] Joining apparatus 31 further includes a die guard 51, also referred to as a die assembly 53, which is coupled to a mounting surface 55 of frame 33 via a threaded fastener 57. Mounting surface 55 sits at the bottom of a depression or pocket 59 machined into a lower arm 61 of frame 33. Alternately, the mounting surface can simply be a flat plane of the frame or a stationary fixture. Furthermore, fastener 57 is preferably a cap screw having a hexagonally shaped tool-receptacle internally within an enlarged head thereof.

[0009] Reference should now be made to Figures 5 - 9. Die guard 51 includes a shield section 71 and a retainer section 73, both located in the same and integral, single piece die guard part which is preferably machined from steel. Shield section 71 includes an internally extending through-bore 75 (see Figure 11) which is longitudinally extending between a workpiece-facing surface 77 and a backside surface 79. Multiple spaced apart apertures 81 radially extend through a curved wall of shield section 71 in directions generally perpendicular to the longitudinal centerline direction of through-bore 75. Apertures 81 functionally allow workpiece and manufacturing plant debris to fall out of shield section 71. Apertures 81 are longitudinally closer to backside surface 79 than they are to workpice-facing surface 77. It is noteworthy that backside surface 79 includes a step 91 such that a longitudinal dimension 93, between the opposite surfaces 77 and 79 at shield section 71, is less than a similarly measured dimension 95 at retainer section 73.

[0010] Another through-bore 97 is located in retainer section 73 and is openly accessible in a direction generally parallel to that of die bore 75. Retainer bore 97 includes an inwardly stepped shoulder 99 which receives the backside of the head of cap screw fastener 57. The threaded end of a shaft of fastener 57 is rotatably received within an internally threaded hole in mounting surface 55 of the C-frame.

[0011] Opposite endwalls of shield and retainer sections 71 and 73, respectively, are somewhat semi-circular and curved when viewed in a top true-view, and sidewalls 101 spanning between the sections have a tapered true view appearance (see Figure 7) such that they are widest where they intersect a plane through a centerline of shield section 71 and are closest together where they intersect a plane through a centerline of fastener 57. Furthermore, workpiece-facing surface 77 has a generally uniform and constant height at both the shield section and the retainer section including the connecting area therebetween. This provides a low profile height at or less than 10 mm off of backside surface 79 at dimension 95, and more preferably having a height of 9 mm or less. This low profile configuration advantageously allows die access to complicated backside surfaces of the workpieces otherwise not achievable with various prior designs.

[0012] The die components will now be described in greater detail. Reference should now be made to Figures 5 - 16 wherein die assembly 53 includes three die blades 121, an elastomeric and flexible biasing ring 123 and a die 125. Each die blade 121 has a generally U-shape in cross-section with upper and lower outwardly extending feet 131 and 135, respectively, joined by a generally straight intermediate structure 137 which has an arcuate and smooth internal surface 139. Ring 123 annularly surrounds intermediate structure 137 of die blades 121 and when the die blades are compressed together, internal surfaces 139 create a generally continuous circular-cylindrical shape. Ring 123 preferably has a generally inverted U-cross-sectional shape with an open groove in a lower surface thereof to allow its bifurcated annular walls to compress together when a clinch joint 141 is formed between workpieces 45.

[0013] Die 125 includes a longitudinally elongated anvil 161 which centrally projects from a die body 163. Furthermore, die body 163 includes a circular and laterally enlarged shoulder 165 adjacent anvil 161 and a laterally enlarged and circular flange 167. Anvil 161, shoulder 165 and flange 167 are all coaxially aligned with each other and are a single integral piece made of steel. A locating pin 169 longitudinally and integrally projects from a centerline of die body 163 coaxially aligned with yet projecting opposite from anvil 161. Anvil 161 has a generally flat, workpiece-contacting upper surface 171 and a circular surrounding lateral surface 173 with an annular groove 175 therein. Peripheral surfaces of shoulder 165 and flange 167 are both smooth and flat in cross-section although a chamfer 177 may optionally be present at the lower corner of flange 167. Radii may also be present at surface intersections.

[0014] A metal-working leading end 63 of punch 37 is aligned with a centerline of anvil 161. Clinch joint 141 interlocks together sheet metal workpieces 45 in an interlocking fashion with a generally circular expanded button located closest to the anvil and a cylindrically depressed cup shape on the punch side. The clinch joint is preferably leak-proof and does not employ a separate fastener such as a rivet. An inner surface 143 of shield section 71 has a centrally depressed annular groove 145 to receive an arm of ring 123, and a lower annular groove 147 to allow movement of foot 135 of die blades 121.

[0015] During clinching joint 141 deformation, the lateral and outward expansion of workpieces 45 between punch 47 and anvil 161 cause die blades 121 to outwardly move away from lateral side surface 173 of anvil 161 while compressing ring 123 against shield section 71 (as can be observed in Figure 5). After the clinching joint is

formed, the punch is retracted, the joined workpieces are removed from die 53, and ring 123 will urge die blades 121 back together again against anvil 161 (as can be observed in Figure 9).

[0016] The assembly of the joining apparatus can best be observed with reference to Figures 10 - 16. First, the die blades, die and die guard are manufactured by machining and are then heat treated or coated as may be desired for the specific workpiece material to be clinched. Elastomeric ring 123 is also injection-molded from a polymeric material. Next, die blades 121 are held together while ring 123 is located thereon as is shown in Figure 10 to create a die blade sub-assembly with the ring encircling and compressing the die blades together.

[0017] Subsequently, the die blade sub-assembly is inserted into a workpiece facing end of through-bore 75 in an offset orientation generally perpendicular to its final installed position as can be observed in Figures 11 and 12. Figure 13 shows the next step where the die blade sub-assembly is rotated to its final installed position while inside of shield section 71 of the die guard. Next, die 125 is linearly inserted into the backside of bore 75, as can be seen in Figure 14. Anvil 161 is inserted internally within the central gap of die blades 121 until shoulder 165 aligns and snuggly fits internal to an inner bottom edge of die shield section 71, and the outwardly stepped flange 167 abuts and contacts against the stepped backside surface 79 as is shown in Figures 9 and 15. In this configuration, shoulder 165 snugly fits into shield section 71 but less than 10 Newtons and more preferably 9 or less Newtons of force is required to insert. The same force is required to later remove die 165 from shield section 71, which can be easily done by a person pushing a pencil or screwdriver against end 171 of anvil 161 during disassembly.

[0018] Referring to Figure 16, fastener 57 is thereafter inserted into its bore 97 in retainer section 73 to engage with a mounting surface of the C-frame. When fastener 57 tightly secures die guard 51 to the frame, flange 167 of die 125 is firmly trapped between the stepped backside surface 79 of the die guard and mounting surface 55 of the frame. This avoids the need for a more permanent snap-fit interlock or extraneous fastening of the die to the shield section, thereby simplifying the manufacture of and disassembly of the die. On occasion the anvil will become worn during repeated use such that replacement is desired, thereby utilizing the benefits of the present construction.

[0019] Figure 17 shows an alternate embodiment of the present joining apparatus. This apparatus is identical to that previously disclosed except that a helically coiled compression spring 323 is employed instead of an elastomeric ring. This flexible spring 323 annularly surrounds the intermediate structure in the middle of the die blades within shield section 71 of die guard 51. Spring 323 can be employed with any of the embodiments disclosed above or after.

[0020] Figure 18 illustrates another embodiment of the joining apparatus that is the same as those previously discussed except that the die blades and anvil face are differently shaped. The anvil face is concave for this version. The present exemplary die blades 321 include chamfers 322 at the inner and upper corners thereof. During clinching joint formation, these chamfers 322 create three pinched corners on the adjacent button of the workpiece which contacts against the upper edges of die blades 321 and anvil 161 of the die. These chamfers provide relief when the material flows to form the clinch button, particularly for sheet aluminum workpieces.

[0021] Figure 19 illustrates still another embodiment of the present joining apparatus that is essentially identical to that of the prior configurations. However, only two moveable die blades 421 are employed and they create a generally oval inside shape 422 with a corresponding generally oval and laterally elongated anvil 461. A radius or fillet 423 is located at each upward edge of each die blade 421. The punch may also be provided with an oval shaped leading end. Thus, the clinching joint in the workpieces will be created with a laterally elongated and generally oval button and cup shapes for the interlocking joint.

[0022] Furthermore, a circular formation 462 coaxially projects from a backside of a flange 467 of the die. And, a separate roll pin 469 longitudinally projects from a backside of formation 462 but in an offset position closer to a periphery thereof and not on the centerline of the die. The function of this offset pin will be discussed later.

[0023] Reference is now made to Figures 20 - 22. This embodiment of the present joining apparatus is essentially the same as all of the prior ones. Notwithstanding, the die assembly is different in that a lanced or partially pierced joint is formed between the workpieces and then the pierced edges are outwardly or laterally expanded after the partial piercing so as to overlap the pierced workpiece opening. But a separately installed fastener such as a rivet is not required. Two die blades 521 are employed on either side of a laterally elongated anvil 561 which has flat lateral sides adjacent die blades 521 and curved ends spanning therebetween. Flexible elastomeric ring 521 or the coiled spring is employed to bias the die blades toward the anvil and allow for outward expansion thereof during joint forming. A punch is similarly shaped to the anvil.

[0024] A formation 562 with a circular periphery longitudinally extends from a backside of a die flange 567 with a separate roll pin 569 projecting from a backside thereof in a laterally offset manner. A centerline of pin 569 is parallel to the die bore. Pin 569 fits within a matching hole in the C-frame. Thus, the die assembly can be rotated to various positions within the same die guard 51 depending on the lanced joint orientation desired within the same workpiece or for different workpieces. Different perpendicular anvil and die blades orientations can be observed by comparing Figure 20 to that of Figure 21. This same rotational orientation difference can be employed with the oval joint embodiment of Figure 19.

