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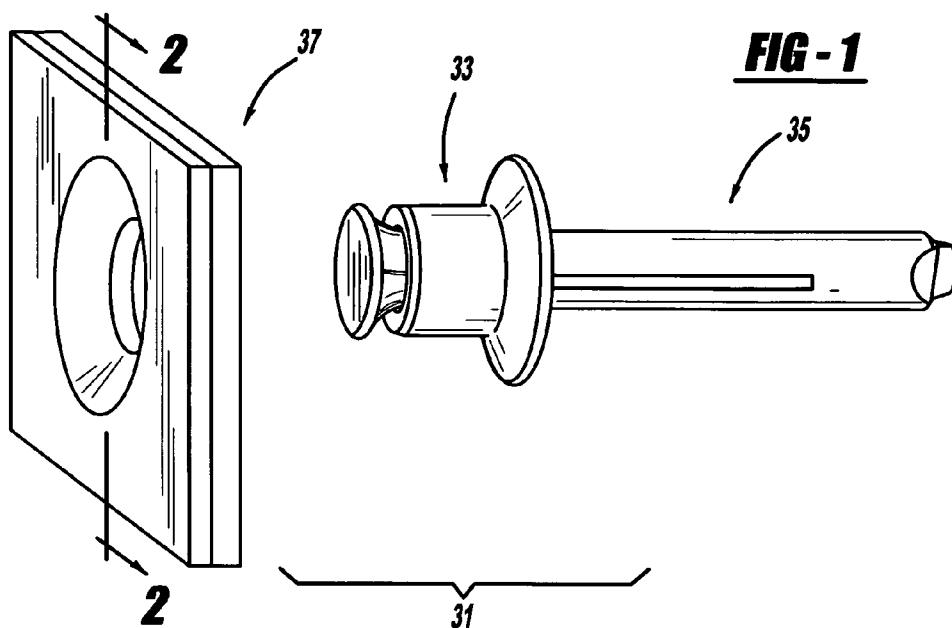
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(54) Title: BLIND RIVET



(57) Abstract: A blind rivet assembly is provided. In another aspect of the present invention, a blind rivet has ends that are received within countersinks in one or more workpieces and a mandrel head is completely pulled through the rivet without being severed from a mandrel stem. A further aspect of the present invention includes a mandrel with one or more ribs located on an outwardly tapering shoulder.

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BLIND RIVET

BACKGROUND

[0001] The present invention generally relates to rivets and more particularly to a blind rivet assembly.

[0002] It is known to set blind rivets with a mandrel. For example, reference should be made to U.S. Patent No. 5,689,873 entitled "Tacking Fastener" which issued to Luhm on November 25, 1997, Great Britain Patent No. 286,471 entitled "Improvements in and Relating to Rivets and Riveting," and Great Britain Patent No. 2 150 661 entitled "Pull-Type Blind-Riveting Assemblies." These rivets, however, outwardly extend past outside surfaces of workpieces after rivet setting. This disadvantageously takes up too much space, and is prone to interference or damage during assembly. More recently, flush blind rivets, using breakable mandrels, have been employed. While these constructions have significantly improved the industry, further improvements are desirable.

SUMMARY

[0003] In accordance with the present invention, a blind rivet assembly is provided. In another aspect of the present invention, a blind rivet has ends that are received within countersinks in one or more workpieces and a mandrel head is completely pulled through the rivet without being severed from a mandrel stem. A further aspect of the present invention includes a mandrel with one or more ribs located on an outwardly tapering shoulder. Methods of making and setting rivets are also provided.

[0004] The present invention blind rivet is advantageous over conventional blind rivets since the ends of the present invention blind rivet are flush or below flush from the outside workpiece surfaces. This achieves a smaller packaging space for improved inner packing density of fastened components with less opportunity for snagging otherwise protruding rivet heads and flanges. Furthermore, the present invention blind rivet does not employ a broken mandrel head. Therefore, assembly is less expensive and has a higher

quality since the broken heads do not have to be located after setting, and the broken heads are not loose which can cause rattling and shorting of electrical circuits. Reducing setting loads are required for the pull-through mandrel versus a breakable head mandrel, thus improving the longevity of setting tools, 5 extending times between routine maintenance and contributing to improved productivity. Moreover, the blind rivet of the present invention advantageously is set from only one side of the workpieces. The dimensional relationships and shapes of the blind rivet and mandrel are advantageous by maximizing fastening performance on a consistent basis, for example by allowing appropriate axial 10 compression lengths and lateral expansion size hole filling of the set blind rivet in countersunk workpieces. Additional advantages and features of the present invention will become apparent from the following description and appended claims, taken in conjunction with the accompanying drawings.

15 **BRIEF DESCRIPTION OF THE DRAWINGS**

[0005] Figure 1 is a partially exploded perspective view showing the preferred embodiment of a blind rivet assembly of the present invention, prior to rivet setting;

20 **[0006]** Figure 2 is a cross-sectional view, taken along line 2-2 of Figure 1, showing workpieces employed in the preferred embodiment blind rivet assembly, prior to rivet setting.

[0007] Figure 3 is a side elevational view showing a blind rivet and mandrel employed in the preferred embodiment blind rivet assembly, prior to rivet setting;

25 **[0008]** Figure 4 is a cross-sectional view, taken along line 2-2 of Figure 1, showing the blind rivet employed in the preferred embodiment blind rivet assembly, prior to rivet setting;

[0009] Figure 5 is a side elevational view showing the mandrel employed in the preferred embodiment blind rivet assembly, prior to rivet setting;

30 **[0010]** Figure 6 is a cross-sectional view, taken along line 6-6 of Figure 5, showing the mandrel employed in the preferred embodiment blind rivet assembly, prior to rivet setting;

[0011] Figure 7 is a cross-sectional view, taken along line 7-7 of Figure 5, showing the mandrel employed in the preferred embodiment blind rivet assembly, prior to rivet setting;

5 [0012] Figure 8 is a fragmentary perspective view showing the mandrel employed in the preferred embodiment blind rivet assembly, prior to rivet setting;

[0013] Figure 9 is a fragmentary side elevational view showing the mandrel employed in the preferred embodiment blind rivet assembly, prior to rivet setting;

10 [0014] Figure 10 is a fragmentary side elevational view showing the mandrel employed in a first alternate embodiment blind rivet assembly, prior to rivet setting;

[0015] Figure 11 is a fragmentary side elevational view showing the mandrel employed in a second alternate embodiment blind rivet assembly, prior to rivet setting;

15 [0016] Figure 12 is a fragmentary side elevational view showing the mandrel employed in a third alternate embodiment blind rivet assembly, prior to rivet setting;

20 [0017] Figure 13 is a fragmentary side elevational view showing the mandrel employed in a fourth alternate embodiment blind rivet assembly, prior to rivet setting;

[0018] Figure 14 is a fragmentary side elevational view showing the mandrel employed in a fifth alternate embodiment blind rivet assembly, prior to rivet setting;

25 [0019] Figure 15 is a fragmentary side elevational view showing the mandrel employed in a sixth alternate embodiment blind rivet assembly, prior to rivet setting;

[0020] Figure 16 is a fragmentary side elevational view showing the mandrel employed in a seventh alternate embodiment blind rivet assembly, prior to rivet setting;

30 [0021] Figure 17 is a fragmentary side elevational view showing the mandrel employed in an eighth alternate embodiment blind rivet assembly, prior to rivet setting;

[0022] Figure 18 is a fragmentary side elevational view showing the mandrel employed in a ninth alternate embodiment blind rivet assembly, prior to rivet setting;

5 **[0023]** Figure 19 is a perspective view showing the preferred embodiment blind rivet assembly protruding through the workpieces, prior to rivet setting;

[0024] Figure 20 is a partially cross-sectional view, taken along line 2-2 of Figure 1, showing the preferred embodiment blind rivet assembly, including a setting tool, prior to rivet setting;

10 **[0025]** Figure 21 is a partially cross-sectional view, taken along line 2-2 of Figure 1, showing the preferred embodiment blind rivet assembly, prior to rivet setting;

[0026] Figure 22 is a partially fragmented, side elevational view showing the preferred embodiment blind rivet assembly, prior to rivet setting;

15 **[0027]** Figure 23 is a perspective view showing the first alternate embodiment blind rivet assembly, after rivet setting;

[0028] Figure 24 is a blind end elevational view showing the preferred embodiment blind rivet assembly slightly exaggerated, after rivet setting;

20 **[0029]** Figure 25 is a perspective view showing the mandrel employed in the preferred embodiment blind rivet assembly, after rivet setting;

[0030] Figure 26 is a cross-sectional view, taken along line 2-2 of Figure 1, showing the preferred embodiment blind rivet assembly, including the setting tool, after rivet setting;

25 **[0031]** Figure 27 is a partially cross-sectional view, taken along line 2-2 of Figure 1, showing the preferred embodiment blind rivet assembly, after rivet setting;

[0032] Figure 28 is a partially fragmented, side elevational view showing the preferred embodiment blind rivet assembly, after rivet setting;

30 **[0033]** Figure 29 is a side elevational view showing a tenth alternate embodiment blind rivet assembly, prior to rivet setting;

[0034] Figure 30 is a cross-sectional view, taken along line 30-30 of Figure 29, showing the tenth alternate embodiment rivet assembly, prior to rivet setting;

[0035] Figure 31 is a partially fragmented, side elevational view 5 showing the tenth alternate embodiment blind rivet assembly, after rivet setting; and

[0036] Figure 32 is a cross-sectional view, taken along line 30-30 of Figure 29, showing an eleventh alternate embodiment rivet assembly, prior to rivet setting.

