Sept. 15, 1964 R. H. GAPP 3,148,578

RIVET AND METHOD OF RIVETING

Filed Oct. 16, 1961 2 Sheets-Sheet 1

Fig. 1.

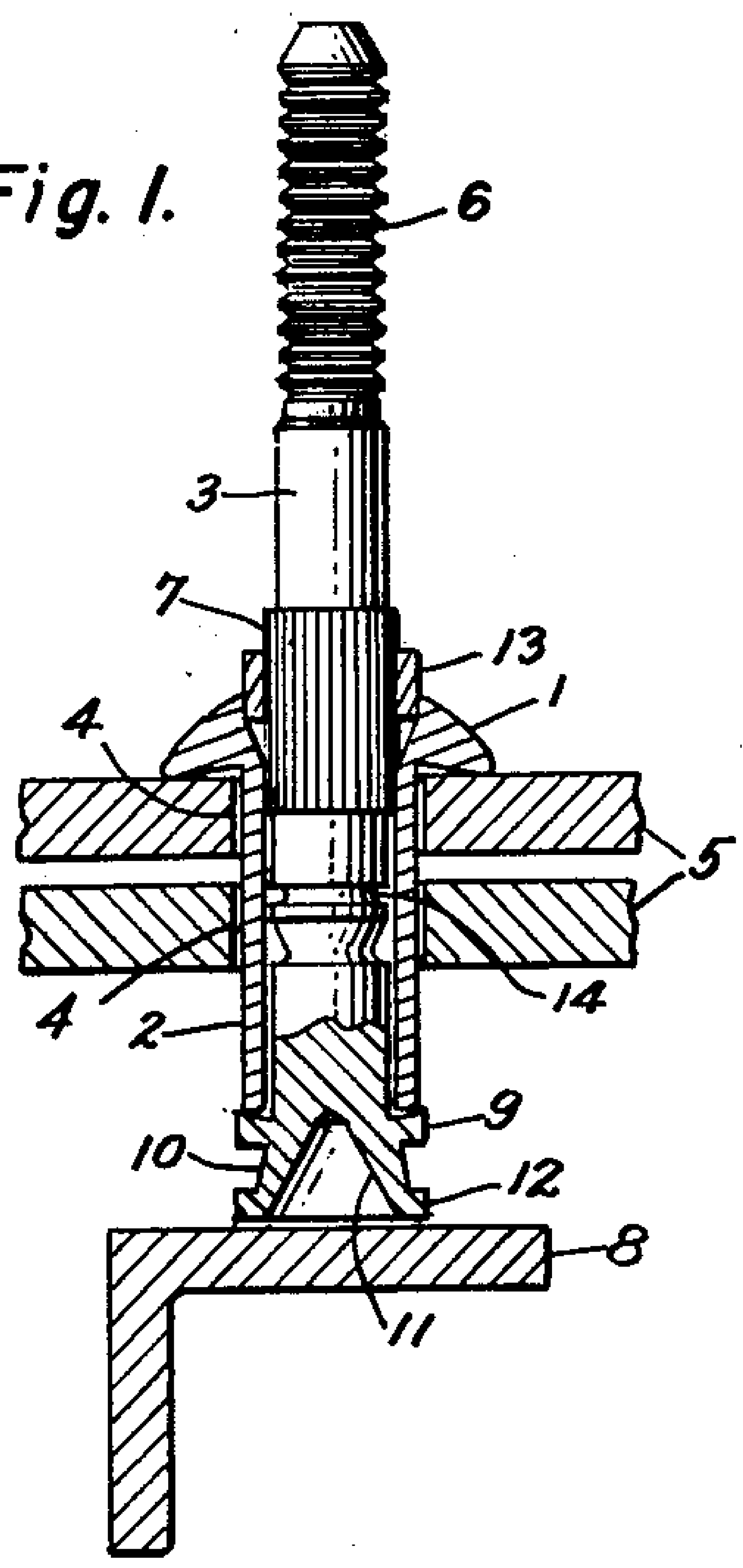


Fig. 2.

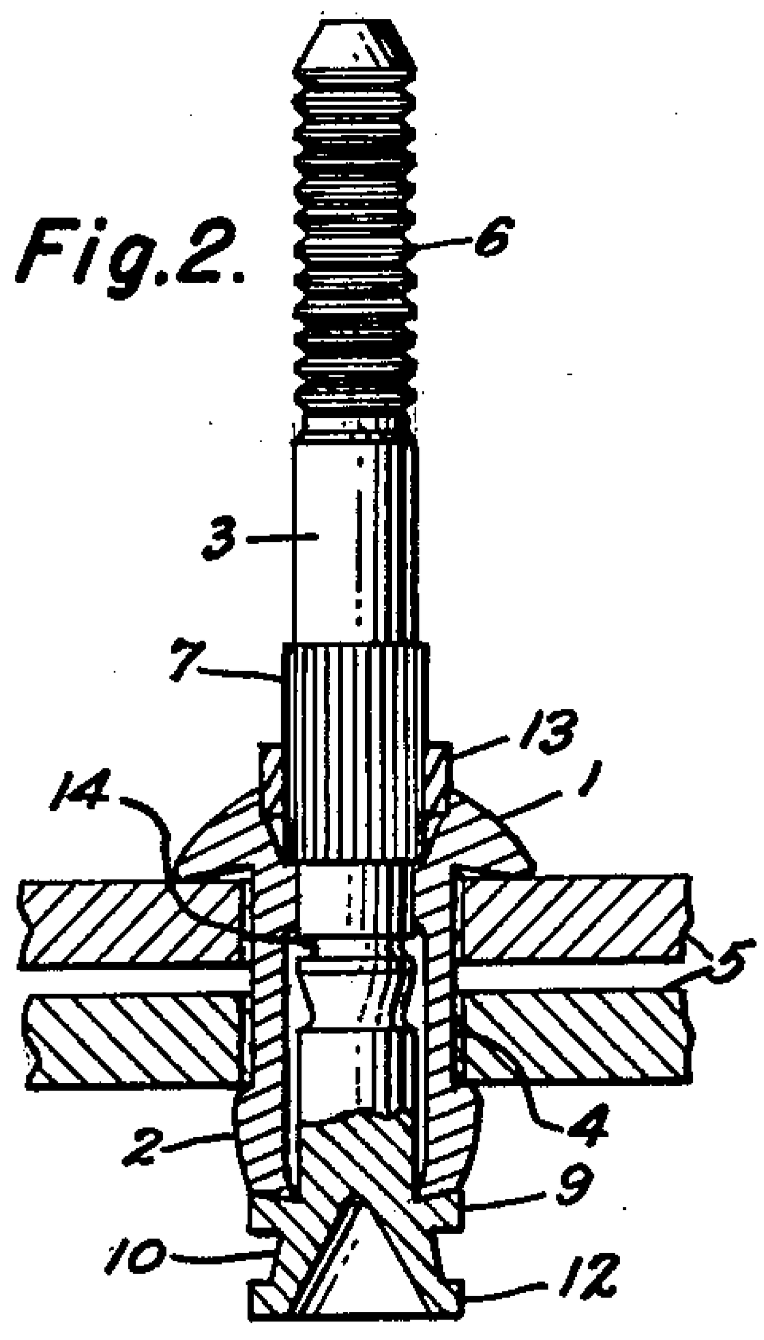


Fig. 3.