[0025] While various embodiments have been dis-

closed, it should be appreciated that other variations are possible. For example, a different quantity of die blades may be employed although certain benefits may not be realized. Furthermore, the ring or spring biasing component may be differently configured although some of the advantages of the present components may not be obtained. Moreover, each of the components disclosed herein may have different shapes or materials but certain benefits may not be achieved. It should also be appreciated that the terms "top," "bottom," "upper," "lower" and other such phrases are merely relative terms which may vary if the parts are inverted or differently oriented. The method steps may be performed in any order or even simultaneously for some operations. The features of any embodiment may be interchanged with any of the other embodiments, and the claims may be multiply dependent in any combination.

Claims

1. A joining apparatus comprising:

a metal-working die including a central anvil extending in a longitudinal direction and a die body enlarged in a lateral direction;
multiple die blades located adjacent to lateral surfaces of the anvil and operably moveable relative to the anvil;
a die guard comprising a shield section and a retainer section integrally being a single part, the shield section including a through-bore and the retainer section including a through-bore;
the anvil being removeably located within the through-bore of the shield section such that the die blades are positioned between the anvil and an internal surface of the shield section;
a fastener removeably located in the through-bore of the retainer section; and
a metal workpiece-facing surface of the die guard being substantially of a uniform height at both of the shield and retainer sections.

2. A joining apparatus comprising:

a metal-clinching die including a central anvil extending in a longitudinal direction and a die body enlarged in a lateral direction;
multiple die blades located adjacent to lateral surfaces of the anvil and operably moveable relative to the anvil;
a die guard comprising a shield section and a retainer section integrally being a single part, the shield section including a through-bore and the retainer section including a through-bore, the through-bores being accessible in parallel directions;
the anvil being removeably located within the through-bore of the shield section such that the die blades are positioned between the anvil and an internal surface of the shield section;
a fastener removeably located in the through-bore of the retainer section; and
a backside surface of the die guard having a longitudinally shorter step at the shield section as compared to at the retainer section, and a flange of the die body being located against the step.

3. The apparatus of Claim 1 or 2, wherein the die body further comprises:

a shoulder located closest to the anvil and a flange located adjacent the shoulder opposite the anvil;
the shoulder being laterally smaller than the flange;
ends of the die blades contacting the shoulder in at least one movement position;
a peripheral surface of the shoulder being flat in cross-section and located within the internal surface of the shield section; and
the flange having a substantially circular periphery which is laterally larger than the through-bore of the shield section.

4. The apparatus of any of Claims 1 - 3, wherein the die body further comprises:

a shoulder located closest to the anvil and a flange located adjacent the shoulder opposite the anvil the flange being entirely located against and external to a backside of the shield section;
the shoulder being laterally smaller than the flange;
ends of the die blades contacting the shoulder in at least one movement position;
a peripheral surface of the shoulder being flat in cross-section and located within the internal surface of the shield section; and
the flange having a substantially circular periphery which is laterally larger than the through-bore of the shield section.

5. The apparatus of any of Claims 1 - 4, further comprising a stepped edge being at a backside surface of the shield section such that a sidewall of the shield section has a smaller longitudinal dimension as compared to the sidewall at the retainer section, the flange of the die body located against the smaller dimensioned portion of the stepped edge.

6. The apparatus of any of Claims 1 - 5, wherein the die guard has inwardly tapering sidewalls between the shield and retainer sections when observed in a true view from the workpiece-facing surface, with the

narrowest true view lateral dimension between the sidewalls being adjacent the retainer section.

7. The apparatus of any of Claims 1 - 6, further comprising:

biasing means surrounding lateral surfaces of the die blades, the biasing means being located between the die blades and the shield section within the through-bore thereof;
the internal surface of the shield section including a first annular depression for receiving a portion of the biasing means and a spaced apart second annular depression adjacent the shoulder of the die body; and
a longitudinal distance from a workpiece-contacting end of the die blades to an opposite end of the die blades being at least twice a longitudinal thickness of the die body.

8. The apparatus of any of Claims 1 - 7, further comprising:

a frame, including a mounting surface, upon which a backside surface of the retainer section contacts when the fastener secures the die guard to the frame;
a laterally enlarged flange of the die body being trapped between a backside surface of the shield section and the mounting surface of the frame when the fastener secures the die guard to the frame; and
the die, including the anvil, being removable from the backside surface of the shield section when the fastener is detached from the frame.

9. The apparatus of any of Claims 1 - 8, wherein:

the die is removable from a backside of the die guard without requiring the die blades to be removable from the die guard;
the die blades are removable from the workpiece-facing surface of the die guard;
longitudinal centerlines of the bores of the shield and retainer sections are substantially parallel; and
a height of the entire die guard, between the backside and the workpiece-facing surface, is 10 mm or less.

10. The apparatus of any of Claims 1 - 9, further comprising:

a longitudinally moveable punch aligned with the anvil;
a fluid or electromagnetically powered actuator operably moving the punch; and
metal workpieces clinched together between the punch and the anvil to form a non-pierced clinch joint.

11. The apparatus of any of Claims 1 - 10, further comprising an offset structure projecting from a backside of the die body to engage with a matching formation of an actuator a frame to which the die guard is secured, the offset structure and die being rotatable to reorient the die within the shield section if different joint orientations are desired for the same die and die guard.

12. A method of assembling a die assembly, the method comprising:

(a) compressing die blades toward each other with a flexible spring or elastomeric ring to create a die blade sub-assembly;
(b) inserting the die blade sub-assembly into a workpiece-facing end of a die bore in a die guard;
(c) inserting at least a portion of a die into a backside end of the die bore in the die guard such that an anvil of the die is located between the die blades;
(d) locating an enlarged flange of the die to fit against but be positioned external to a backside surface of the die guard; and
(e) the die guard including a mounting bore which is laterally offset from the die bore but within the same die guard.

13. The method of Claim 12, further comprising:

inserting a fastener into the mounting bore;
engaging the fastener with a C-frame which is attached to a punch and a powered actuator, the fastener securing the die guard to the frame opposite the punch; and
the flange of the die being removeably trapped between the backside surface of the die guard and the frame.

14. The method of Claims 12 or 13, further comprising:

positioning the flange of the die within a step in the backside surface of the die guard; and
allowing the die blades to laterally move within the die bore after assembly thereof.

15. The method of any of Claims 12 - 14, further comprising:

deforming metallic workpieces between the die and punch to create an unpierced clinch joint in the workpieces; and
removing the die from the backside end of a shield section of the die guard with no more than 9 Newtons of force applied to the anvil from the

workpiece-facing end of the die bore, the shield section laterally surrounding the die blades, and the die guard being a single piece.

Amended claims in accordance with Rule 137(2) EPC.

1. A joining apparatus (31) comprising:

a metal-working die (125) including a central anvil (161) extending in a longitudinal direction and a die body (163) enlarged in a lateral direction;
multiple die blades (121) located adjacent to lateral surfaces (173) of the anvil (161) and operably moveable relative to the anvil;
a die guard (51) comprising a shield section (71) and a retainer section (73) integrally being a single part, the shield section (71) including a through-bore (75) and the retainer section (73) including a through-bore (97);
the anvil (161) being removeably located within the through-bore (75) of the shield section (71) such that the die blades (121) are positioned between the anvil (161) and an internal surface (143) of the shield section (71);
a fastener (57) removeably located in the through-bore (97) of the retainer section (73); and
a metal workpiece-facing surface (77) of the die guard (51) being substantially of a uniform height at both of the shield and retainer sections (71, 73).

2. The apparatus (31) of Claim 1, wherein the die body (163) further comprises:

a shoulder (165) located closest to the anvil (161) and a flange (167) located adjacent the shoulder opposite the anvil;
the shoulder (165) being laterally smaller than the flange (167);
ends of the die blades (121) contacting the shoulder (165) in at least one movement position;
a peripheral surface of the shoulder (165) being flat in cross-section and located within the internal surface (143) of the shield section (71); and
the flange (167) having a substantially circular periphery which is laterally larger than the through-bore (75) of the shield section (71).

3. The apparatus (31) of Claim 1 or 2, wherein the die body (163) further comprises:

a shoulder (165) located closest to the anvil (161) and a flange (167) located adjacent the shoulder opposite the anvil the flange being entirely located against and external to a backside of the shield section (71);
the shoulder (165) being laterally smaller than the flange (167);
ends of the die blades (121) contacting the shoulder (165) in at least one movement position;
a peripheral surface of the shoulder (165) being flat in cross-section and located within the internal surface (143) of the shield section (71); and
the flange (167) having a substantially circular periphery which is laterally larger than the through-bore (75) of the shield section (71).

4. The apparatus (31) of any of Claims 1 - 3, further comprising a stepped edge being at a backside surface (79) of the shield section (71) such that a sidewall of the shield section (71) has a smaller longitudinal dimension (93) as compared to the sidewall at the retainer section (73), the flange (167) of the die body (163) located against the smaller dimensioned portion (93) of the stepped edge.

5. The apparatus (31) of any of Claims 1 - 4, wherein the die guard (51) has inwardly tapering sidewalls (101) between the shield and retainer sections (71, 73) when observed in a true view from the workpiece-facing surface (77), with the narrowest true view lateral dimension between the sidewalls being adjacent the retainer section (73).

6. The apparatus (31) of any of Claims 1 - 5, further comprising:

biasing means (123, 323) surrounding lateral surfaces of the die blades (121), the biasing means being located between the die blades (121) and the shield section (71) within the through-bore (75) thereof;
the internal surface (143) of the shield section (71) including a first annular depression (145) for receiving a portion of the biasing means (123, 323) and a spaced apart second annular depression (147) adjacent the shoulder (165) of the die body (163); and
a longitudinal distance from a workpiece-contacting end of the die blades (121) to an opposite end of the die blades (121) being at least twice a longitudinal thickness of the die body (163).