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DETAILED DESCRIPTION

[0037] The preferred embodiment of a blind rivet assembly 31 of the present invention is shown in Figures 1-3. Blind rivet assembly 31 includes a blind rivet 33, a mandrel 35 and workpieces 37. Workpieces 37 are preferably 15 component panels, boxes, cabinets or housings of electronic computer, electronic server or other such devices. Workpieces 37 include a tool-side outer surface 39 and an opposite blind-side outer surface 41 within which are countersunk depressions 43 joined by circular-cylindrical holes 45 located at the workpiece interface. Each countersink 43 has a generally frusto-conical shape 20 with a total angle α equal to or between 120° and 90°, and more preferably between 110° and 90° total.

[0038] Figures 3 and 4 best illustrate blind rivet 33. Blind rivet 33 includes a body 51 and a tool-side flange 53. A frusto-conical outside surface 55 tapers along an outside of flange 53 and an outside surface 57 of body 51 has a 25 circular-cylindrical shape. A through-bore 59 extends between a tool end face 61 and a blind or tail end 63 of blind rivet 33. Through-bore 59 has a generally constant inside diameter between ends 61 and 63 prior to rivet setting. Outside diameter β of flange 53 has a preferred dimension equal to or between 5.0 and 5.4 mm while an outside diameter Φ of rivet body 51 has a dimension equal to or 30 between 3.08 mm and 2.9 mm.

[0039] Referring to Figures 5-9, the preferred embodiment of mandrel 35 includes an axially elongated stem 81 and a laterally enlarged head 83. Stem

81 is predominantly circular-cylindrical but locally interrupted by various depressions 85 and adjacent protrusions 87 which assist in securing the rivet onto the mandrel during shipping and tool feeding. A chamfered end 89 and extension 91 are located at an end of stem 81 opposite head 83 so as to assist
5 in alignment with a setting tool.

[0040] Head 83 includes a generally flat blind or tail end 101, and a shoulder 103. Shoulder 103 of the presently preferred embodiment is defined by a pair of differently angled and straight tapering surfaces 105 and 107. Tapering surfaces 105 and 107 are coaxial with each other and with stem 81. Four ribs
10 111 are located on shoulder 103 and are equi-distantly spaced around shoulder 103. Ribs 111 are elongated in a predominantly axially aligned direction but are offset angled essentially like shoulder 103. An outside diameter Ω of mandrel head 83 is preferably equal to or between 3.5 mm and 2.9 mm, and a nominal angle of the total mandrel shoulder Ψ is preferably equal to or between 110° and
15 90° prior to rivet setting. Furthermore, an axial thickness of mandrel head 83, at a lip and not including the shoulder, is preferably equal to or between 1.0 mm and 0.35 mm before rivet setting. It is preferred that outside diameter Ω of mandrel head 83 is greater than outside diameter Φ of rivet body 51 to achieve proper hole filling and axial setting compression. Blind rivet 33 and mandrel 33
20 are also preferably made from grade SAE1006 steel.

[0041] Figure 10 illustrates an alternate embodiment mandrel 35a like the preferred embodiment, however, shoulder 103a includes straight tapering, frusto-conical surfaces 105a and 107a, but without ribs. Another alternate embodiment mandrel 35b is shown in Figure 11. Mandrel 35b has a shoulder
25 103b including straight tapered, frusto-conical surfaces 105b and 107b like that of Figure 9, and ribs 111b also like that of Figure 9. Nevertheless, there is an inward spacing or step 121 between an outermost portion of shoulder 103b and a lip 123 of head 83b thereby causing an overhang.

[0042] Still another alternate embodiment mandrel 35c is illustrated in
30 Figure 12. Shoulder 103c has a single angled frusto-conical taper in addition to the stepped spacing 121c of lip 123c. No ribs are employed with this exemplary embodiment. Referring now to Figure 13, an alternate embodiment mandrel 35d

provides an arcuately curved taper at shoulder 103d, ribs 111d and inwardly stepped lip 123d. Alternate embodiment Figure 14 has an arcuately tapered shoulder 103e, no ribs and the inward shoulder spacing relative to lip 123e.

Figure 15 employs an arcuately tapered shoulder 103f in combination with ribs

5 111f but no inward spacing of shoulder 103f relative to lip 123f. As can be seen in Figure 16, another alternate embodiment mandrel 35g includes an arcuately tapered shoulder 103g but without ribs and without the inward shoulder-to-lip 123g spacing.

[0043] Referring now to Figure 17, an alternate embodiment mandrel

10 35h includes a concave curved surface 131 depressed below the nominal tail end 101h. This encourages lateral compression and folding of head 83h during rivet setting. Figure 18 alternately shows mandrel 35i with a convex surface 133 outwardly curving from tail end 101i to change the folded characteristics of head 83i during rivet setting.

[0044] Reference should now be made to Figures 19-22, where the

15 rivet setting procedures and construction will be discussed. A rivet setting tool 201 includes a piston rod 203, a jaw pusher 205, a compression spring 207 outwardly biasing the pusher 205, a set of jaws 209, a jaw case 211, an outer barrel 213 and a nose piece 215. Mandrel 35 and rivet 33 are pre-assembled

20 together with an interference fit due to bulge 87 (see Figure 5) prior to insertion in setting tool 201. Thereafter, stem 81 of mandrel 35 is inserted into nose piece 215 and temporarily retained by jaws 209.

[0045] Next, rivet tool is located adjacent workpieces 37 such that the

25 blind end of the blind rivet and mandrel are inserted through the corresponding hole in workpieces 37 such that tool-side flange 53 completely fits within the adjacent countersink 43 and the tool end of blind rivet 33 is predominantly flush or below flush outside surface 39 of the tool-side workpiece. It is noteworthy that there is a slight gap between the outside surface of the rivet body and the inside diameter of the workpiece hole before rivet setting.

[0046] Comparing the pre-rivet setting condition of Figure 20 to the

30 post-rivet setting condition of Figure 26, the stem of the mandrel is gripped between the jaws of setting tool 201 and the rivet flange is abutted by the nose

piece. As the tool is activated, the piston rod is caused to retract by a piston actuator which inwardly urges the jaws due to the action of the jaw case. Approximately 1,500 newtons of force are used by the setting tool to pull the mandrel through the rivet, which is approximately 500 newtons less than necessary for breakable head-type mandrels. As the mandrel head is pulled into the rivet body, the head collapses and is pulled completely through the blind rivet without severing the mandrel head. At this stage, the power supply to the piston ceases and the piston returns to its ready state which opens the jaws, whereafter the spent mandrel is vacuum extracted into a mandrel collector bottle at the rear of the setting tool and discarded. Subsequently, the tool is then ready for the next rivet setting operation.

[0047] Referring to Figures 24, 25, 27 and 28, the preferred embodiment blind rivet assembly is shown in the set and fully installed condition. Mandrel head 83 and more particularly outwardly tapering shoulder 103 (see Figures 8 and 21), outwardly expand blind end 63 of blind rivet 33 into the adjacent countersink 43 of the blind side workpiece 37. Further pulling through of mandrel head 83 causes rivet body to laterally expand and fill up hole 45 (see Figure 2) of workpieces 37 in an interference fit manner and at the same time the mandrel head folds, it remains intact as 83' and is extracted from the rivet. The frusto-conical shapes of the countersinks and rivet flange, the outwardly expanded cup-like shape of the blind end of the rivet body, and the preferred dimensional relationships specified herein, further cause a desirable axial compression and shortening of blind rivet 33 so as to cinch and tightly fasten together workpieces 37 at the riveted joint. Blind end 63 of blind rivet 33 is located flush or below flush (as shown) of the blind surface 41 of the corresponding workpiece 37 after rivet setting with an expanded, cup-like shape of through-bore 59 caused by the rivet setting.