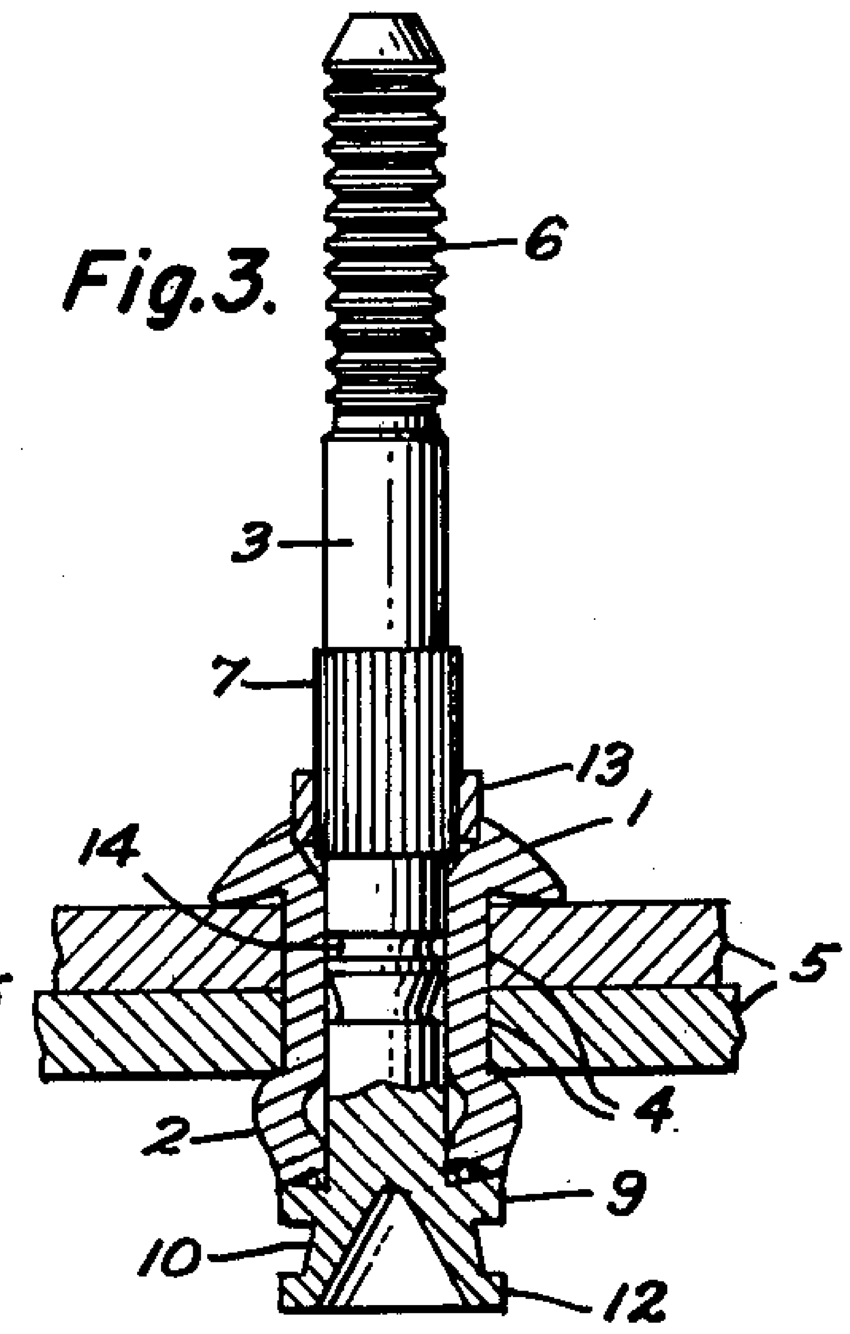


Fig. 7

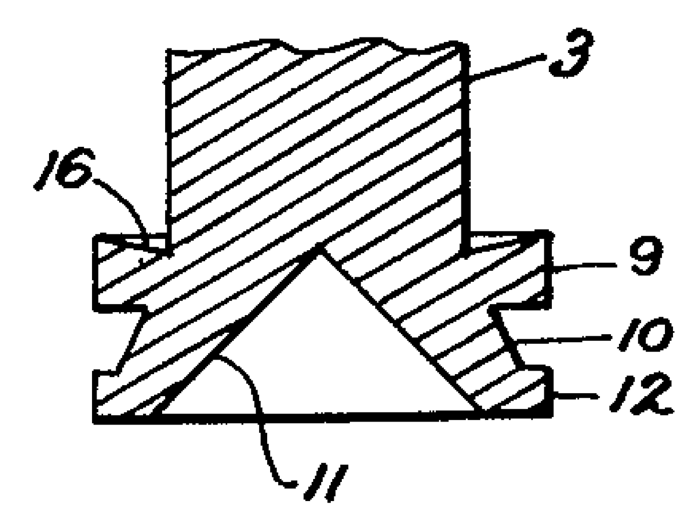


Fig. 4.

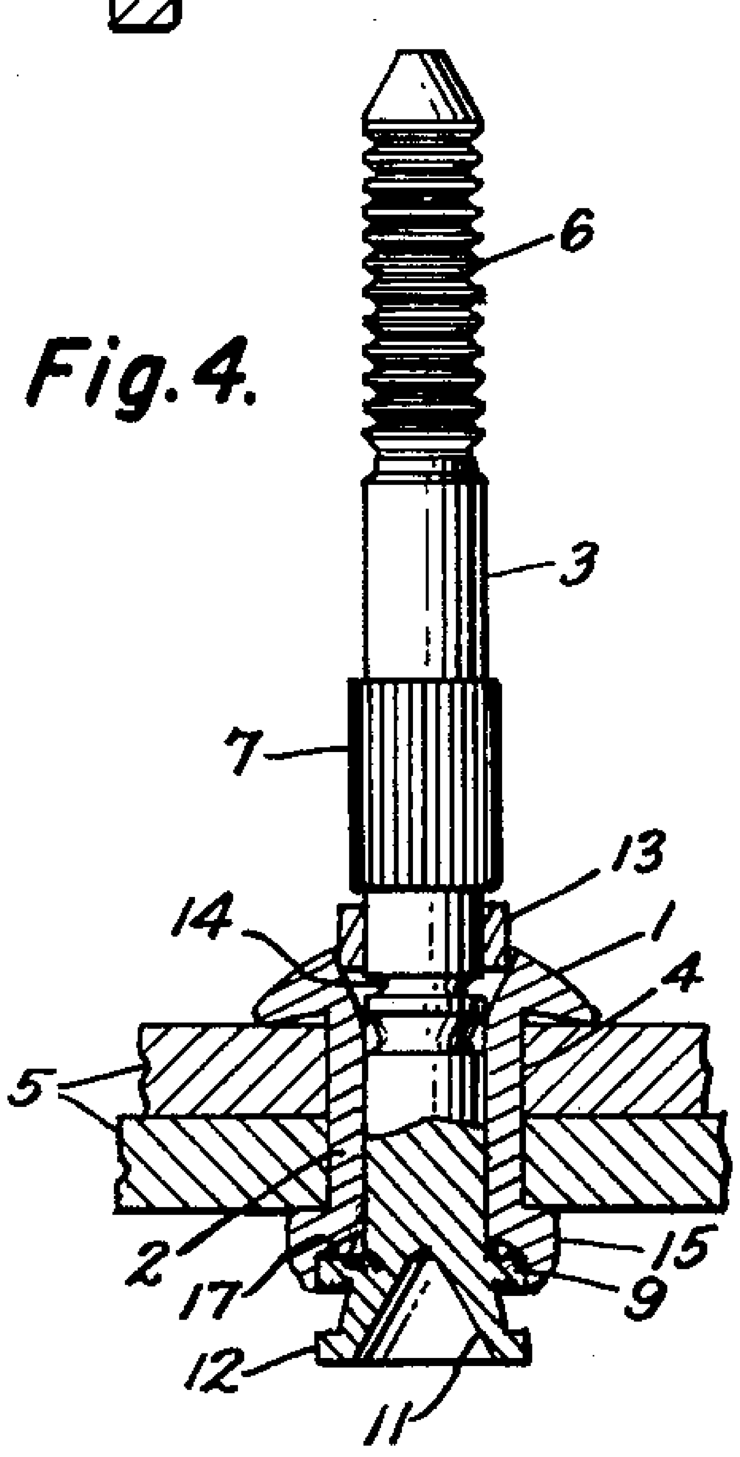


Fig. 5.