7. The apparatus (31) of any of Claims 1 - 6, further comprising:

a frame (33), including a mounting surface (55), upon which a backside surface (79) of the retainer section (73) contacts when the fastener (57) secures the die guard (51) to the frame (33);
a laterally enlarged flange (167) of the die body

(163) being trapped between a backside surface (79) of the shield section (71) and the mounting surface (55) of the frame (33) when the fastener (57) secures the die guard (51) to the frame (33); and

the die (125), including the anvil (161), being removable from the backside surface (79) of the shield section (71) when the fastener (57) is detached from the frame (33).

8. The apparatus (31) of any of Claims 1 - 7, wherein:

the die (125) is removable from a backside of the die guard (51) without requiring the die blades (121) to be removable from the die guard (51);

the die blades (121) are removable from the workpiece-facing surface (77) of the die guard (51);

longitudinal centerlines of the bores (75, 97) of the shield and retainer sections (71, 73) are substantially parallel; and

a height of the entire die guard (51), between the backside and the workpiece-facing surface (77), is 10 mm or less.

9. The apparatus (31) of any of Claims 1 - 8, further comprising:

a longitudinally moveable punch (37) aligned with the anvil (161);

a fluid or electromagnetically powered actuator operably moving the punch (37); and

metal workpieces (45) clinched together between the punch (37) and the anvil (161) to form a non-pierced clinch joint.

10. The apparatus (31) of any of Claims 1 - 9, further comprising an offset structure projecting from a backside of the die body (163) to engage with a matching formation of an actuator a frame (33) to which the die guard (51) is secured, the offset structure and die (125) being rotatable to reorient the die within the shield section (71) if different joint orientations are desired for the same die (125) and die guard (51).

11. A method of assembling a die assembly (53), the method comprising:

(a) compressing die blades (121) toward each other with a flexible spring (323) or elastomeric ring (123) to create a die blade sub-assembly;

(b) inserting the die blade sub-assembly into a workpiece-facing end of a die bore (75) in a die guard (51);

(c) inserting at least a portion of a die (125) into a backside end of the die bore (75) in the die guard (51) such that an anvil (161) of the die (125) is located between the die blades (121);

(d) locating an enlarged flange (167) of the die (125) to fit against but be positioned external to a backside surface (79) of the die guard (51); and

(e) the die guard (51) including a mounting bore (97) which is laterally offset from the die bore (75) but within the same die guard (51).

12. The method of Claim 11, further comprising:

inserting a fastener (57) into the mounting bore (97);

engaging the fastener (57) with a C-frame (33) which is attached to a punch (37) and a powered actuator, the fastener securing the die guard (51) to the frame (33) opposite the punch (37); and

the flange (167) of the die (125) being removeably trapped between the backside surface (79) of the die guard (51) and the frame (33).

13. The method of Claims 11 or 12, further comprising:

positioning the flange (167) of the die (125) within a step in the backside surface (79) of the die guard (51); and

allowing the die blades (121) to laterally move within the die bore (75) after assembly thereof.

14. The method of any of Claims 11 - 13, further comprising:

deforming metallic workpieces (45) between the die (125) and punch (37) to create an unpierced clinch joint in the workpieces; and

removing the die (125) from the backside end of a shield section (71) of the die guard (51) with no more than 9 Newtons of force applied to the anvil (161) from the workpiece-facing end of the die bore (75), the shield section (71) laterally surrounding the die blades (121), and the die guard (51) being a single piece.