[0048] Moreover, ribs 111 (see Figure 8) gouge and indent axially elongated grooves 221 into the expanded tail end 63 of rivet 33, but without any significant severing of rivet body 33. These ribs cause a further outward bulging and splaying of blind end 63 between grooves 221 such as to form a shamrock-like pattern. This also creating more concentrated compression points at the

grooved areas of the rivet body prior to lateral compression and compaction of ribs 111, shoulder 103 and lip 123 (again see Figure 8) during complete pull through of mandrel 81 relative to blind rivet 33. Furthermore, the rib and shoulder configuration stretches out the thinning areas of blind end 63 of the 5 rivet during setting. The post-rivet setting configuration of mandrel 81, showing the laterally folded and axially elongated head deformation, can be observed in Figure 25.

[0049] Figure 23 shows the set condition of blind end 63 of rivet 33 using the alternate mandrel 35a shown in Figure 10. This embodiment is 10 otherwise similar to that of Figures 27 and 28 except that no rib-created grooves nor shamrock pattern are created.

[0050] Referring to Figures 29-31, another alternate embodiment blind rivet assembly 251 of the present invention employs a mandrel 253, blind rivet 255 and workpiece 257. Mandrel 253 is like any of the mandrel embodiments 15 previously disclosed hereinabove, including having a tapered shoulder with optional ribs. Blind rivet 251, however, has a circular-cylindrical body 259 and an arcuately domed or pan-head type tool-side flange 261. A constantly dimensioned through-bore 263 extends through the entire blind rivet 251. Blind rivet 251 and mandrel 253 are made from aluminum but may also be steel. 20 Furthermore, workpieces 257 are aircraft panels but may alternately be other components. During rivet setting, a setting tool completely pulls mandrel 253 through rivet 251 such that a blind end of rivet body 259 is outwardly deformed into a cup-like shape but not axially severed. The head of mandrel 253 is folded but not broken from the stem, like the previously disclosed mandrel 25 embodiments.

[0051] Figure 32 illustrates yet another blind rivet assembly embodiment. This blind rivet assembly 281 includes a mandrel like any of those previously disclosed hereinabove. A blind rivet 283 is like that shown in Figure 30 29 except a pair of opposed slots 285 radially extend inward from a periphery 287 of tool-side flange 289. Flange 289 is otherwise arcuately domed with a flat underside adjacent the rivet body, like that of Figure 29.

[0052] The set blind rivet 283 is employed to temporarily hold the aircraft workpieces together and thereafter drilled out or otherwise removed from the workpieces. Slots 285 assist in reducing curling drilled debris from the rivet otherwise interfering with the removal of the rivet or undesirably contaminating 5 the component. For both of the embodiments of Figures 29-32, the pull-through and unsevered mandrel advantageously prevents the need to find traditional severed mandrel heads from the fastened components or factory. Nevertheless, it should be appreciated that the blind rivet embodiments of Figures 29-32 do not achieve many of the desired advantages of the flush-style embodiments of the 10 present invention.

[0053] While various embodiments of the present invention blind rivet assembly have been disclosed, it should be appreciated that other configurations may be employed. For example, more or less ribs can be provided although various advantages of the present invention may not be realized. Furthermore, 15 any of the mandrel configurations disclosed herein can be mixed and matched with others depending upon the specific characteristics of the riveted joint desired although various advantages of the present invention may not be achieved. Moreover, alternate mandrel stem depressions and shapes can be used although various advantages of the present invention may not be achieved. 20 While specific dimensional relationships are preferred, it should be appreciated that other dimensions may be used but that many of the advantages may not be achieved. It is intended by the following claims to cover these and any other departures from the disclosed embodiments which fall within the true spirit of this invention.

CLAIMS

The invention claimed is:

1. A rivet assembly comprising:

5 at least one workpiece having a first outer surface and an opposite second outer surface, a countersink located in each outer surface connected by a hole;

10 a blind rivet comprising a body and a tool-side flange, the body including a cylindrical outside surface from the flange to a blind end prior to rivet setting, and a surface of the flange tapering outwardly from the outside surface of the body; and

15 a mandrel comprising an elongated stem and a head, the stem extending through the rivet prior to setting, the head being laterally larger than the stem prior to rivet setting, and an outwardly tapering shoulder located on the head adjacent the stem;

the head being completely pulled through the rivet during rivet setting without severing the head from the stem of the mandrel, and the mandrel being discarded after setting the blind rivet;

20 the pulling through of the head during setting causing the blind end of the rivet body to outwardly expand into the adjacent countersink; and

the flange of the rivet being located in the adjacent countersink after rivet setting.

2. The rivet assembly of Claim 1, further comprising at least one rib

25 projecting from the shoulder of the mandrel.

3. The rivet assembly of Claim 2, wherein the at least one rib comprises at least two ribs, the ribs being elongated in a direction substantially coinciding with a direction of elongation of the stem, and the rivet body is 30 unsevered after the ribs pass through the blind rivet during rivet setting.

4. The rivet assembly of Claim 2, wherein the rib creates a depressed groove in a bore of the rivet body adjacent at least the blind end during rivet setting.

5 5. The rivet assembly of Claim 1, wherein the at least one workpiece includes a pair of electrical device components.

6. The rivet assembly of Claim 5, wherein at least one of the electric device components includes a computer housing.

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7. The rivet assembly of Claim 1, wherein the shoulder of the mandrel has a frusto-conical, tapered shape.

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8. The rivet assembly of Claim 1, wherein the shoulder of the mandrel includes two differently angled frusto-conical, tapered surfaces.

9. The rivet assembly of Claim 1, wherein the shoulder of the mandrel has a curved, tapered shape when viewed from a side of the mandrel.

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10. The rivet assembly of Claim 1, further comprising an end of the mandrel head opposite the stem includes a concave surface.

11. The rivet assembly of Claim 1, further comprising an end of the mandrel head opposite the stem includes a convex surface.

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12. The rivet assembly of Claim 1, wherein the head of the mandrel inwardly deforms during rivet setting.

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13. The rivet assembly of Claim 1, wherein the rivet and mandrel have the following relationship before rivet setting:

an outside diameter of the mandrel head is equal to or between 3.5 mm and 2.9 mm, and an outside diameter of the blind end of the rivet body is equal to or between 3.08 mm and 2.9 mm.

5 14. The rivet assembly of Claim 1, wherein an axial thickness of the mandrel head, not including the shoulder, is equal to or between 1.0 mm and 0.35 mm before rivet setting, and a nominal angle of the mandrel shoulder is equal to or between 110° and 90° as measured from one side to the other of the shoulder before rivet setting.

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15 15. The rivet assembly of Claim 1, further comprising a setting tool operably setting the blind rivet to the workpiece from a single side of the workpiece, the setting tool comprising at least one jaw operably pulling the mandrel stem and a nosepiece operably abutting against the tool-side flange, and a piston of the tool operably causing the mandrel to be pulled through the rivet, the blind rivet being attached to the mandrel through an interference fit before the mandrel is inserted into the tool.

20 16. A rivet assembly comprising:
a first workpiece including a substantially frusto-conical depression;
at least a second workpiece including a substantially frusto-conical depression;
a blind rivet comprising a tool end and an opposite blind end, the rivet including a through-bore; and
25 a mandrel comprising a stem and a head, the stem being located in the through-bore of the rivet at least prior to rivet setting, the mandrel head including a shoulder which laterally enlarges from the stem to a blind end of the mandrel head, and at least one rib projecting from the mandrel shoulder at least prior to rivet setting;
30 the mandrel head outwardly expanding the blind end of the rivet into the adjacent depression during rivet setting; and

the rivet portion adjacent the tool end having a substantially frusto-conical outside surface located in the adjacent depression at least after rivet setting.

5 17. The rivet assembly of Claim 16, wherein the head of the mandrel is completely pulled through the rivet during rivet setting without severing the head from the stem of the mandrel.

10 18. The rivet assembly of Claim 16, wherein the at least one rib comprises at least two ribs, the ribs being elongated in a direction substantially coinciding with a direction of elongation of the stem, and the rivet body is unsevered after the ribs pass through the blind rivet during rivet setting.

15 19. The rivet assembly of Claim 16, wherein the rib creates a depressed groove in the rivet during rivet setting.

20 20. The rivet assembly of Claim 16, wherein the shoulder of the mandrel has a frusto-conical, tapered shape.

20 21. The rivet assembly of Claim 16, wherein the shoulder of the mandrel includes two differently angled frusto-conical, tapered surfaces.

22. The rivet assembly of Claim 16, wherein the shoulder of the mandrel has a curved, tapered shape when viewed from a side of the mandrel.

25 23. The rivet assembly of Claim 16, wherein there is a lateral gap between an outside diameter of the rivet and the narrowest hole portions connecting the depressions in the workpieces before rivet setting but not after rivet setting.

30 24. The rivet assembly of Claim 16, further comprising an end of the mandrel head opposite the stem includes a concave surface.