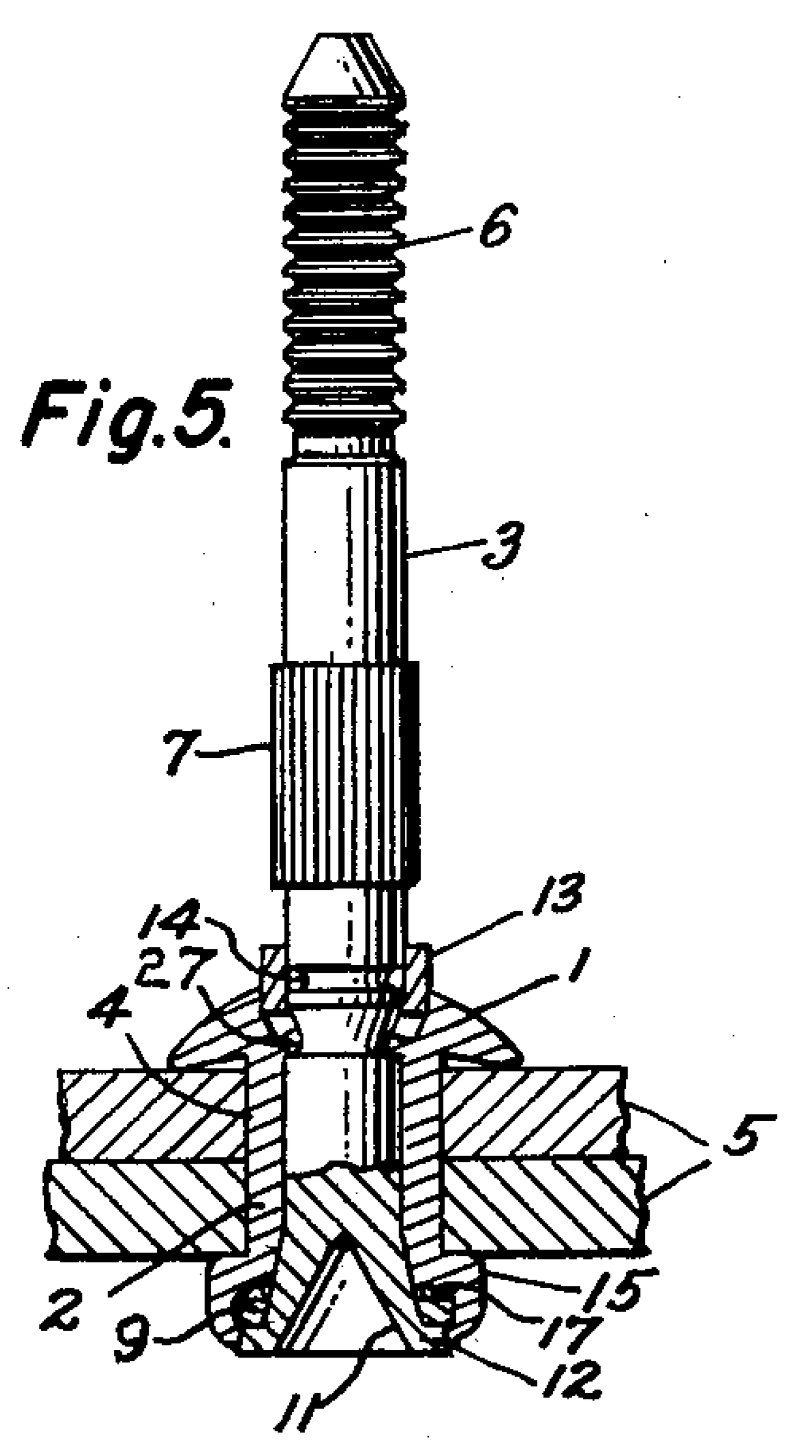


Fig. 8.

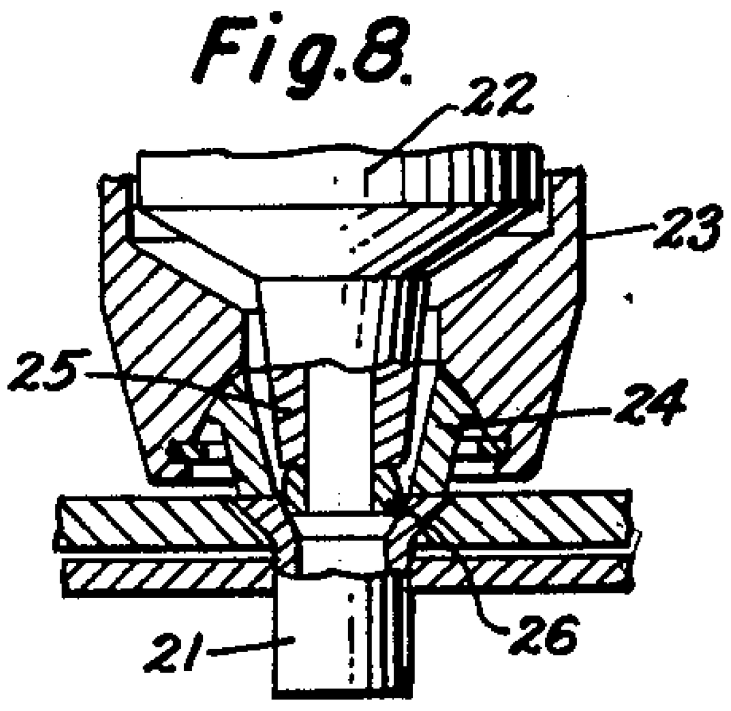
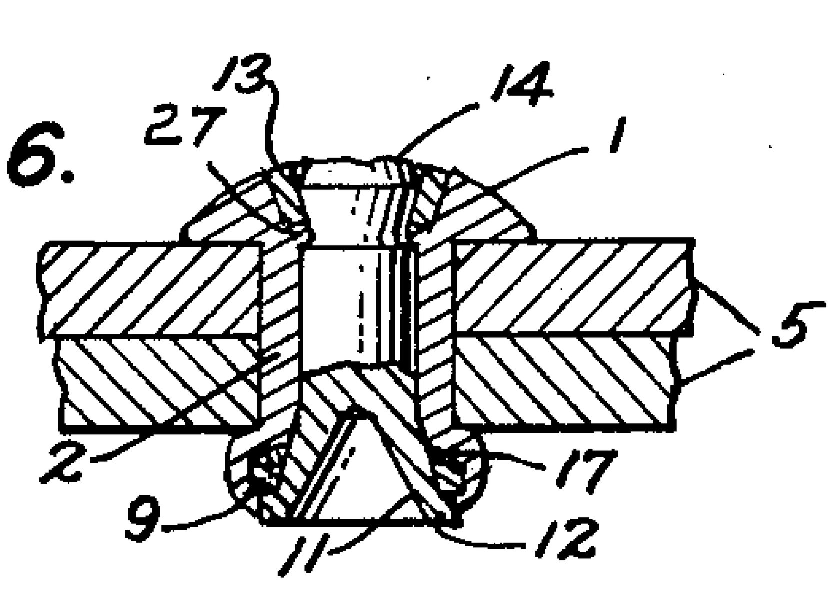


Fig. 6.