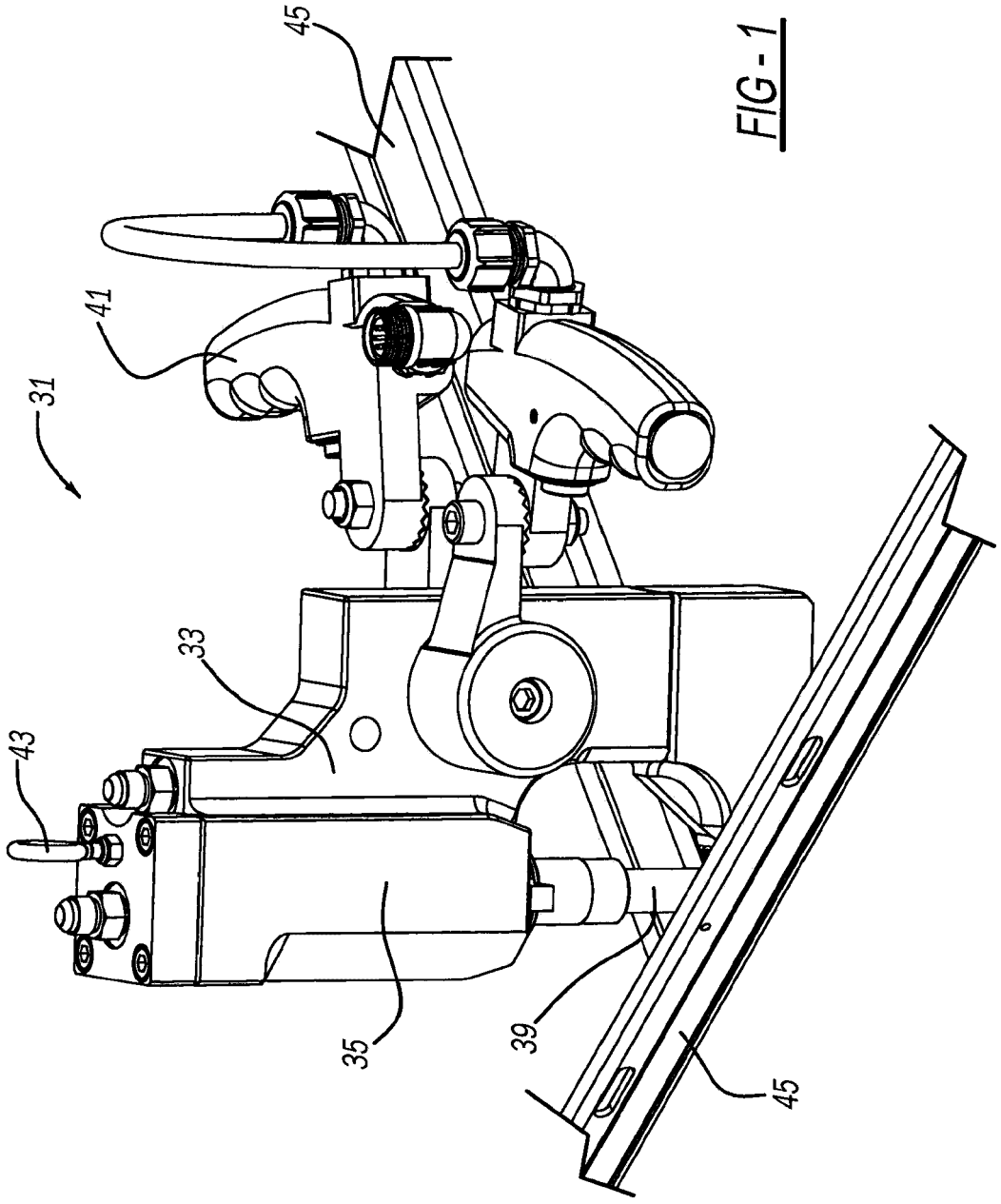


FIG - 1

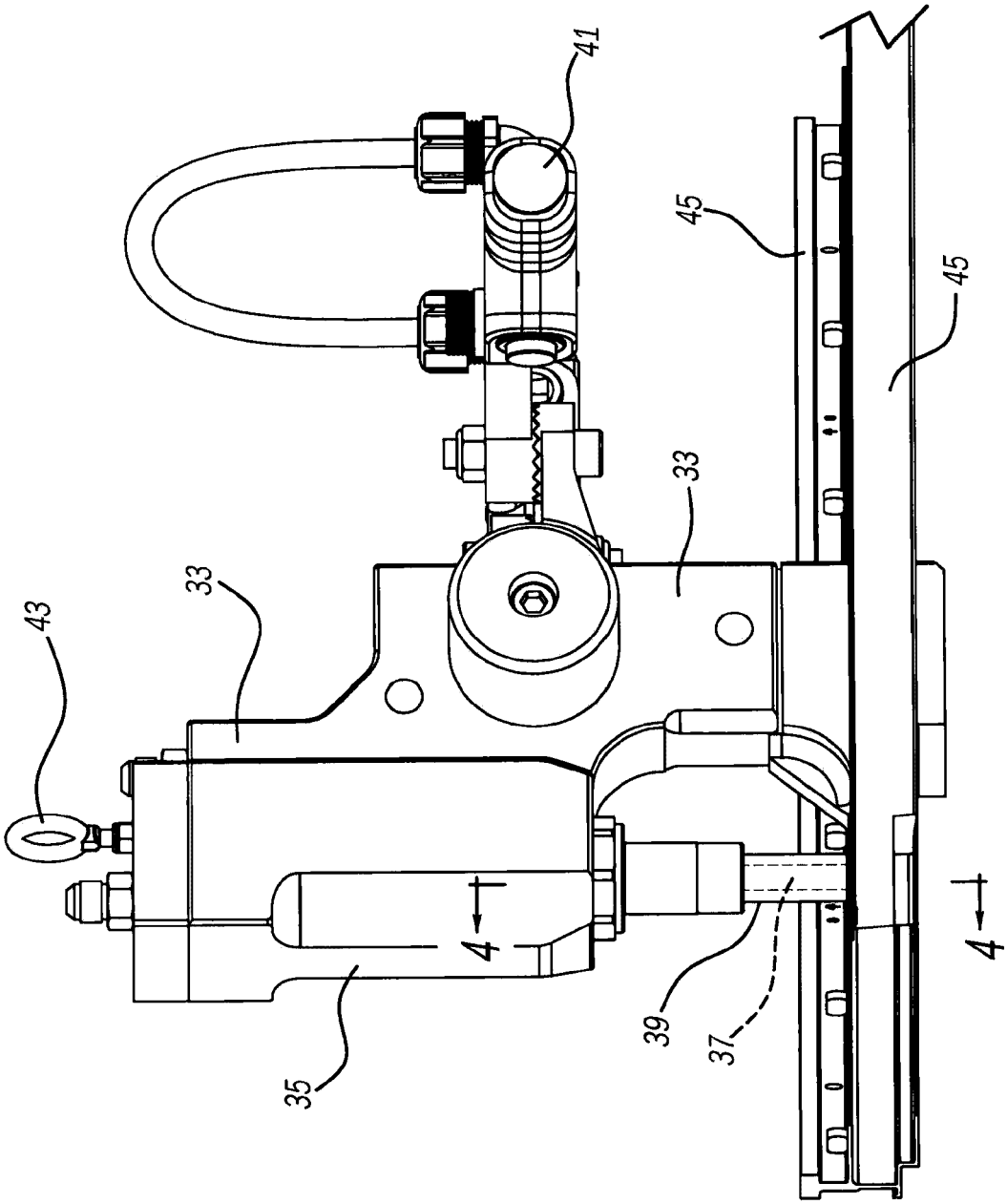


FIG-2

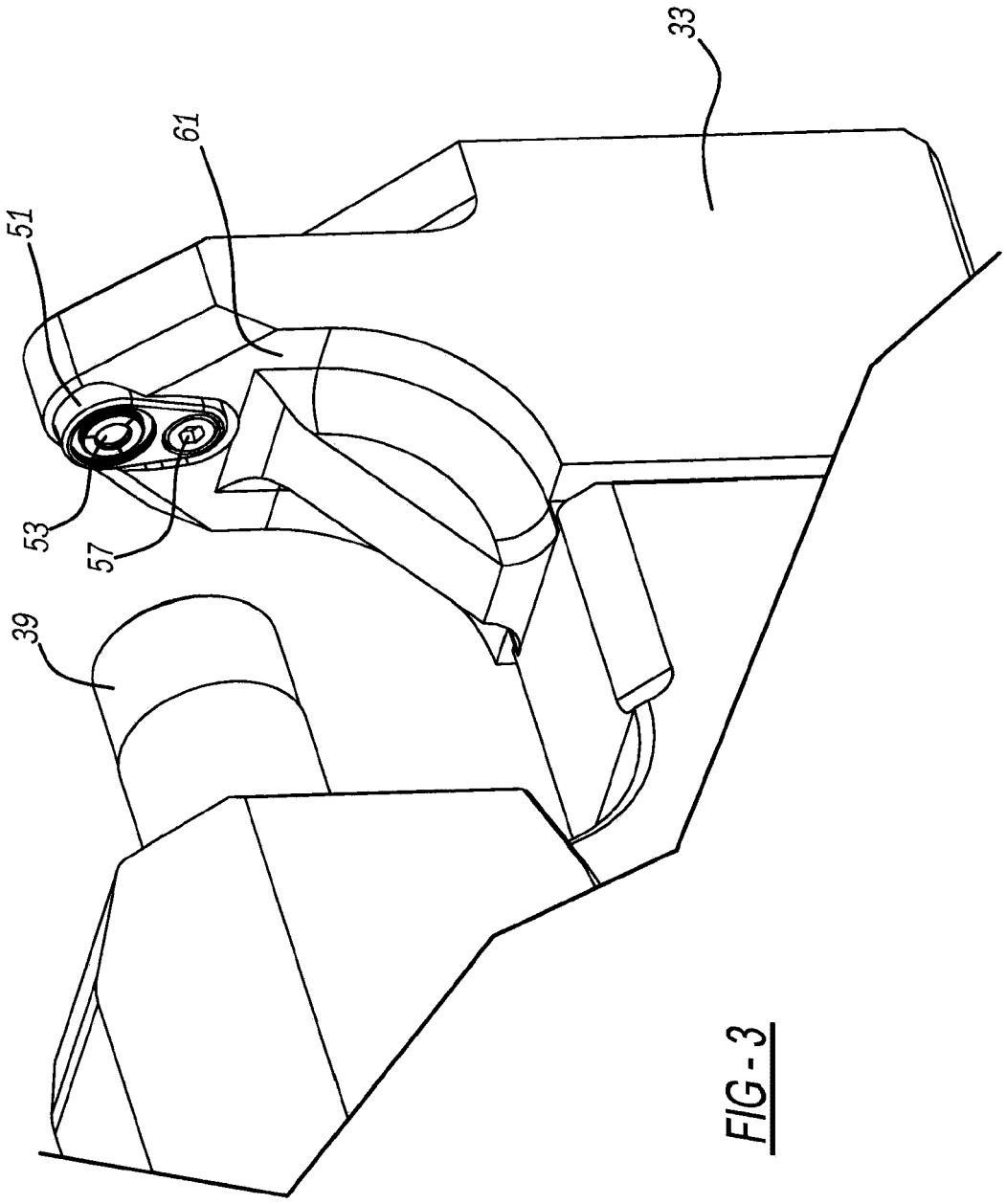
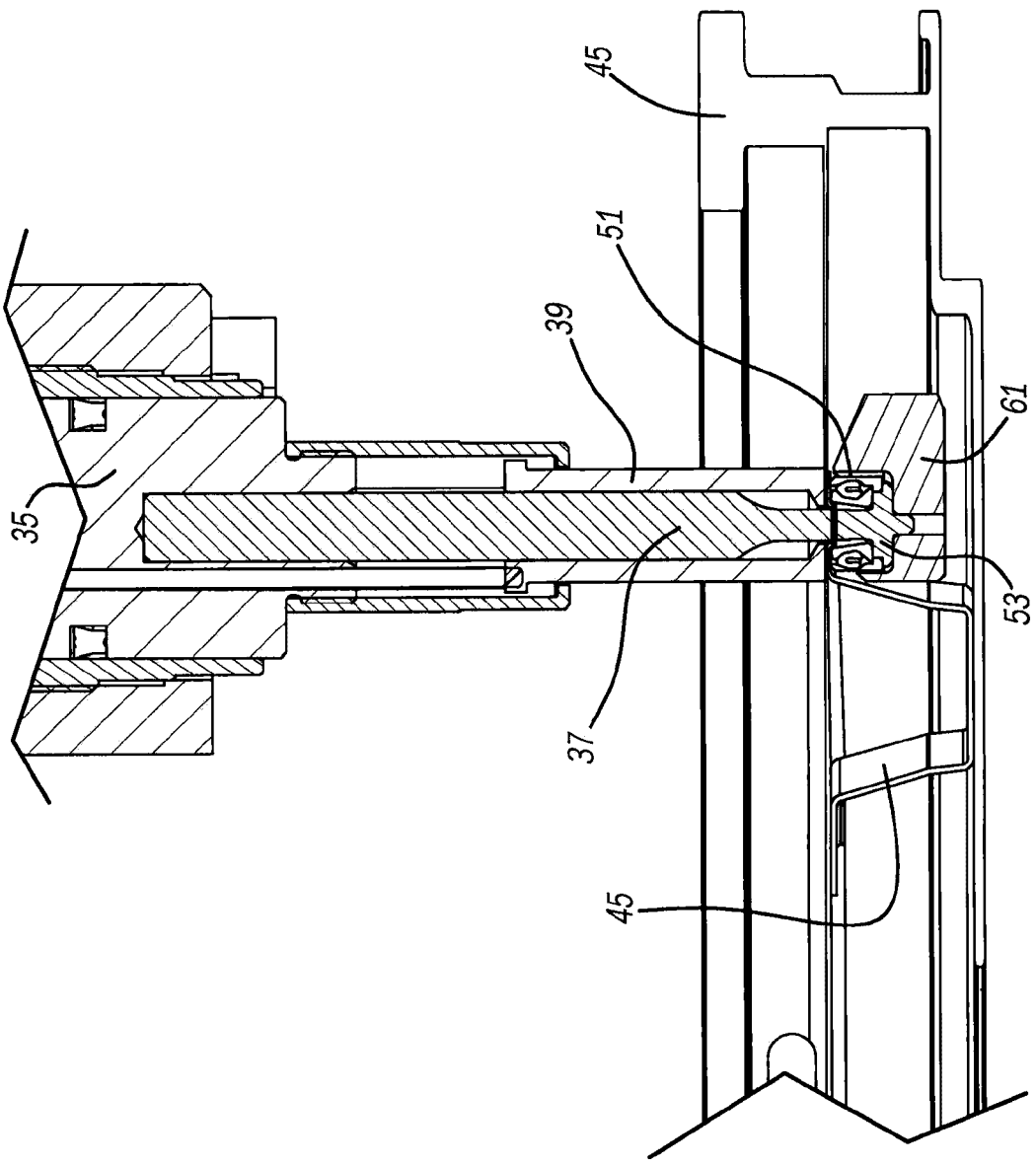