25. The rivet assembly of Claim 16, further comprising an end of the mandrel head opposite the stem includes a convex surface.

5 26. The rivet assembly of Claim 16, wherein the head of the mandrel inwardly deforms during rivet setting.

27. The rivet assembly of Claim 16, wherein the rivet and mandrel have the following relationship before rivet setting:

10 an outside diameter of the mandrel head is equal to or between 3.5 mm and 2.9 mm, and an outside diameter of the blind end of the rivet is equal to or between 3.08 mm and 2.9 mm.

28. The rivet assembly of Claim 16, wherein an axial thickness of the 15 mandrel head, not including the shoulder, is equal to or between 1.0 mm and 0.35 mm before rivet setting, and a nominal angle of the mandrel shoulder is equal to or between 110° and 90° as measured from one side to the other of the shoulder before rivet setting.

20 29. A rivet assembly comprising:

a first workpiece including a substantially frusto-conical depression; at least a second workpiece including a substantially frusto-conical depression;

25 a blind rivet comprising a tool end and an opposite blind end, the rivet including a through-bore; and

a mandrel comprising a stem and a head, the stem being located in the through-bore of the rivet at least prior to rivet setting, the mandrel head including a shoulder which laterally enlarges from the stem to a blind end of the mandrel head;

30 the mandrel head outwardly expanding the blind end of the rivet into the adjacent depression during rivet setting;

wherein the head of the mandrel is completely pulled through the rivet during rivet setting without severing the head from the stem of the mandrel;

the tool end and blind end of the rivet being flush or below flush of a tool-surface and a blind-surface of the workpieces; and

5 the head of the mandrel deforming and having a reduced lateral cross-sectional area during rivet setting.

30. The rivet assembly of Claim 29, further comprising at least one rib projecting from the shoulder of the mandrel.

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31. The rivet assembly of Claim 30 wherein the at least one rib comprises at least two ribs, the ribs being elongated in a direction substantially coinciding with a direction of elongation of the stem, and the rivet body is unsevered after the ribs pass through the blind rivet during rivet setting.

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32. The rivet assembly of Claim 29, wherein the shoulder of the mandrel has a frusto-conical, tapered shape.

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33. The rivet assembly of Claim 29, wherein the shoulder of the mandrel includes two differently angled frusto-conical, tapered surfaces.

34. The rivet assembly of Claim 29, wherein the shoulder of the mandrel has a curved, tapered shape when viewed from a side of the mandrel.

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35. The rivet assembly of Claim 29, further comprising an end of the mandrel head opposite the stem includes a concave surface.

36. The rivet assembly of Claim 29, further comprising an end of the mandrel head opposite the stem includes a convex surface.

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37. The rivet assembly of Claim 29, wherein the rivet and mandrel have the following relationship before rivet setting:

an outside diameter of the mandrel head is equal to or between 3.5 mm and 2.9 mm, and an outside diameter of the blind end of the rivet is equal to or between 3.08 mm and 2.9 mm.

5 38. The rivet assembly of Claim 29, wherein an axial thickness of the mandrel head, not including the shoulder, is equal to or between 1.0 mm and 0.35 mm before rivet setting, and a nominal angle of the mandrel shoulder is equal to or between 110° and 90° as measured from one side to the other of the shoulder before rivet setting.

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39. The rivet assembly of Claim 29, wherein there is a lateral gap between an outside diameter of the rivet and the narrowest hole portions connecting the depressions in the workpieces before rivet setting but not after rivet setting.

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40. A method of setting a rivet to workpieces, the method comprising:

(a) creating a rivet with a laterally enlarged tool-side flange prior to rivet setting;

(b) creating a mandrel with a head and an elongated stem;

20 (c) attaching the rivet to the mandrel before the mandrel is placed in a setting tool; and

(d) locating the tool-side flange completely within a first depression in the workpieces; and

(e) pulling the head of the mandrel completely through the rivet

25 during rivet setting, without severing the mandrel head from the mandrel stem, in order to outwardly expand a tail end of the rivet into a second depression in the workpieces flush or below flush an adjacent outside surface of the workpieces.

30 41. The method of Claim 40, further comprising creating at least one rib on a tapered shoulder of the mandrel and preventing the rib from severing through the rivet during rivet setting.

42. The method of Claim 40, further comprising deforming the head of the mandrel during rivet setting.

43. The method of Claim 40, further comprising creating the rivet and
5 mandrel with the following relationship before rivet setting:

an outside diameter of the mandrel head is equal to or between 3.5 mm and 2.9 mm, and an outside diameter of the tail end of the rivet body is equal to or between 3.08 mm and 2.9 mm.

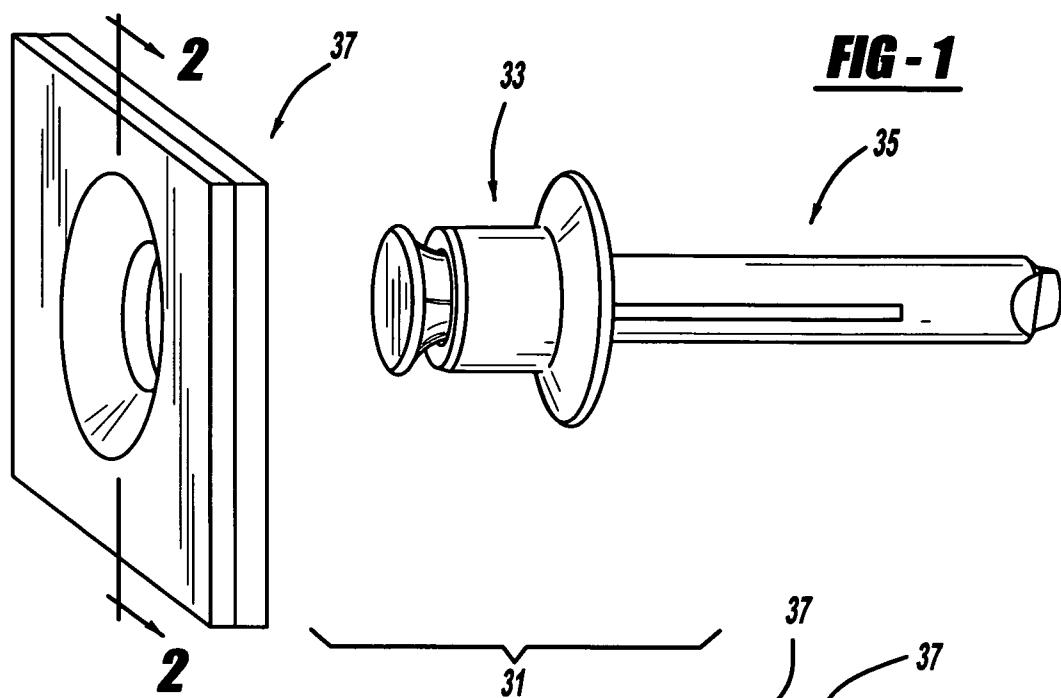
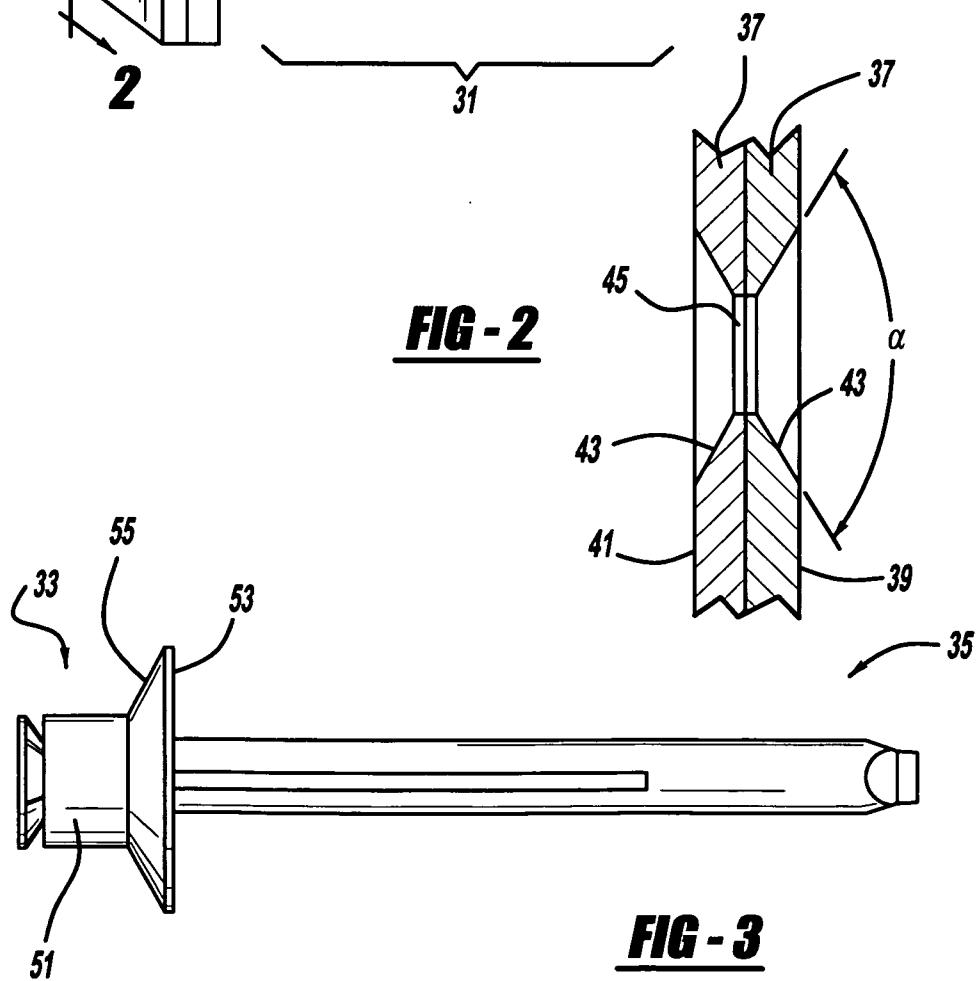
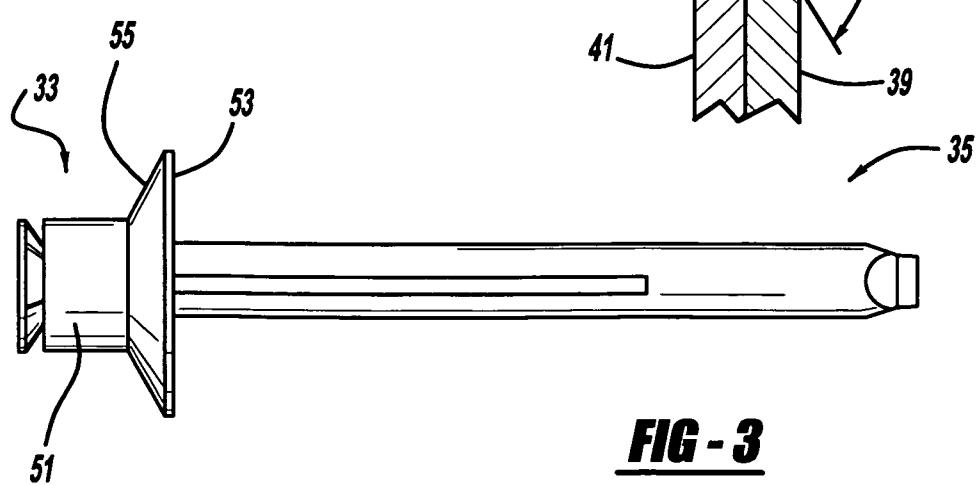
10 44. The method of Claim 40, further comprising:

(a) locating the mandrel stem in jaws of the setting tool;
(b) abutting a nosepiece of the setting tool against the tool-side flange of the rivet;

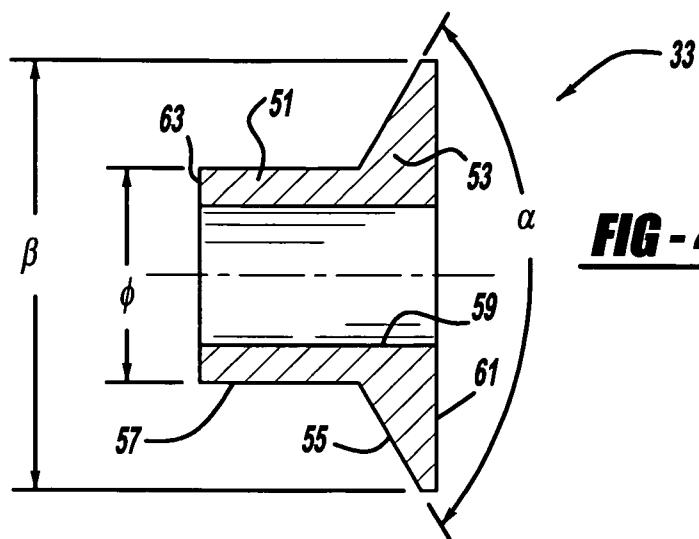
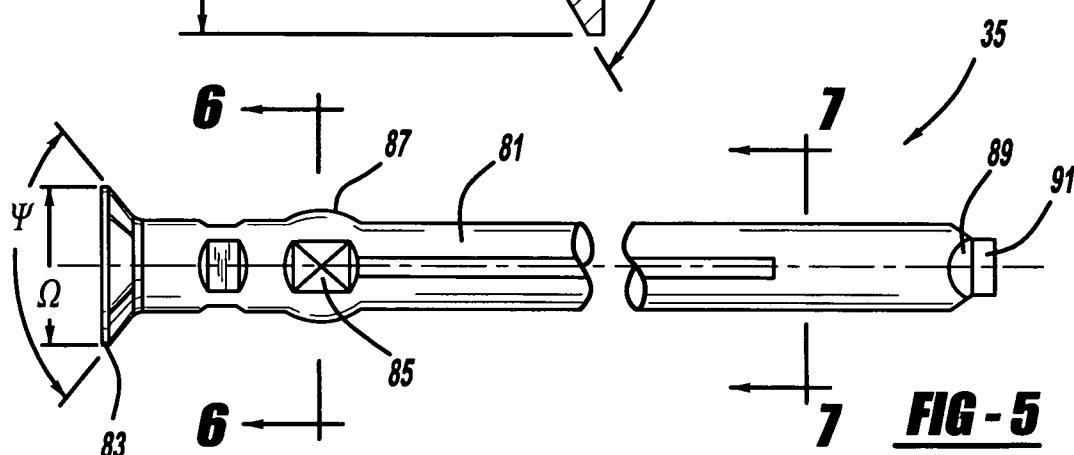
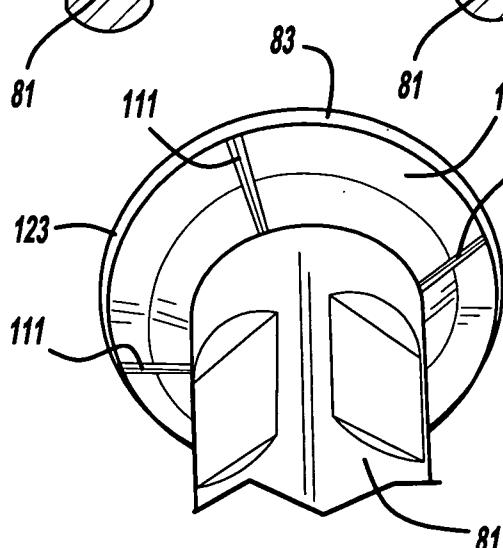
15 (c) exclusively causing rivet setting by pulling and removing the mandrel relative to the rivet during rivet setting from a tool-side of the workpieces; and

(d) discarding the mandrel after setting the rivet.

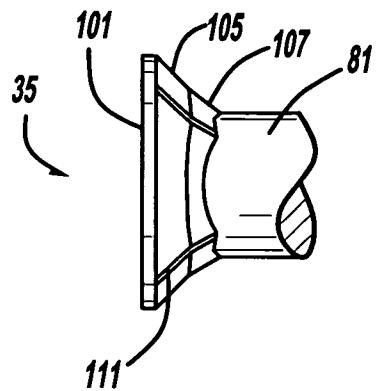
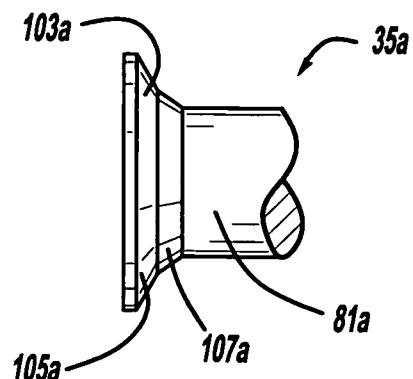
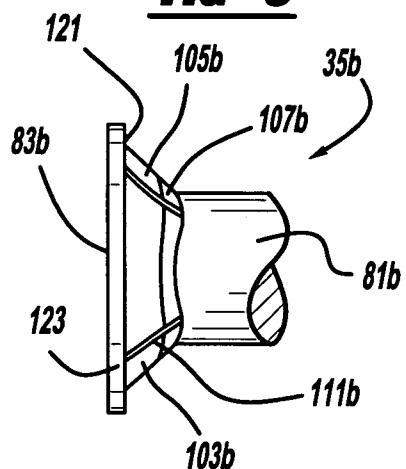
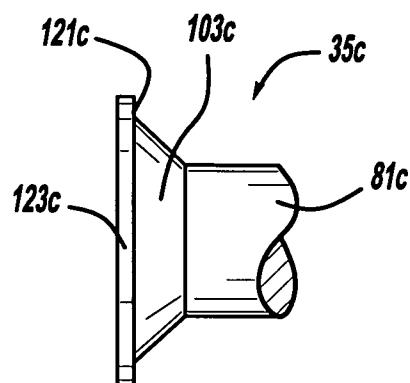
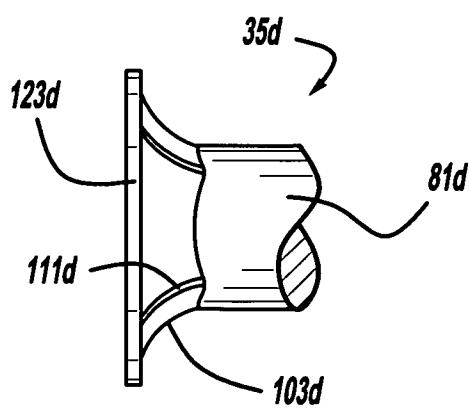
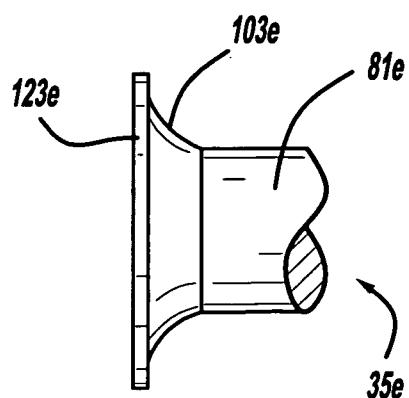
1/8