INVENTOR.
ROLAND HOWARD GAPP
BY George B. White
ATTORNEY.

Sept. 15, 1964 R. H. GAPP 3,148,578

RIVET AND METHOD OF RIVETING

Filed Oct. 16, 1961 2 Sheets-Sheet 2

Fig. 9.

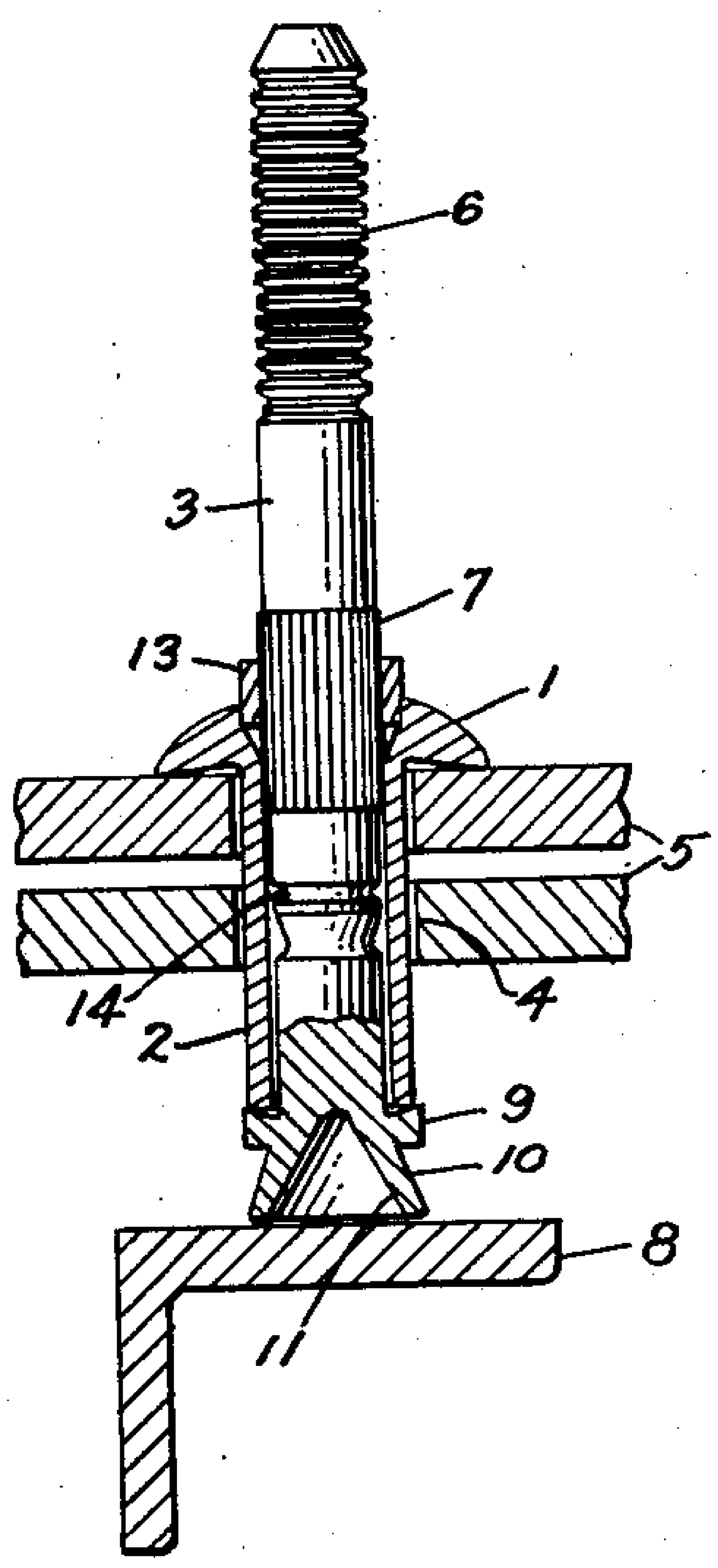


Fig. 10.

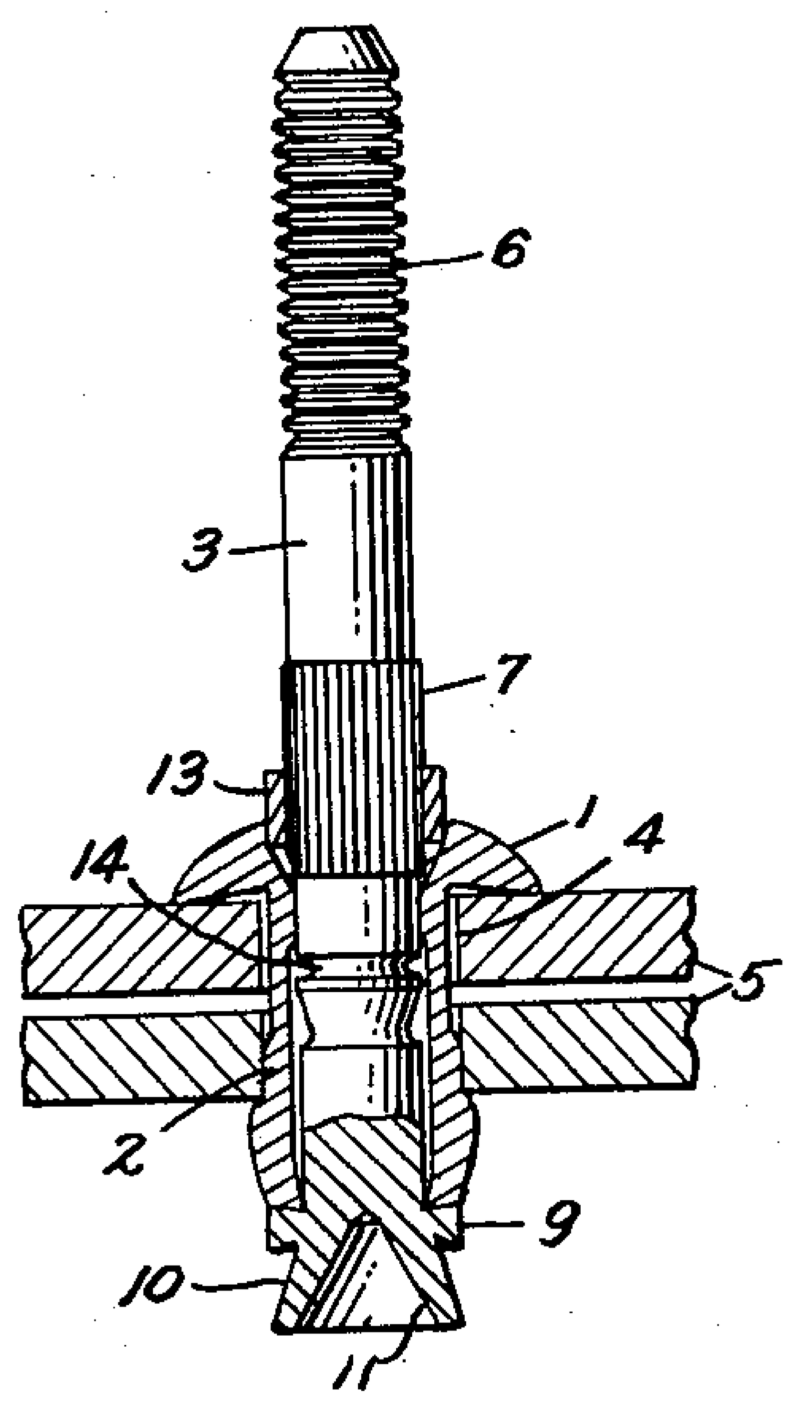


Fig. 11.