FIG - 3

FIG - 4



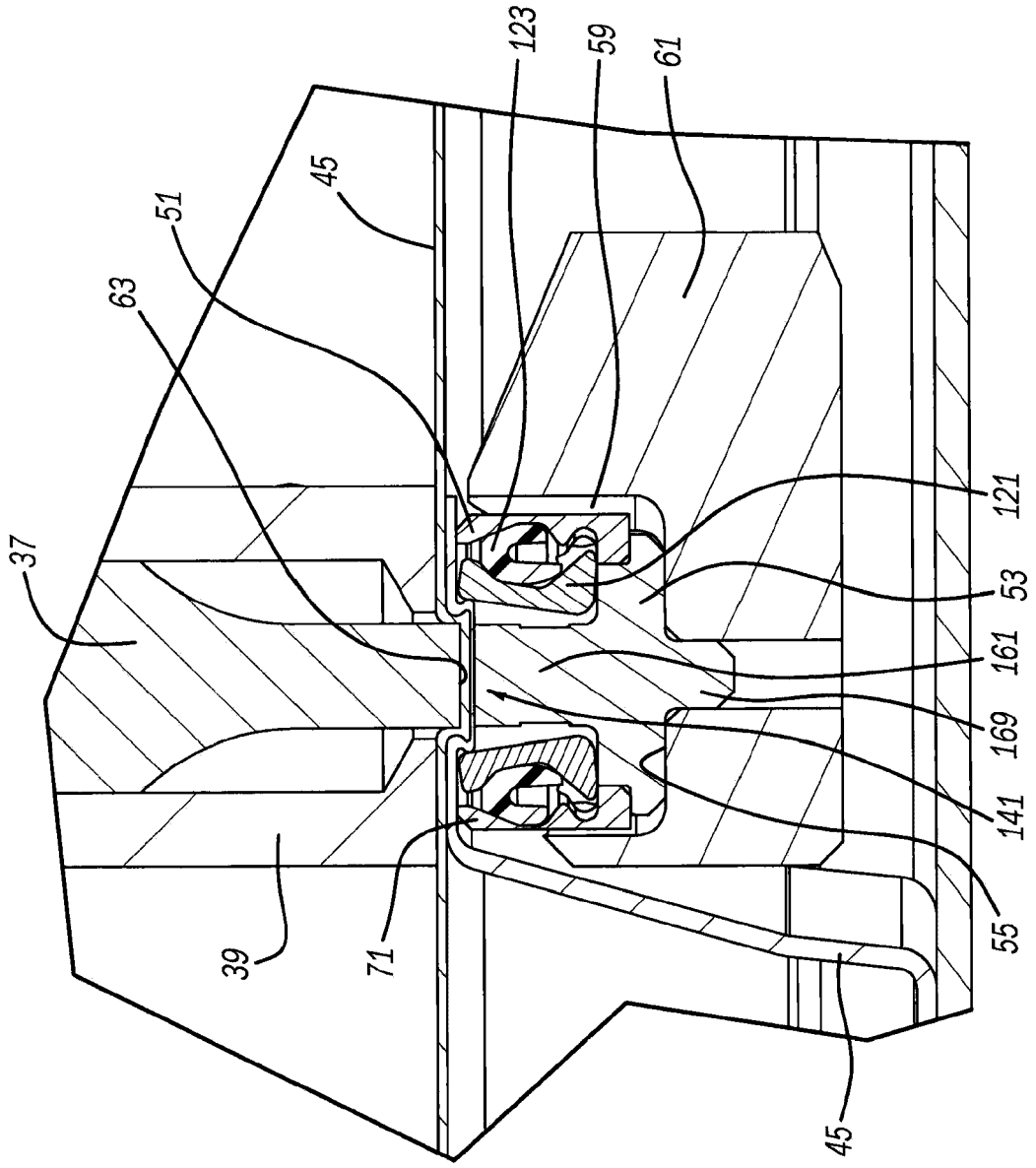


FIG - 5

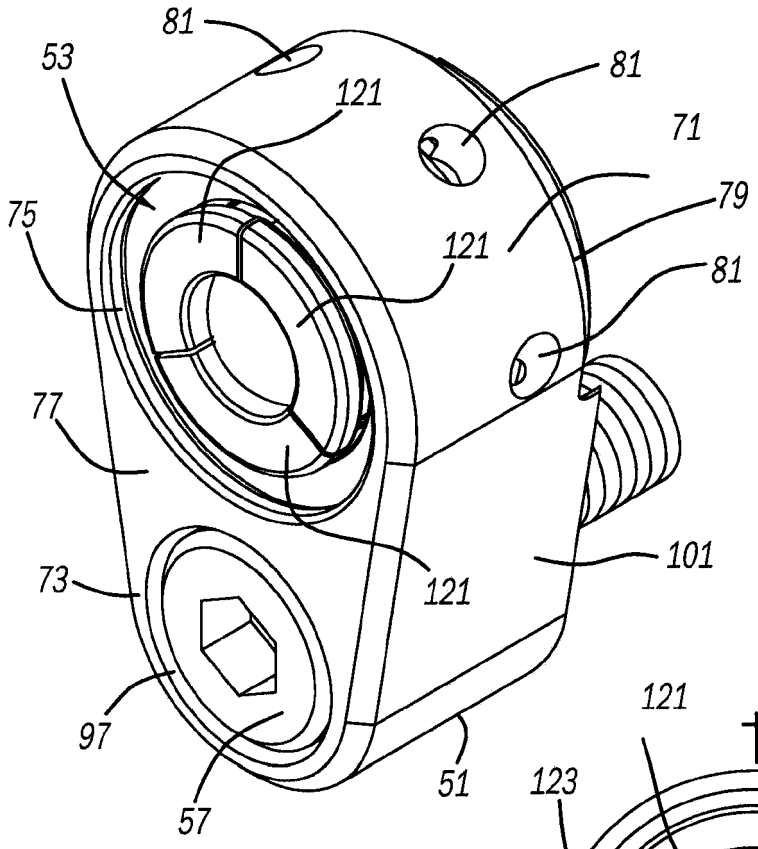

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FIG - 6

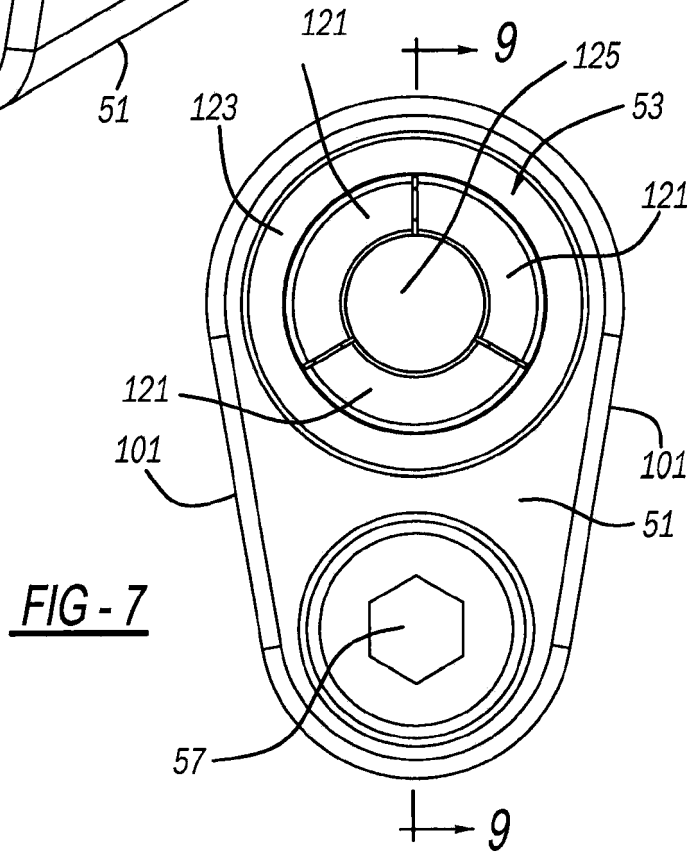
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FIG - 7

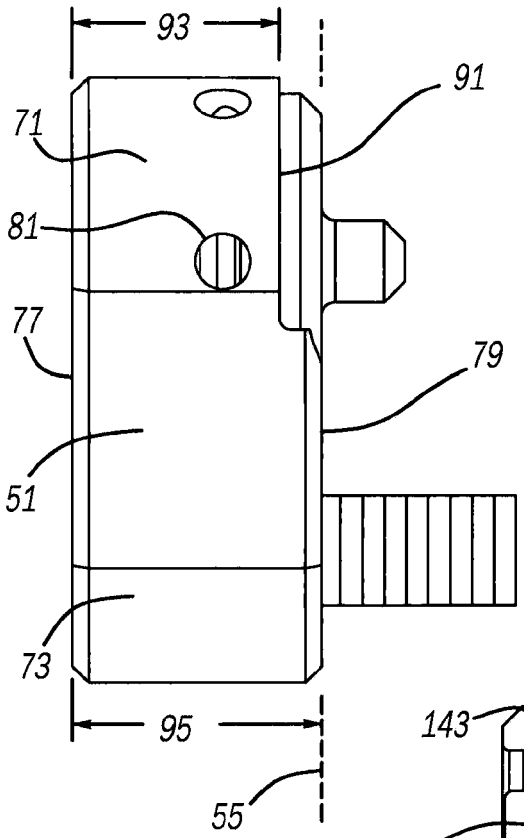
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FIG - 8