**FIG - 2****FIG - 3**

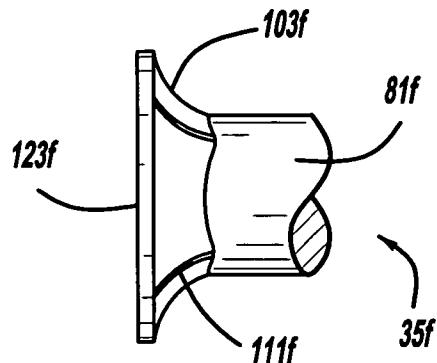
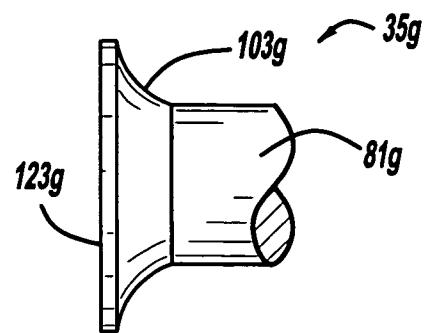
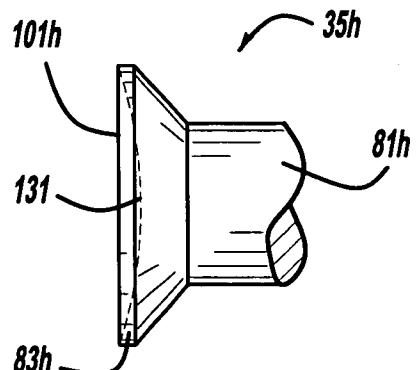
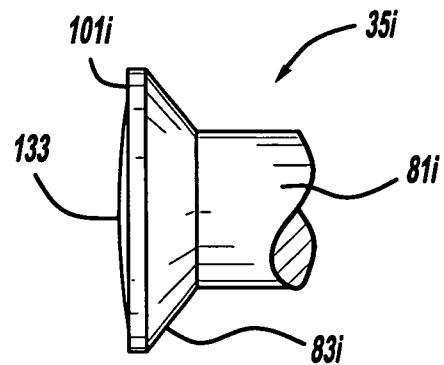
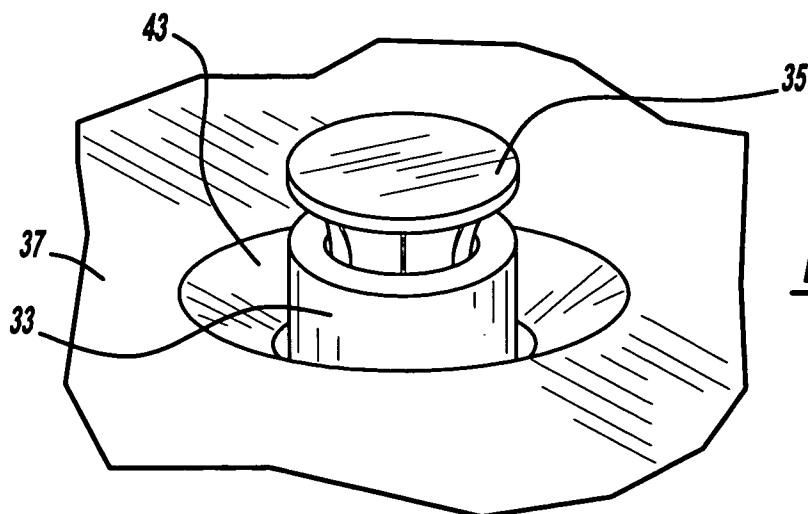
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**FIG - 4****FIG - 5****FIG - 6****FIG - 7****FIG - 8**

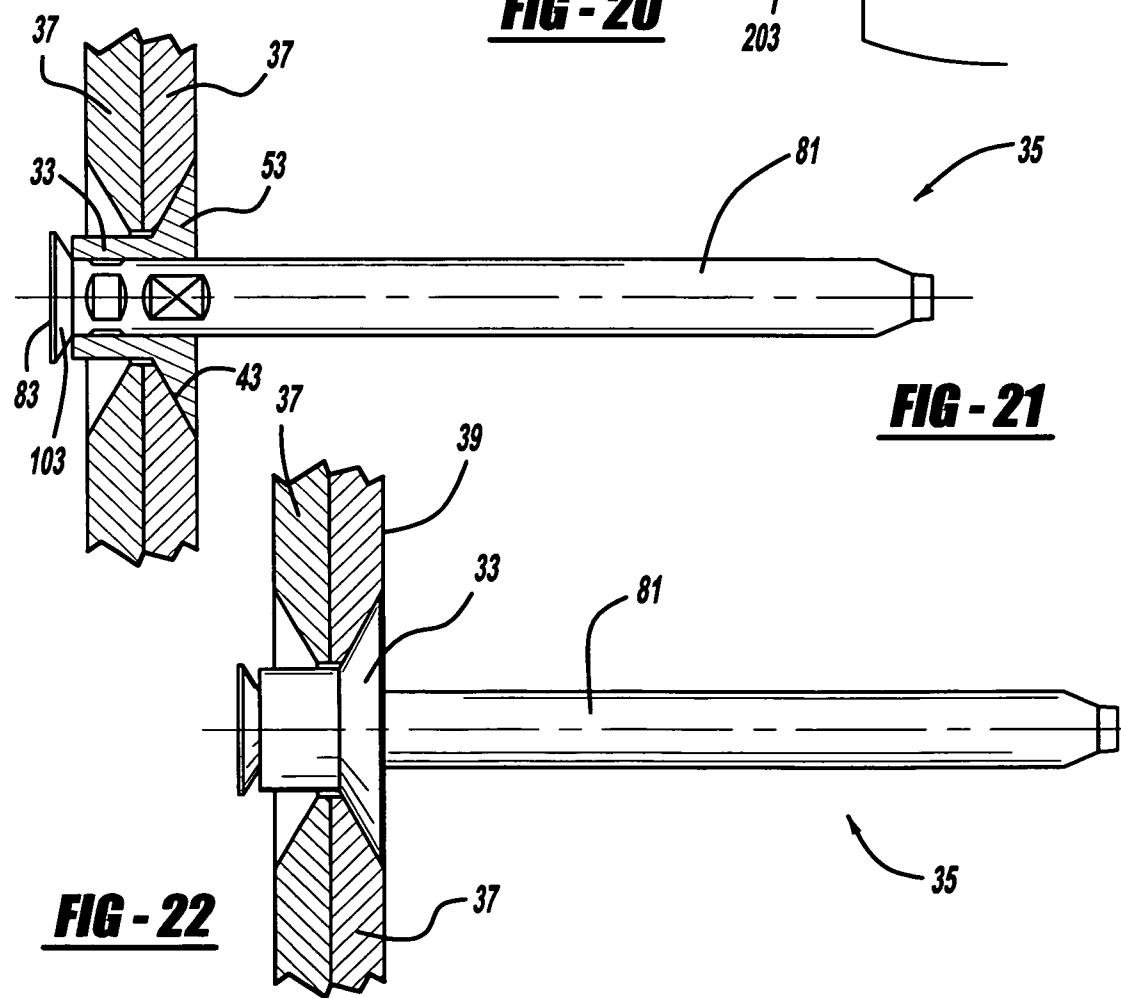
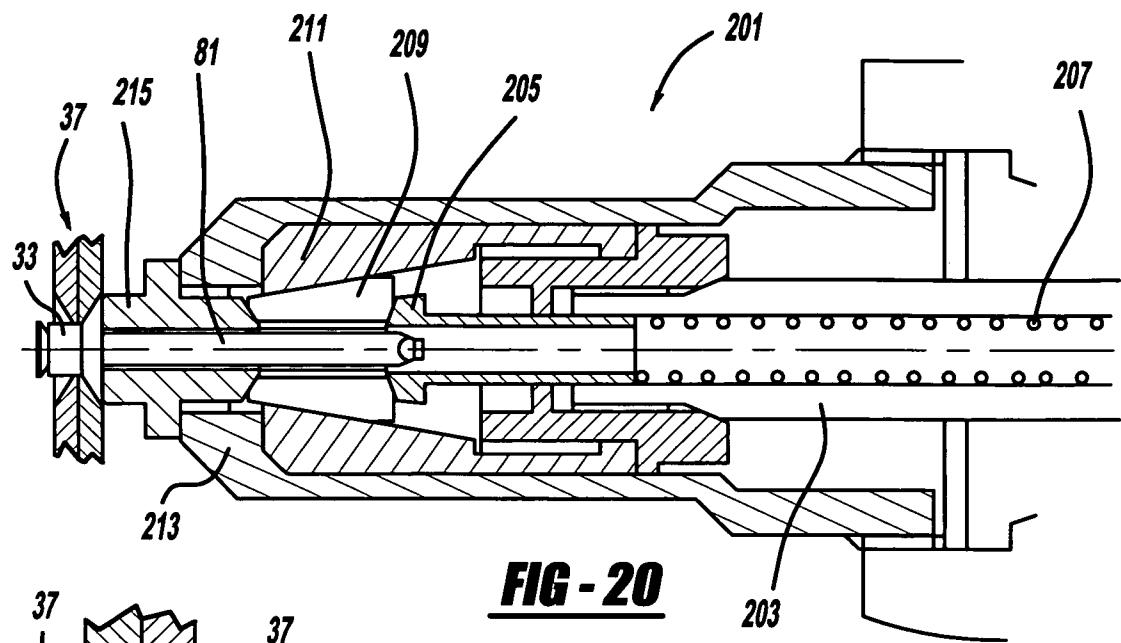
3/8