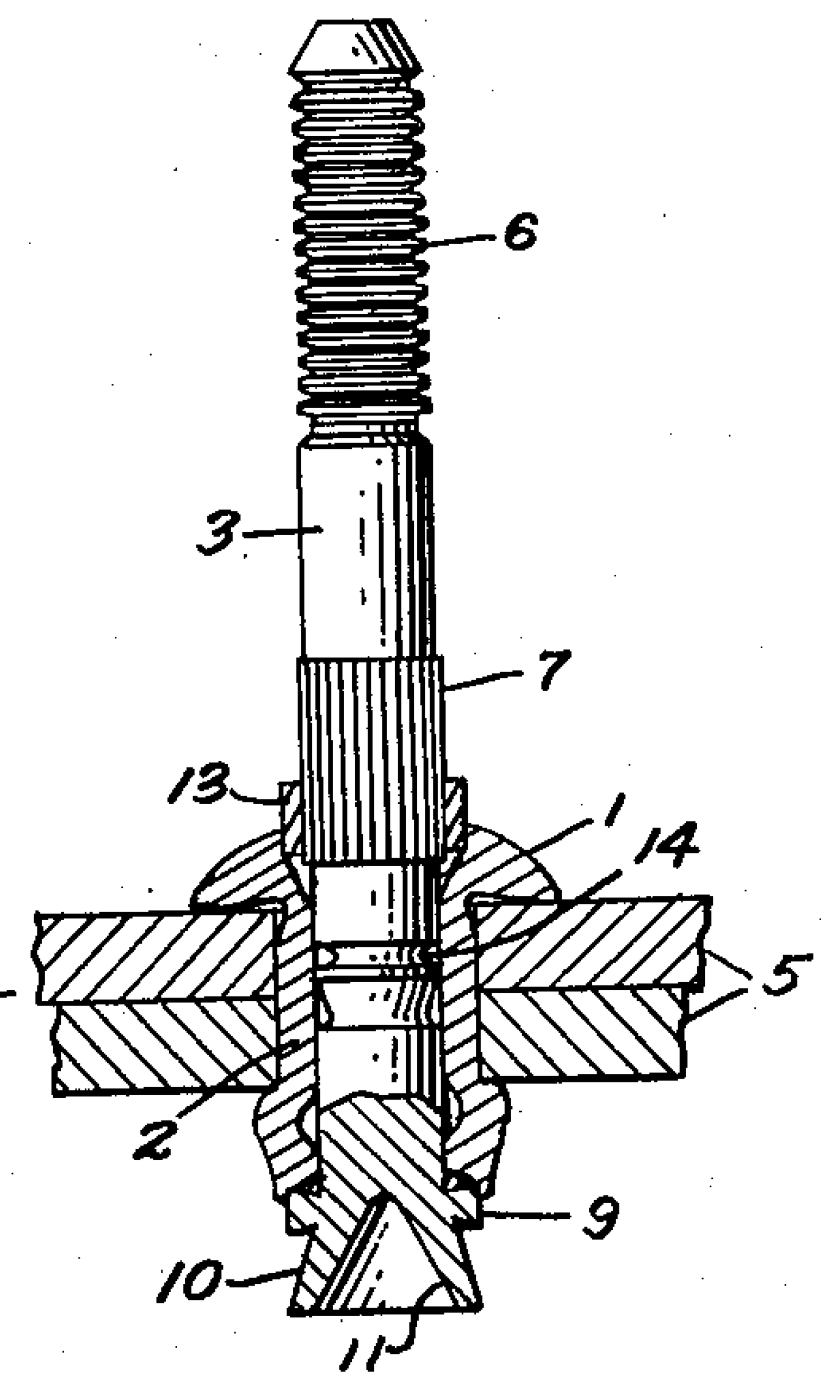


Fig. 12.

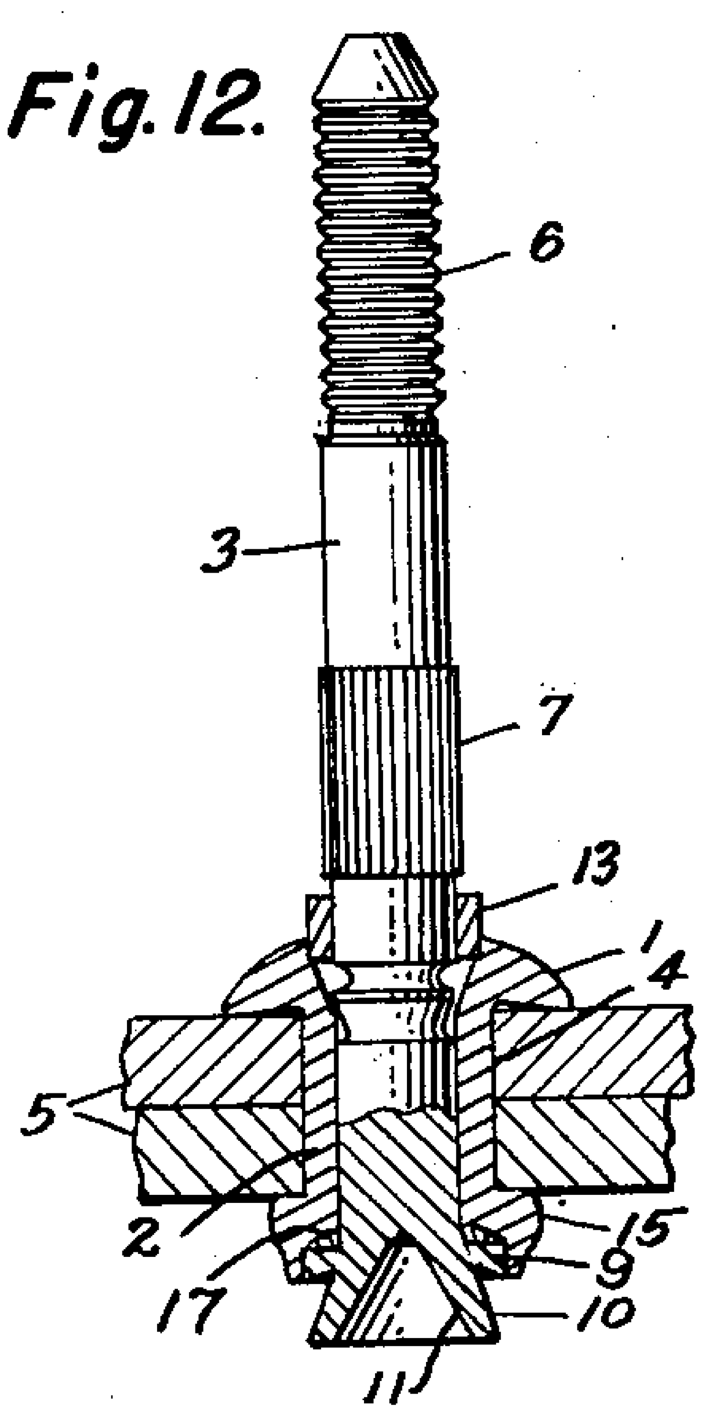


Fig. 13.