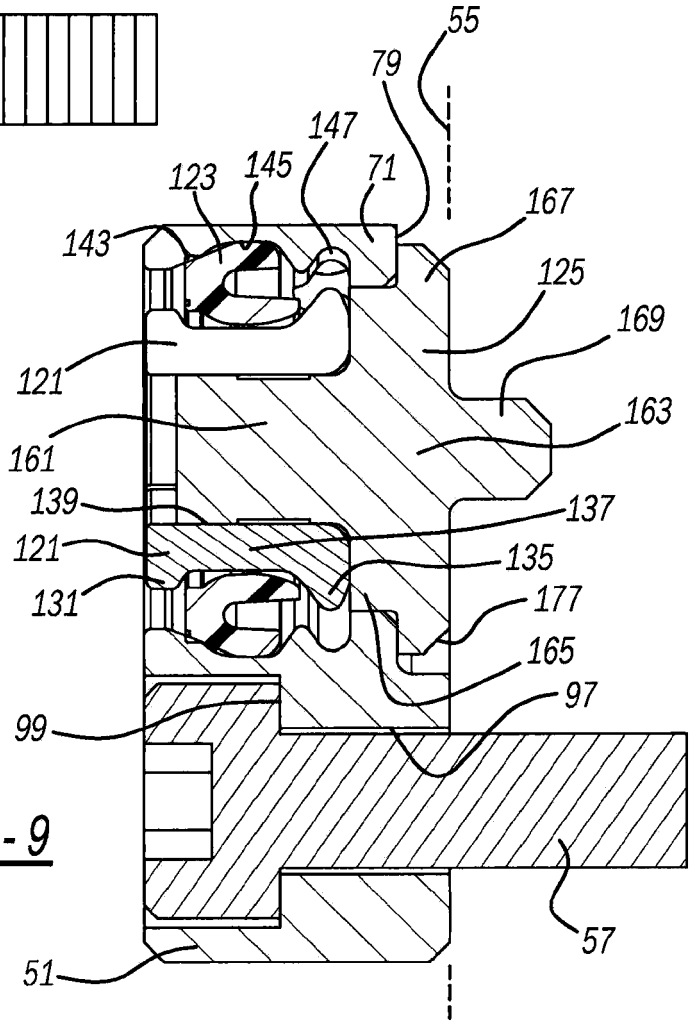
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FIG - 9