**FIG - 9****FIG - 10****FIG - 11****FIG - 12****FIG - 13****FIG - 14**

4/8

**FIG - 15****FIG - 16****FIG - 17****FIG - 18****FIG - 19**

5/8



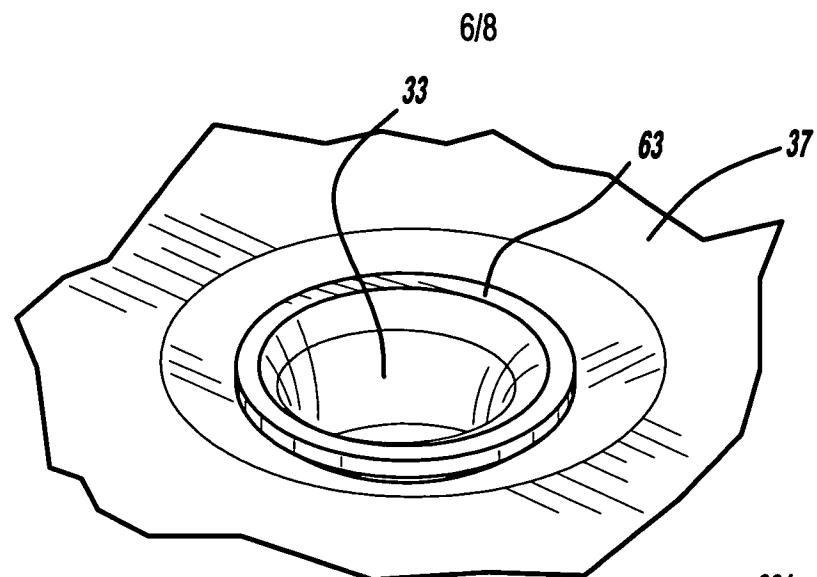


FIG - 23

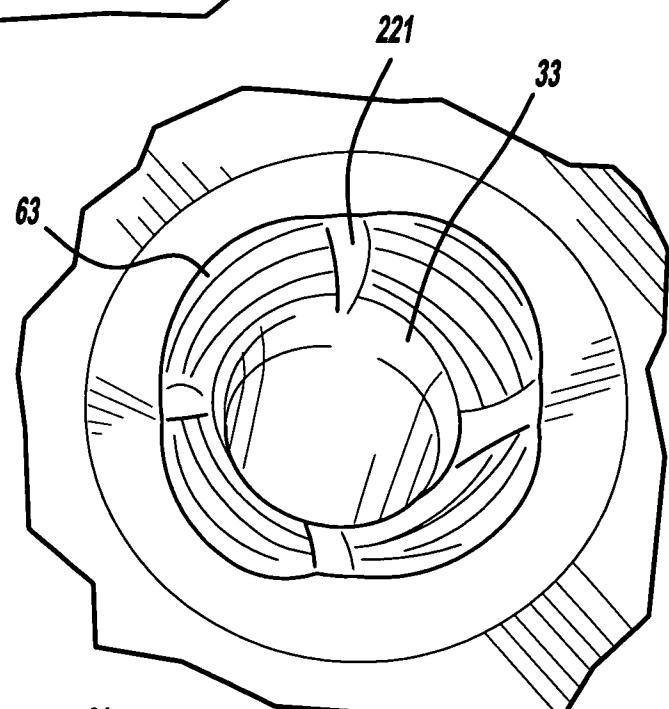


FIG - 24

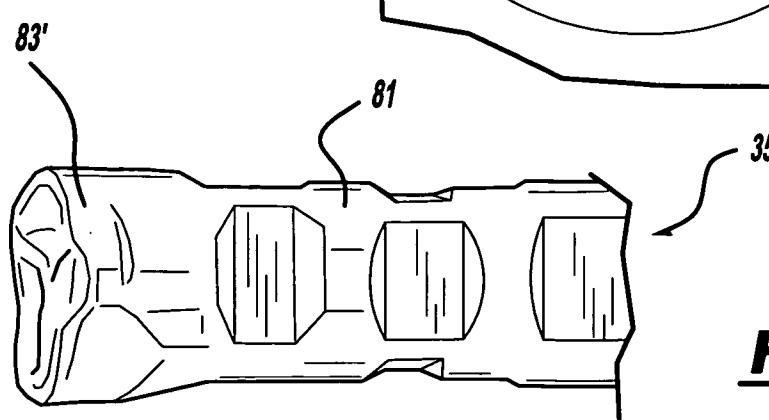
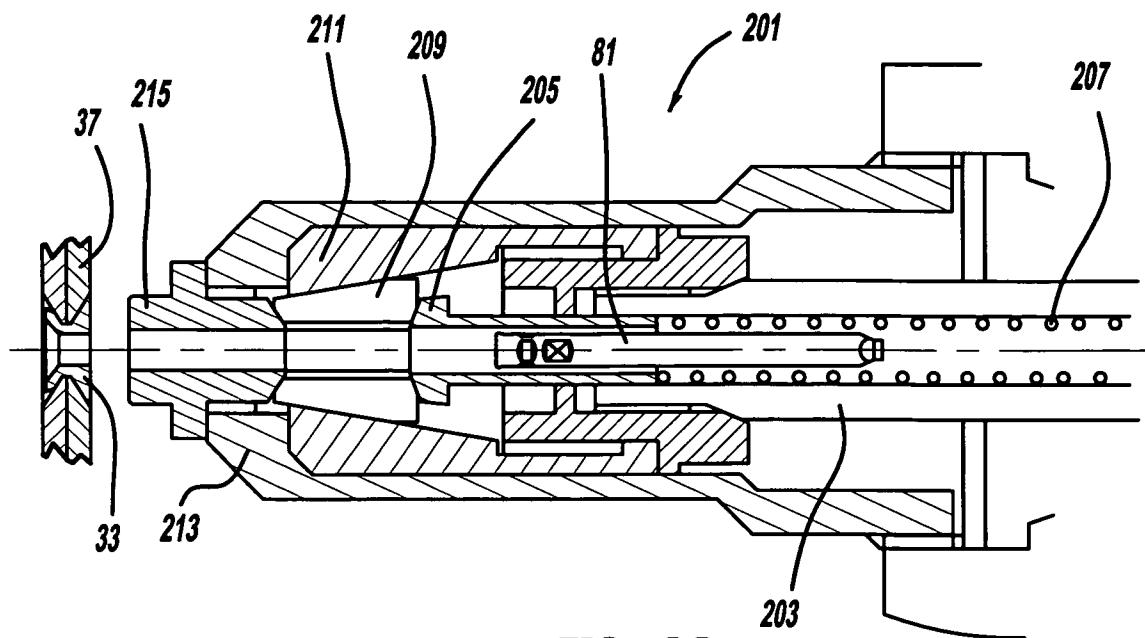
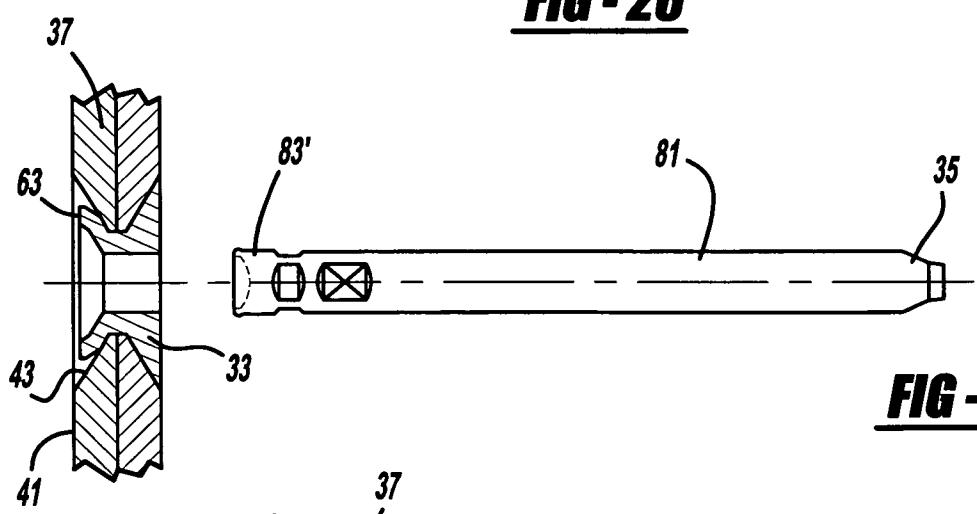
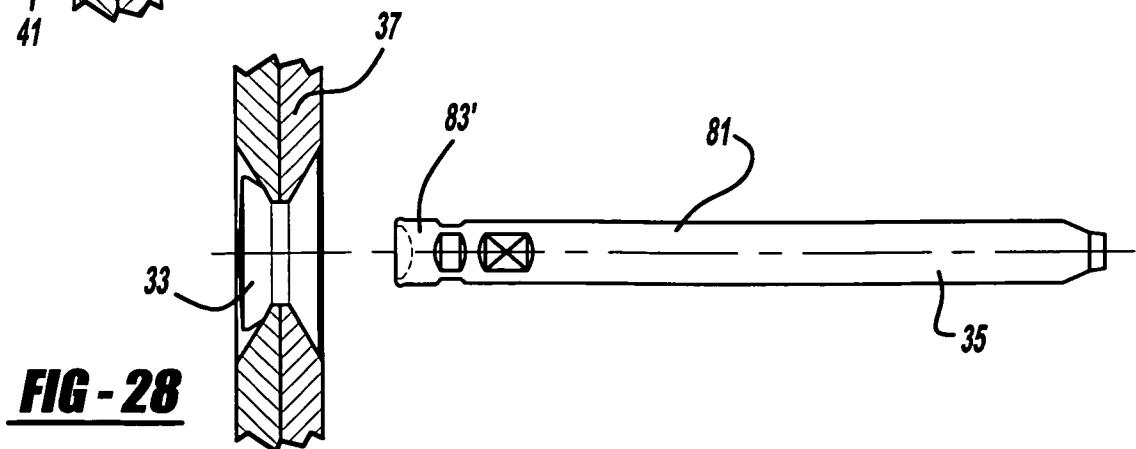
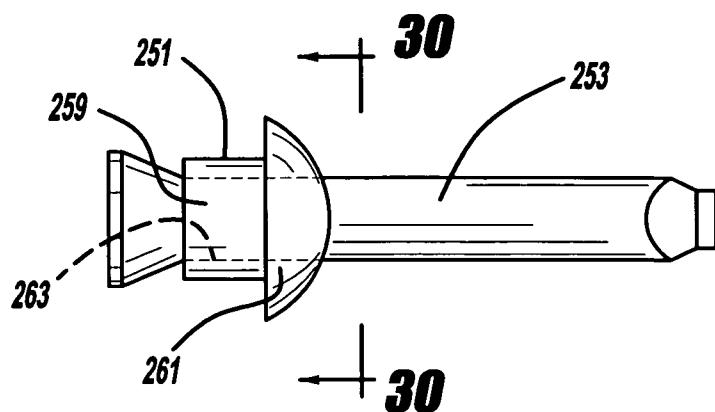
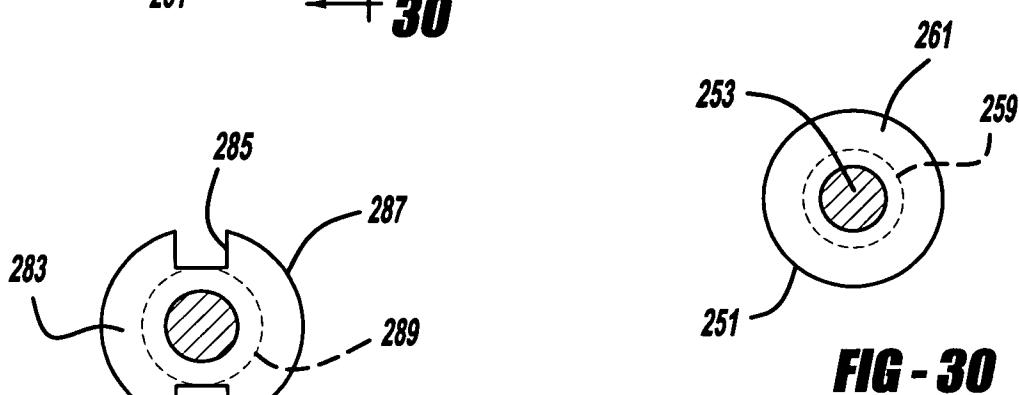
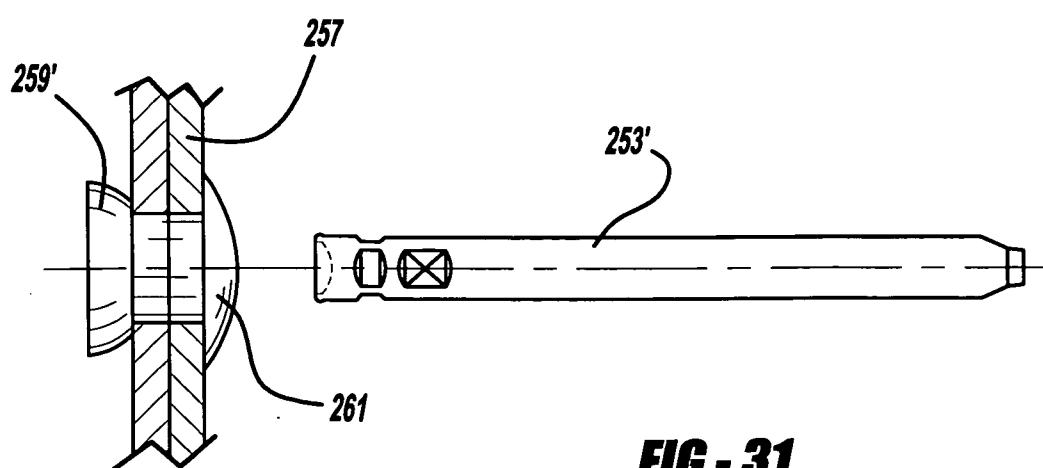


FIG - 25

7/8

**FIG - 26****FIG - 27****FIG - 28**

8/8

**FIG - 29****FIG - 30****FIG - 32****FIG - 31**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 08/09203

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F16B 19/08 (2008.04)

USPC - 411/510

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8)- F16B 19/08 (2008.04)

USPC- 411/510

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

IPC(8)- F16B 19/08 (2008.04)

USPC- 411/37, 501, 503, 509, 510; 470/28, 29

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST, DialogPRO, Google Scholar

Search Terms- blind, rivet, mandrel, head, stem, shoulder, bore

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/0071525 A1 (Millington) 15 April 2004 (15.04.2004), Figures 1-3e, paragraphs, 6, 23, 26, 28, 33, 37, and 38	1-44
A	US 2007/0110540 A1 (Jones et al.) 17 May 2007 (17.05.2007), entire document	1-44

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

21 October 2008 (21.10.2008)

Date of mailing of the international search report

04 NOV 2008

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