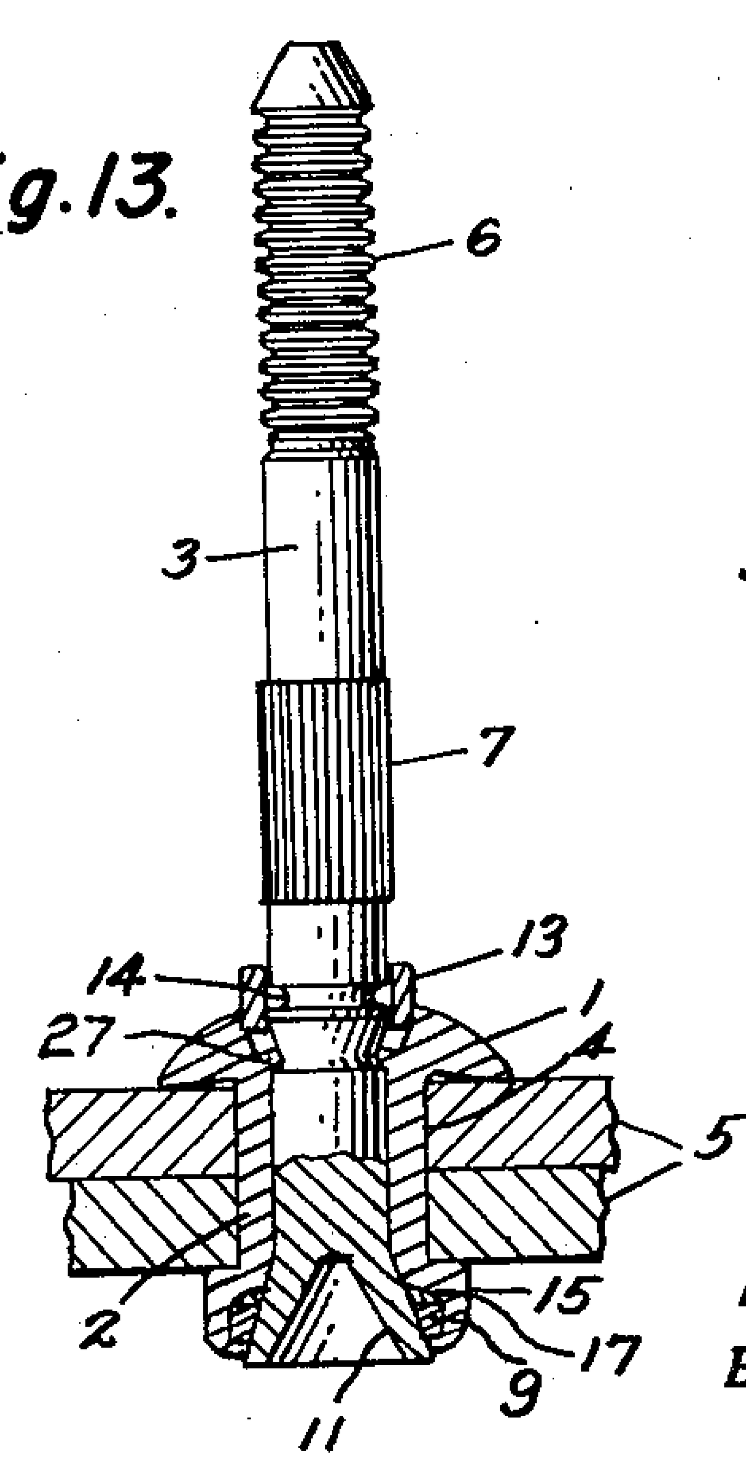
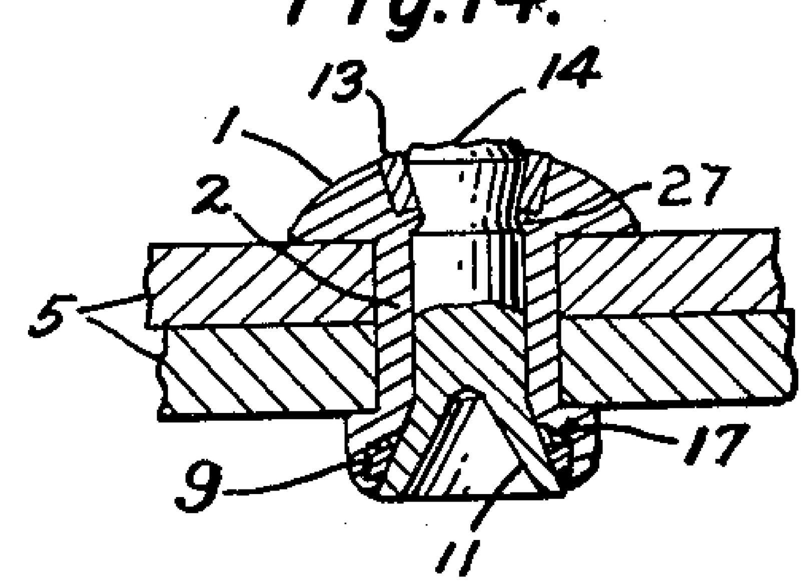


Fig. 14.



INVENTOR.
ROLAND HOWARD GAPP
BY George B. White
ATTORNEY

3,148,578

RIVET AND METHOD OF RIVETING

Roland H. Gapp, Santa Ana, Calif., assignor to Townsend Company, a corporation of Pennsylvania

Filed Oct. 16, 1961, Ser. No. 145,130
4 Claims. (Cl. 85—77)

This invention relates to an improved method of riveting entirely from one side of a structure commonly referred to as "blind riveting" and to a novel rivet especially adapted for this purpose. It relates also to that class of riveting of this type which produces a bulb type of head on the blind side, that is to say, the side opposite that from which the riveting is done.

Under present practice in riveting of this type it is exceedingly difficult to produce a satisfactory bulbed rivet head on the blind side of the structure. This is especially true of the shorter grip ranges and where greater strength is desired. When length of grip varies, it is increasingly difficult to form a satisfactory blind head of the bulbed type with a given rivet length.

One method in common use comprises the "bending" of the section of rivet protruding on the blind side. With this method the original wall thickness of the hollow rivet which is used remains virtually unchanged and it is difficult to obtain uniform bearing of the blind head against the blind side of the sheet. This results in poor clamping together of the sheets.

In any riveting operation it is desirable that the rivet shank fill the rivet hole completely. In the case of blind riveting in order to expand the hollow rivet shank into the hole, recourse has been had to the use of a wire-drawable pin or to an explosive force. Both of these have some well known disadvantages.

It is therefore a general object of my invention to provide a new and novel rivet and method of riveting from one side of a structrue which will produce a bulbed rivet head on the opposite side of the structure and which will have superior clamping power.

It is another object of my invention to provide a rivet and method of riveting from one side of a structure wherein a given rivet will be equally efficient over a wide range of thicknesses of grip.

It is still another object of my invention to provide a blind rivet and method of riveting in which the hole-filling action will be more efficient than any other now in use.

It is amore specific object of my invention to provide a blind rivet having a hole-filling action accomplished primarily by axial compression of the rivet shank.

It is an important specific object of my invention to provide a rivet assembly and a method of riveting from one side only of a structure which utilizes a hollow shank rivet, a head forming stem having as hear collar, and a conical stem section in cooperating relationship with each other in which the predetermined shearing strength of the head forming shear collar is less than the predetermined tensile strength of the stem.