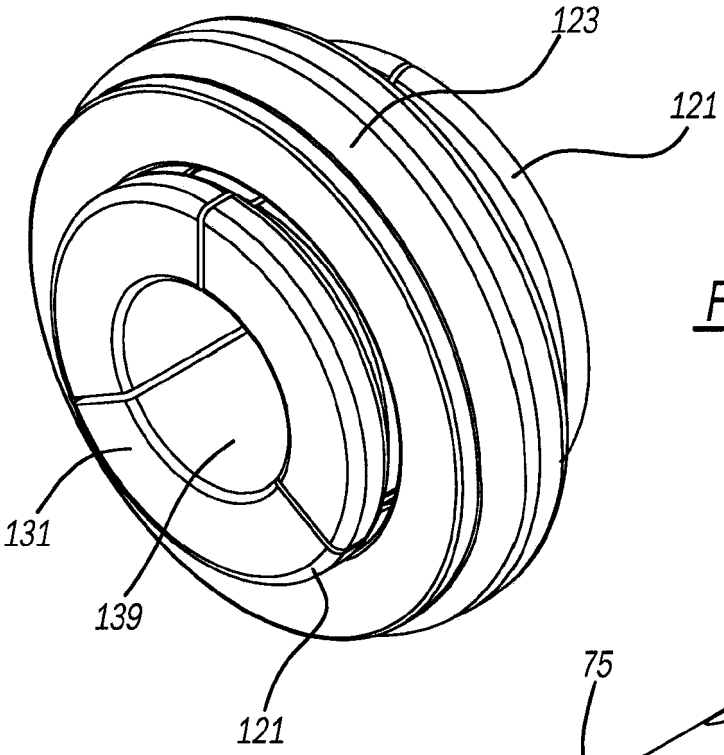

FIG - 10

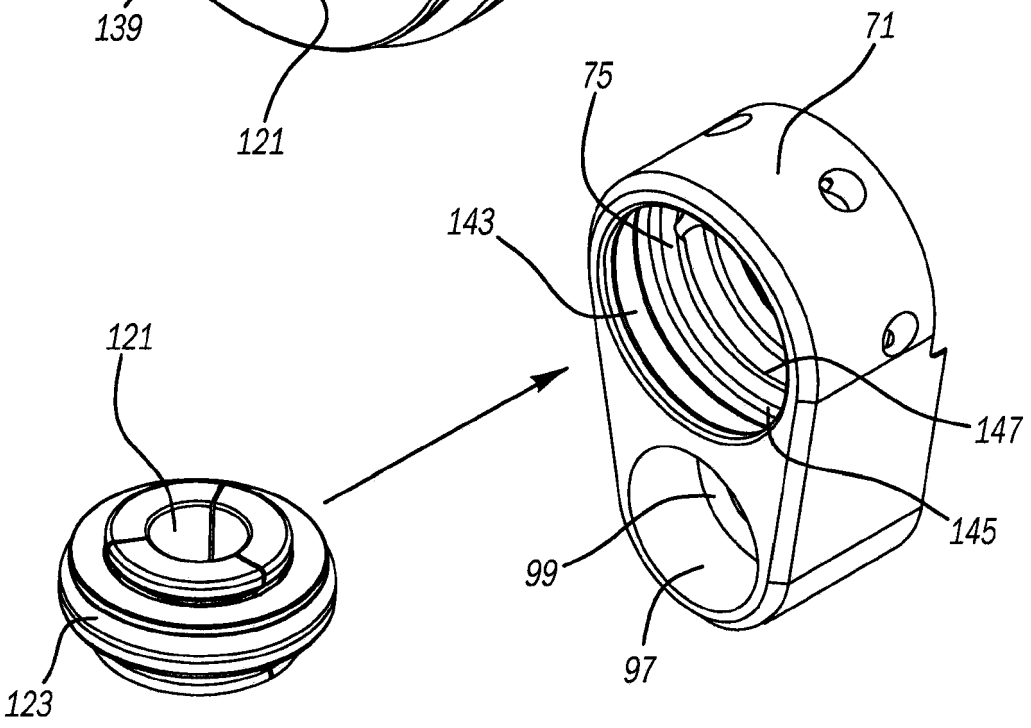

FIG - 11

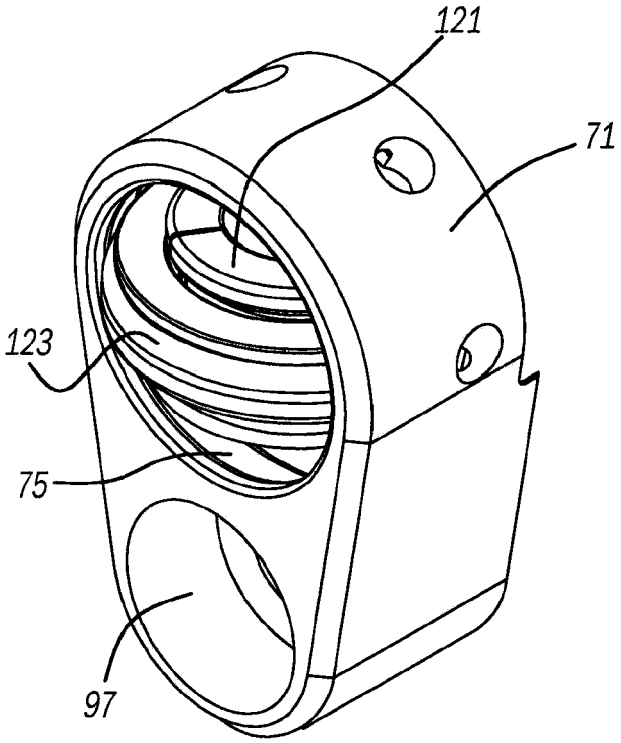

FIG - 12

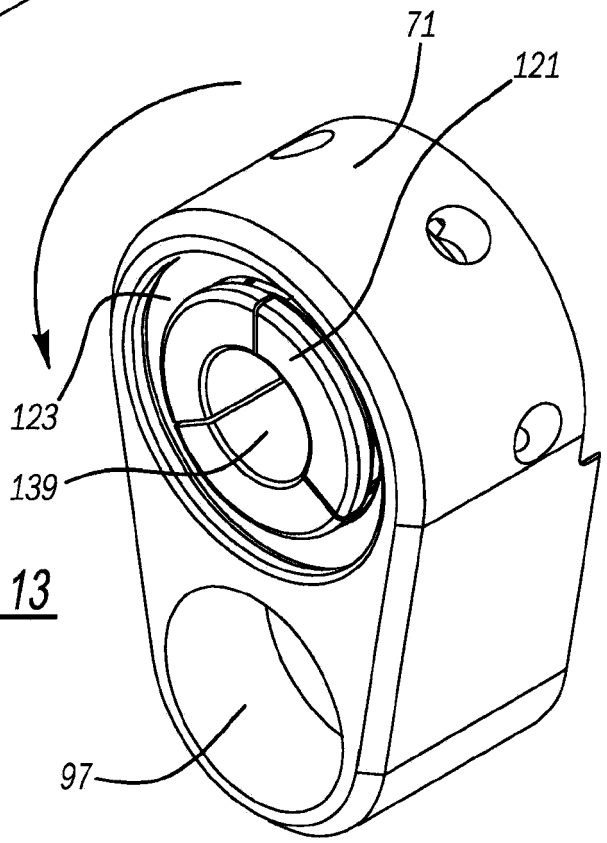

FIG - 13

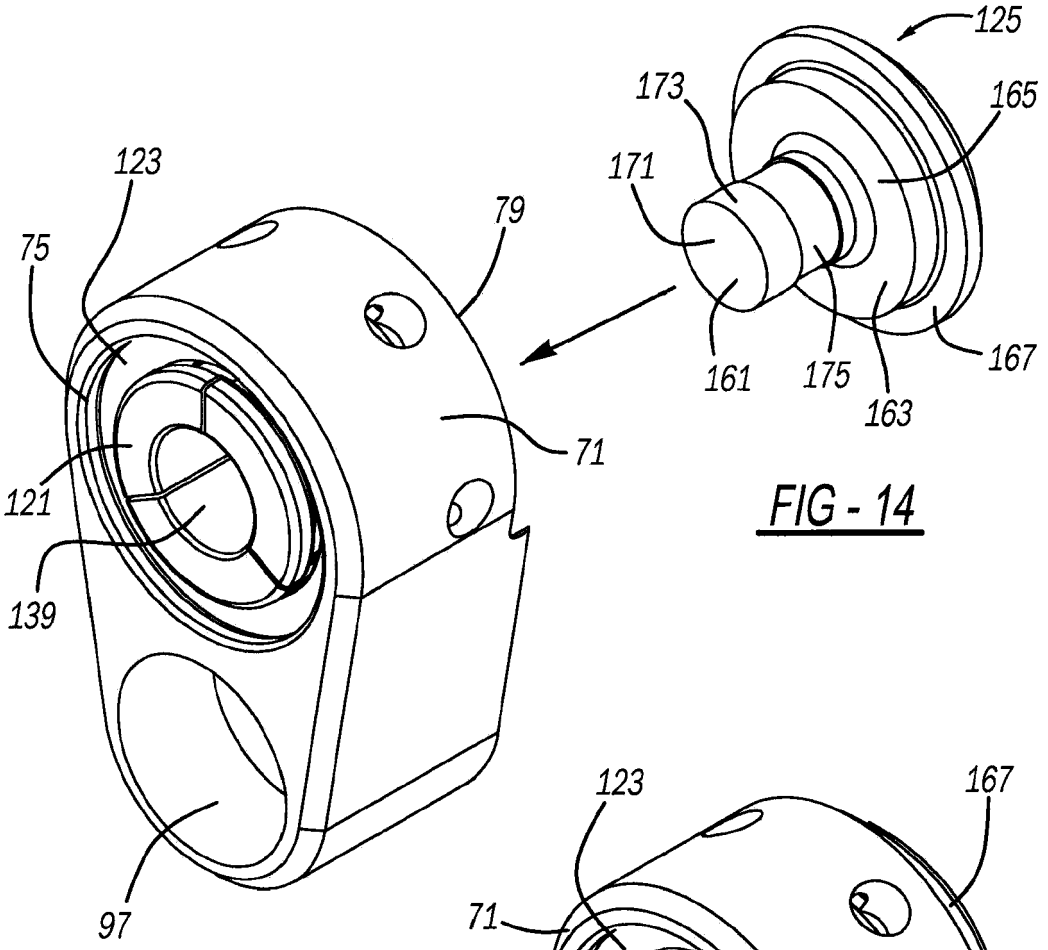
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FIG - 14

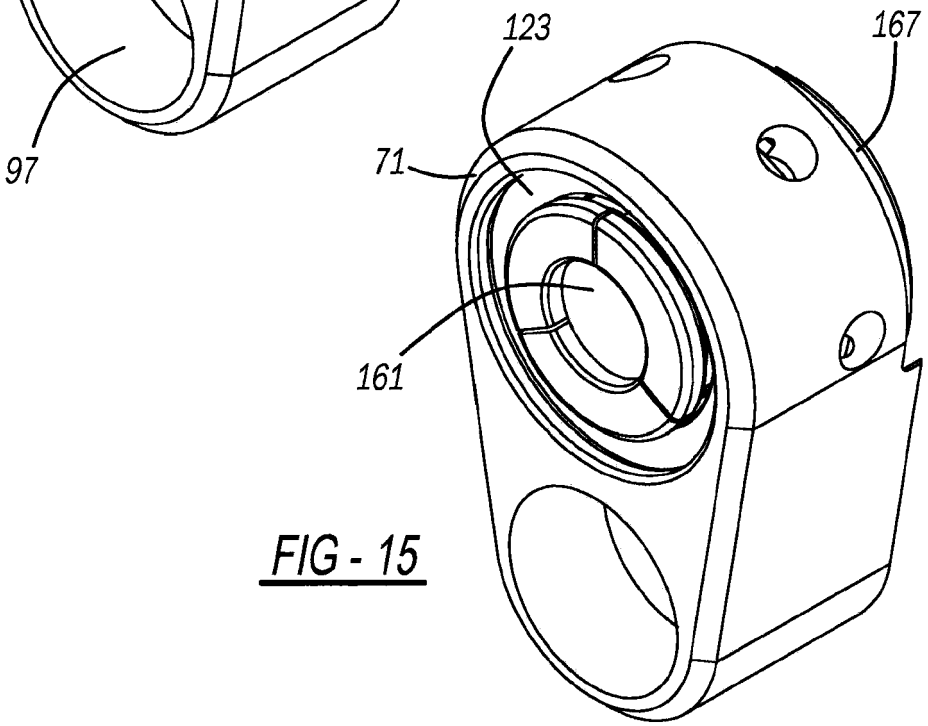
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FIG - 15

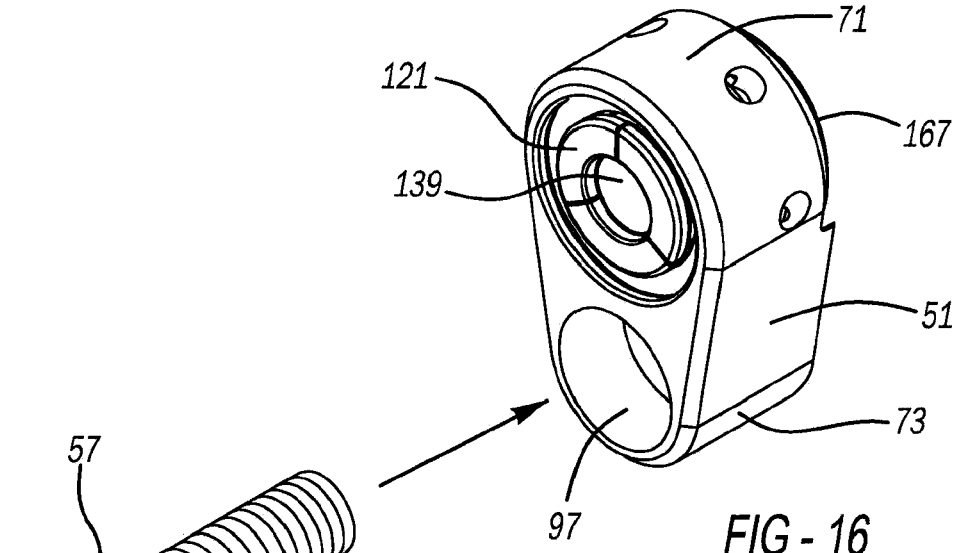

FIG - 16

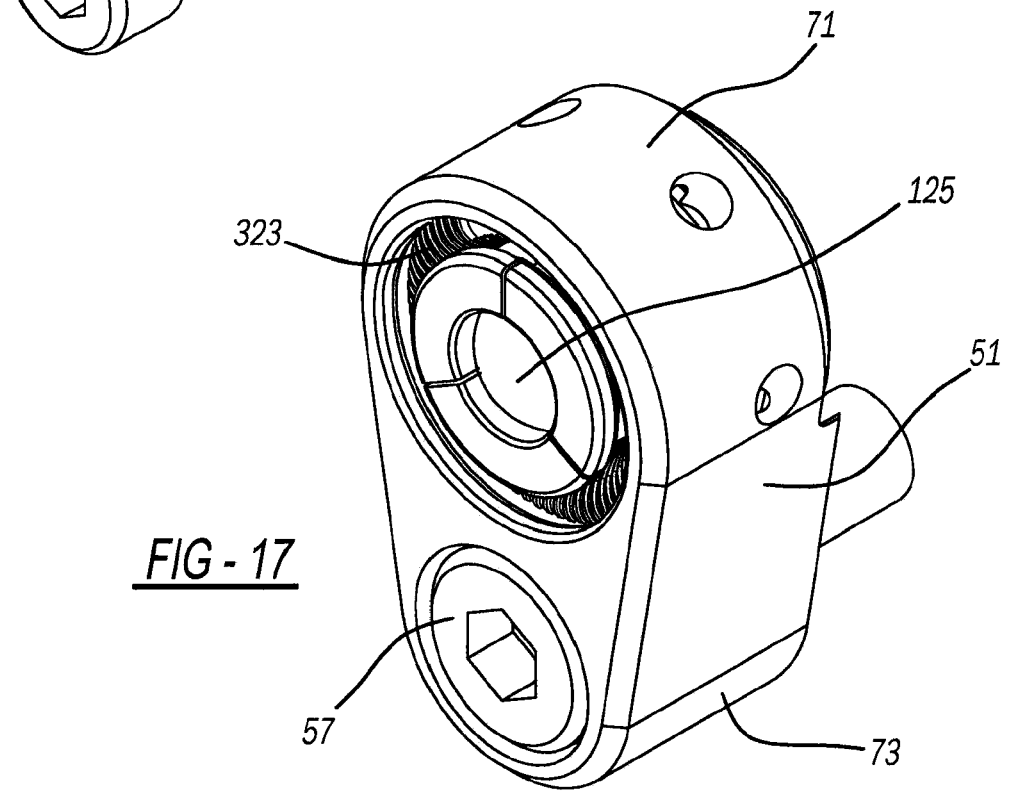

FIG - 17

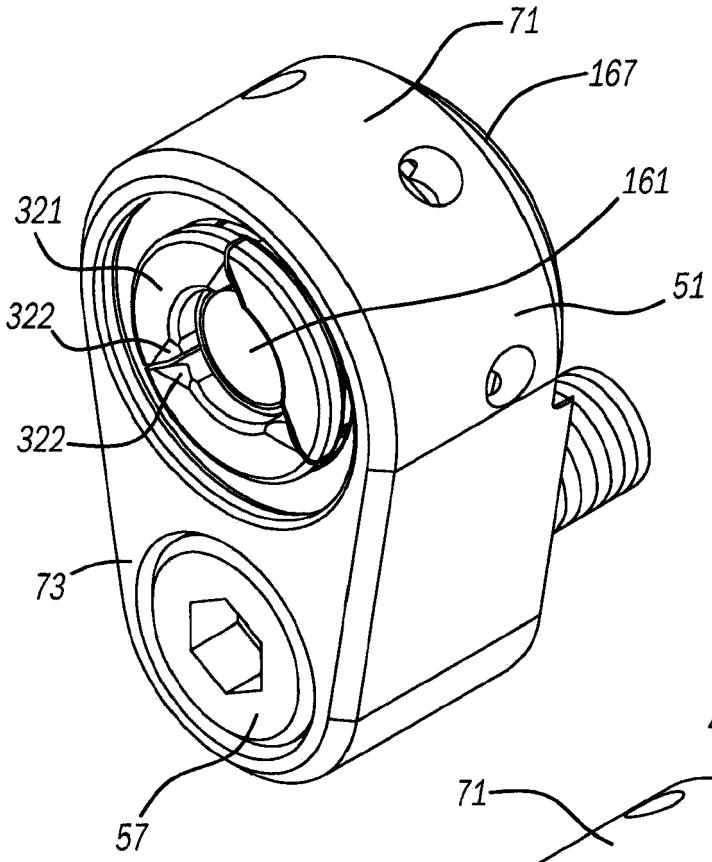
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FIG - 18

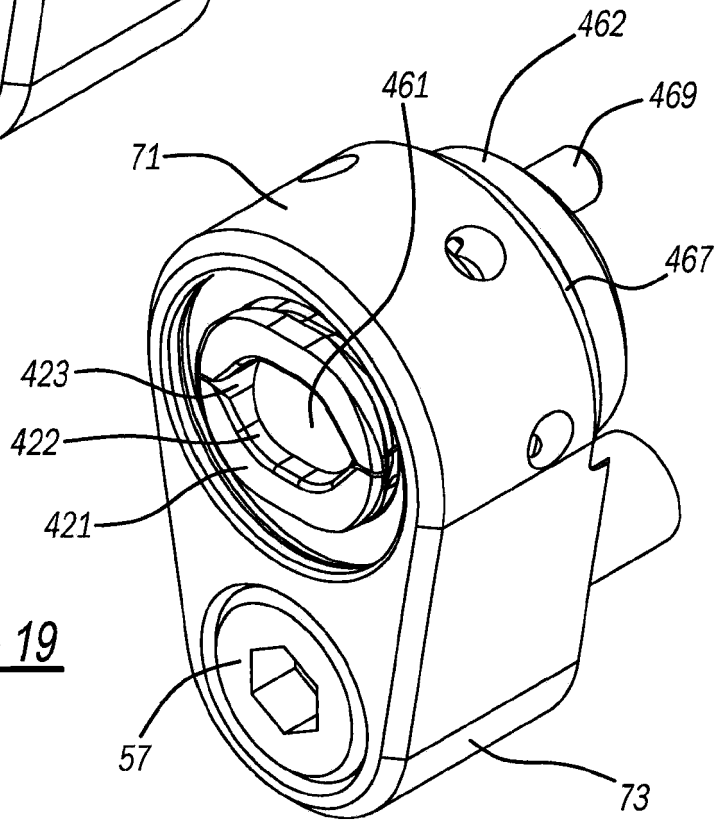
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FIG - 19

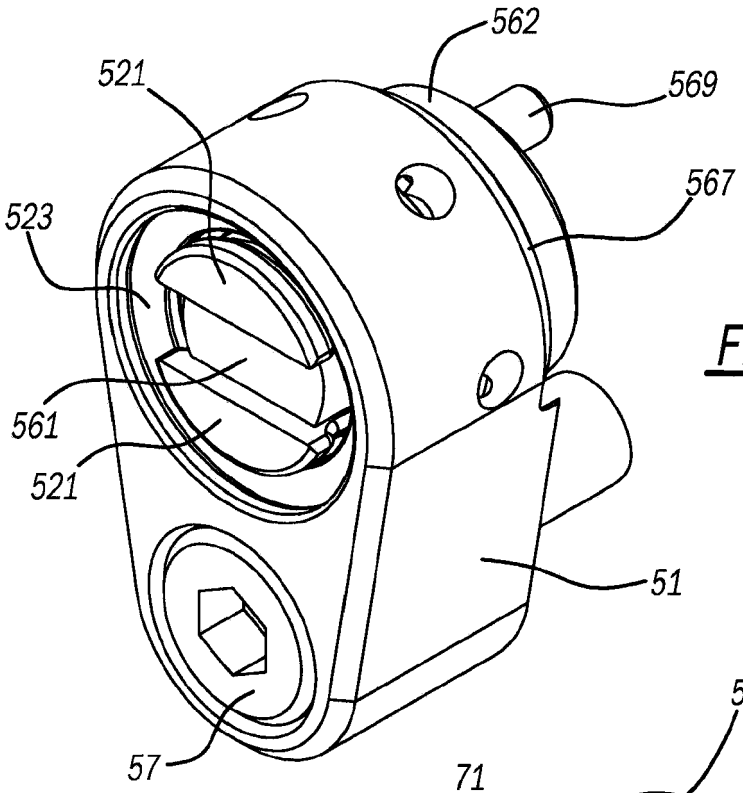

FIG - 20

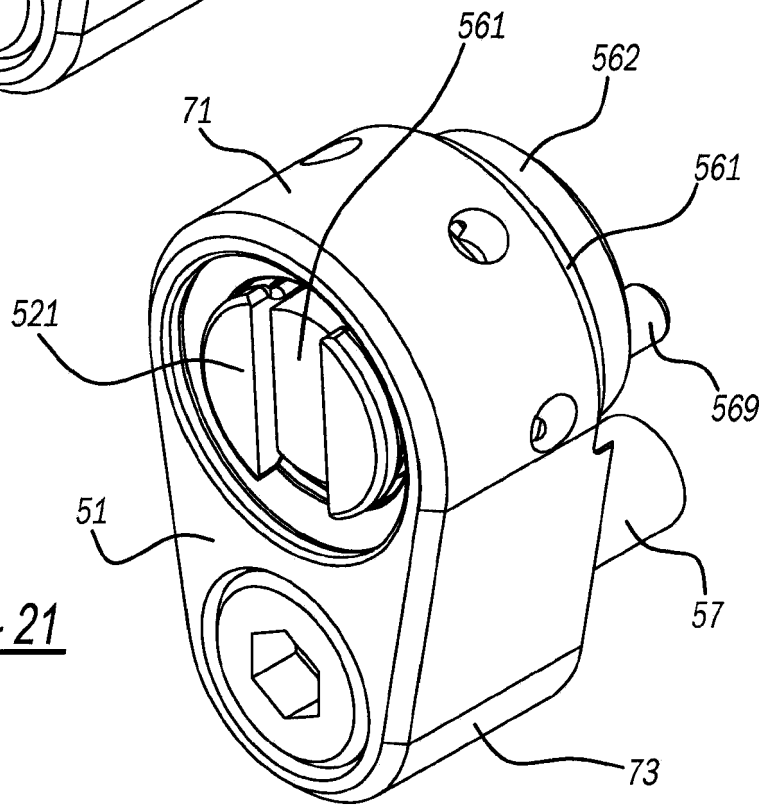

FIG - 21

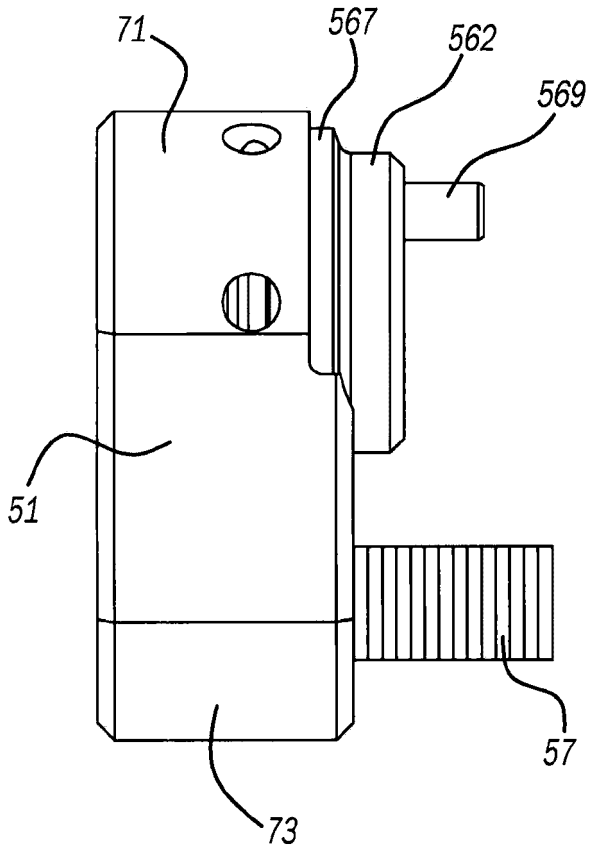

FIG - 22

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EUROPEAN SEARCH REPORT

Application Number
EP 19 18 7992

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	US 5 479 687 A (SAWDON EDWIN G [US]) 2 January 1996 (1996-01-02) * claims 1, 5, 6, 8 * * figures 12-14 * * column 3, lines 34-52 * * column 4, lines 51-60 *	1,3-15	INV. B21D39/03
A	US 2006/196034 A1 (SAWDON EDWIN G [US] ET AL) 7 September 2006 (2006-09-07) * claims 1, 23 * * figures 1-4, 8 * * paragraphs [0019] - [0020] *	1,3-15	
A	US 5 727 302 A (SAWDON EDWIN G [US]) 17 March 1998 (1998-03-17) * claims 1, 11 * * figure 4 *	1,3-15	
A	US 8 650 730 B2 (SAWDON EDWIN G [US]; BTM CORP [US]) 18 February 2014 (2014-02-18) * claim 1 * * figures 4, 6, 12 *	1,3-15	

TECHNICAL FIELDS SEARCHED (IPC)

B21D
B23P
B23Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 January 2020	Stanic, Franjo

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23-01-2020

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- US 5860315 A **[0002]**
- US 5479687 A **[0003]**