I am aware that some changes may be made in the general arrangements and combinations of the several devices and parts, as well as in the details of the construction thereof without departing from the scope of the present invention as set forth in the following specification, and as defined in the hollowing claims; hence I do not limit my invention to the exact arrangements and combinations of the said device and parts as described in the said specification, nor do I confine myself to the exact details of the construction of the said parts as illustrated in the accompanying drawings.

With the foregoing and other objects in view, which will be made manifest in the following detailed descrip-

tion, reference is had to the accompanying drawings for the illustrative embodiment of the invention, wherein:

FIG. 1 is a sectional view showing a preferred embodiment of the rivet of my invention in position to commence the actual riveting operation.

FIG. 2 is a sectional view showing the axial compression at the start of the riveting operation of my invention.

FIG. 3 is a sectional view showing a later step of my method.

FIG. 4 is a sectional view showing yet a later step.

FIG. 5 is a sectional view showing still a later step just prior to setting of the lock ring.

FIG. 6 is a sectional view showing the appearance of the finished rivet of my invention.

FIG. 7 is an enlarged sectional view of the end of the rivet stem of my invention showing a preferred arrangement of the blind head former.

FIG. 8 is a special device for performing the mechanical locking operation on a flat-head rivet.

FIG. 9 is a sectional view showing an alternate embodiment of the rivet of my invention in position to commence the actual riveting operation.

FIG. 10 is a sectional view showing the starting of the riveting operation of the rivet of FIG. 9.

FIGS. 11, 12, and 13 are successive steps in the operation of the riveting operation of the rivet of FIG. 9.

FIG. 14 is a sectional view of the completed riveted joint using the rivet of FIG. 9.

In the method of my invention using the embodiment of FIG. 1, a rivet having a convex head **1** and hollow cylindrical shank **2**, together with stem **3** is positioned in aligned holes **4** of the plates to be joined **5**. The stem **3** may have serrations **6** and knurled grooves **7**, or other means for adapting it to a suitable riveting gun as known in the art.

The available blind site clearance is indicated by the space between the bottom one of the plates **5** and the angle piece **8**.

The lower or blind head-forming end of stem **3** comprises an integral shear ring **9**, a tapered or conical section **10**, which may have an angle of 20°–27° to the axis of the stem, a conical recess **11** the apex of which may be a 90° angle, although this is not critical, and a shoulder collar **12**. The functions of these parts are more fully explained below. On the stem **3** is positioned lock ring **13** and break groove **14**, the functions of which are not unlike those of the corresponding parts of other blind rivets now known in the art.

The materials of construction of my rivet may be varied to suit the needs of the particular application, so long as their mechanical and physical properties, as modified by heat treatment, are so related as to insure operability of my riveting method.

Thus in one embodiment I use soft aluminum for my shank **2** and a heat treated harder aluminum head **1** with an alloy steel stem **3** as more fully described below.

Referring now more specifically to FIG. 2, the start of the riveting operation is shown therein. This is effected by the action of a suitable gun and dolly (not shown) on the head **1** and stem **3** by which the latter is drawn axially through the hollow rivet shank **2**. The action of shear collar **9** on shank **2** subjects the latter to axial compression causing it to bulge as shown, and to start filling the holes **4**.

As the relative motion between stem **3** and rivet head **1** continues, a condition shown in FIG. 3 is reached wherein shank **2** has acquired a considerable bulge and the holes **4** are substantially full of metal, the plates **5** being clamped together by then.

When the operation has progressed to the point shown in FIG. 4, the blind end of shank 2 has been formed into a relatively large diameter bulbed blind head 15 which is crushed up against the blind sheet thus providing a large area of rivet head bearing against the sheet. The part of shank 2 lying within holes 4 has now been expanded by axial compression so as to solidly fill the holes 4. Shear ring 9 has taken the position of penetration within head 15 formed from shank 2 as shown.

At this point reference should be had to FIG. 7 to better understand the unusual results obtained from the head-former of my invention positioned on rivet stem 3. The upper face of shear collar 9 is inclined from the horizontal at an angle of approximately 10° providing a recess in the face and a sharp cutting edge as shown at 16 in FIG. 7. This performs a double function. It prevents any tendency of the rivet shank end to flare out into a tulip type head. It also acts to cut off a doughnut shaped ring of material comprising a washer from the end of rivet shank 2 during the formation of bulb head 15 as shown at 17, in FIG. 4 as more fully described below.

This double effect of the shear collar 9 on the end of rivet shank 2 becomes apparent from a closer study of the steps of FIG. 2, FIG. 3 and FIG. 4. In FIG. 2 the shank 2 is just commencing to deform and the softer metal at the end of shank 2 has been caused to flow into the recess in the face of hard shear collar 9 provided by the inclination of this face as shown at 16, FIG. 7. This acts as a cup to retain the end of shank 2 and continues to force the latter radially inward against pull stem 3 as the latter advances. The action of the hard metal of the collar 9 on the soft metal of shank 2 is similar to that of a cold tube drawing operation in which the softer metal flows out over and around a harder mandrel or drawing element rather than being forced radially outward.

As the shear collar 9 advances, the bulge 15 in shank 2 becomes larger and is forced tighter against plates 5. This causes the sharp edge of face 16, FIG. 7 to dig into the now greatly bulged head 15. As the collar 9 advances further this digging or cutting action continues and when it has advanced a sufficient distance into the expanding bulged head, a doughnut shaped ring will be cut out of the interior of the head next to stem 3 by the cutting edge of face 16.

As the stem 3 is further pulled through rivet head 1, the shearing stress on shear collar 9 reaches a value such that it causes shear collar 9 to shear off of the main body of stem 3. Further movement of the stem 3 relative to rivet head 1 causes shear collar 9 to slide on conical section 10 thus further expanding and tightening bulbed head 15. The doughnut section or washer 17 at this point acts as a cushion or washer between the hard metal of the stem cone 10 and the rivet shank 2 which aids in uniformly transmitting and distributing the stress from the conical section 10 to rivet shank 2, through the bulbed head 15 and to the lower plate 5 and holes 4.

During this latter operation, another unusual effect takes place. The metal comprising the bulbed head 15 is caused to flow around shear ring 9 completely enshrouding it and adding greatly to the effectiveness of the rivet head 15 and increasing the strength and rigidity of the finished joint.

In the embodiment shown in FIGS. 1 to 5 the advancement of stem 3 through rivet head 1 ceases when shoulder collar 12 has reached a position of contact with shear collar 9. When this occurs, break groove 14 is flush with the top of rivet head 1. Shoulder collar 12 thus acts as a limit on the maximum grip which may be realized with a given rivet. It also prevents shear ring 9 from sliding off the stem in the event it became "cocked" during the process.

Final step comprises setting of lock ring 13 and fracturing of stem 3 at break groove 14, the finished joint appearing as shown in FIG. 6. During this last step the resistance provided by the cone 10 pulling into the ring 9 together with the resistance provided by the lock ring 13 itself must be sufficient to cause the stem 3 to fracture rather than continue to pull on through rivet head 1.

All of the foregoing description applies specifically to installation of the rivet at or near maximum grip or thickness into which the particular rivet is designed to work. When installed at or near the minimum grip thickness the operation is similar except that due to the thinner grip the break groove 14 of stem 3 reaches a position flush with the top of rivet head 1 without the shear collar 9 being sheared. At this time the lock ring 13 is set and the stem is fractured at break groove 14. The resistance to pull through provided by the shear collar 9 and the lock ring 13 must be sufficient to cause the stem 3 to fracture rather than continue to pull on through the rivet head 1.

That this will normally be the case with the short rivet grips is obvious from the fact that less stress will be required to expand the rivet shank 2 and form the head 15 when the length of grip approaches the minimum.

The condition of the rivet at the completion of the short grip operation will be similar to that shown in FIG. 4 and FIG. 12. The head 15 will be substantially formed as will the washer 17. The effect of cone 10 going through shear collar 9 will, of course, not be realized, but it will not be needed since with the shorter grips an adequate joint will be formed in accordance with the basic principles of this invention without having to rely on the latter. In the short grip cases also the function of shoulder collar 12 is unimportant since that is performed by the shear collar 9. The embodiment shown in FIG. 9 may therefore be used. The operation of this embodiment is described below.

The features which combine to prevent stem pull through are especially significant in the alternate embodiment of my invention shown in FIGS. 9 to 14 inclusive, in which like parts bear like numbers. The essential difference in this embodiment is that there is no maximum grip limiting shoulder collar shown at 12 on the previous figure.

The foregoing description of my method therefore holds equally for the alternate embodiment, steps of FIG. 9 to FIG. 12. FIG. 13 however, differs from FIG. 5 in that no reliance is placed upon a shoulder collar 12 but reliance is had on the combined action of shear ring 9 and conical section 10 to prevent the stem from pulling through rather than having it fracture when the break groove 14 is substantially flush with the top of rivet head 1.

For this to happen, of course, there must be a proper coordination of the physical properties of the materials used with the dimensions of the parts as indicated above. Thus, the compressive strength of the major portion of the rivet shank 2 relative to the shear value of the shear ring 9 must be such that material flow is initiated and a full and complete blind head 15 is formed against the blind side sheet in all material grips, before the ring 9 shears.

The breaking strength of the stem 3 at break groove 14 must be such that under all normal installation conditions the locking groove which receives lock ring 13 is pulled to the correct position to receive the lock ring. The tensile yield strength of the stem 3 material must be such that no permanent set is produced by a load equal to the breaking strength of the stem 3 at break groove 14. For example, the major portion of the rivet shank 2 may be of an aluminum alloy of 22,000 p.s.i. tensile yield strength, and 42,000 p.s.i. tensile ultimate strength, and the stem 3 may be made of an alloy steel having a tensile yield strength of approximately 190,000 p.s.i. and a tensile ultimate strength of approximately 220,000 p.s.i.

The hardness of the manufactured or preformed rivet head 1 must be sufficiently higher than the rivet shank

2 so that distortion of the rivet head under the compression load applied during installation is limited to a satisfactory degree as noted below. If this is not provided for, then the recess in the rivet head **1** which receives lock ring **13** may become cup-shaped or the rivet shank **2** may move relative to the rivet head **1** in such a way as to shear the rivet head **1** completely from the rivet shank. Moreover, if the lock ring **13** is too hard and lacking in ductility relative to the rivet, it will not swage into the required cone shape but will merely dig into the rivet head **1** and distort it. On the other hand, if the collar is too soft and ductile relative to the rivet, it will either altogether fail to penetrate the cavity between the rivet **1** and stem **3** or it may not satisfactorily resist the tendency of the stem **3** to continue to pull through the rivet **1** after installation is complete. These problems I may solve by giving a heat treatment to the rivet head **1** which renders it much harder than the major portion of rivet shank **2**.

I may solve these problems also by using a flat preformed rivet head **21** and the special installation tool **22** of FIG. 8. In this embodiment my riveting tool head **23** is equipped with a flush button or backer **24** which bears down upon the flat head of rivet **21** supplying the reacting force during the pulling of the stem. Simultaneously the lock ring anvil **25** bears against lock ring **26**. As the rivet stem (not shown in FIG. 8) advances, the reaction of the force on the rivet shank is taken by flush button **24** pressing against the flat rivet head **21** while lock ring anvil **25** holds lock ring **26** in its proper position in the conical recess between the rivet stem (not shown in FIG. 8) and the flat rivet head **21**. Unwanted distortion is thus prevented and upon completion of the pulling operation, the lock ring **26** may be properly set.

The protruding portion **27** of the material in the rivet bore adjacent the head **1** of the rivet protrudes into an adjacent reduced stem section on the stem **3**, as shown on FIGS. 5, 6, 13 and 14. These protrusions are caused by axial flow of material from the inside bore of the rivet shank as a result of pulling the lower portion of the stem **3** into the bore of the shank **2**. Shank **2** is subjected to axial compression causing it to bulge and start to fill the hole **4**. This hole filling or shank wall thickening causes some metal to flow into the reduced stem section immediately below the break groove **14**. The pulling of the lower end of the stem **3** through the shank **2** tends to roll a wave of material ahead of it which comes to rest at the rivet head **1**, as shown.

I claim:

1. A rivet assembly of the class adapted for riveting from one side only of a structure, said assembly comprising; a hollow shank rivet with preformed head on one end, a stem slidably mounted in said hollow shank rivet, a head-former positioned on the tail end of said stem, said head-former comprising; a concentric shear collar positioned against the tail end of said shank with

the face of said collar adjacent the shank being inclined toward said shank at an angle substantially less than 90° with the stem axis, said face defining a concave recess facing said preformed head and having a sharp-edged outer periphery, a conical stem section the smallest diameter of said conical section being positioned against said shear collar, the junction of said shear collar and said conical stem section providing a minimum cross sectional area whereby said collar will shear at said junction the diameter of said conical section being uniformly increased in a direction toward the tail end of said stem and having a shoulder collar positioned at and contiguous with the greatest diameter of said conical section, said shear collar having a predetermined shearing strength lower than the predetermined tensile strength of said stem, means for engaging an axial force on said stem whereby a bulbed head is formed on said shank, means for locking said stem to said shank.

2. A rivet assembly of the class adapted for riveting from one side only of a structure, said assembly comprising; a hollow shank rivet with preformed head on one end, a stem slidably mounted in said hollow shank rivet, a head-former positioned on the tail end of said stem, said head-former comprising; a concentric shear collar positioned against the tail end of said shank with the face of said collar adjacent the shank being inclined toward said shank at an angle substantially less than 90° with the stem axis, said face defining a concave recess facing said preformed head and having a sharp-edged outer periphery, a stem section extended away from said shank beyond the said shear collar, said stem section being gradually increased from its junction with said shear collar toward the tail end of said stem, the junction of said shear collar and said stem section providing a minimum cross sectional area whereby said collar will shear at said junction, a shoulder collar positioned at the greatest diameter of said stem section, said shear collar having a predetermined shearing strength lower than the predetermined tensile strength of said stem, means for engaging an axial force on said stem whereby a bulbed head is formed on said shank, and means for locking said stem to said shank.

3. The rivet assembly of claim 2 in which the outer circumference of said concave recess of said collar is formed into a cutting edge for shearing a circular section from said shank during the formation of said head on said shank.

4. The rivet assembly of claim 2 in which the tail end of said stem has a generally conical axial recess therein.

References Cited in the file of this patent

UNITED STATES PATENTS

2,061,629	Huck	Nov. 24, 1936
2,372,222	Mullgardt	Mar. 27, 1945
2,397,111	Huck	Mar. 26, 1946
2,408,559	Keating	Oct. 1, 1946

Disclaimer

3,148,578.—*Roland H. Gapp*, Santa Ana, Calif. RIVET AND METHOD OF RIVETING. Patent dated Sept. 15, 1964. Disclaimer filed Oct. 6, 1980, by the assignee, *Textron Inc.*

Hereby enters this disclaimer to claims 1–4 of said patent.

[*Official Gazette December 9, 1980.*]