

July 31, 1951

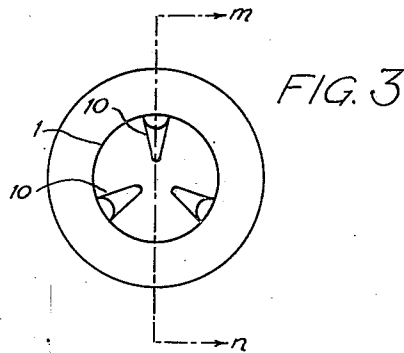
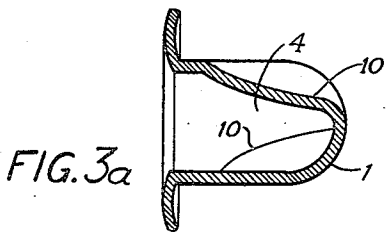
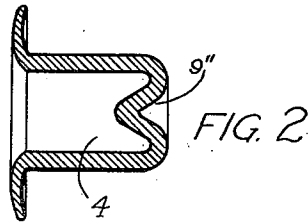
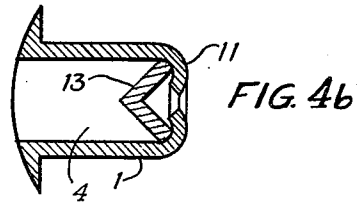
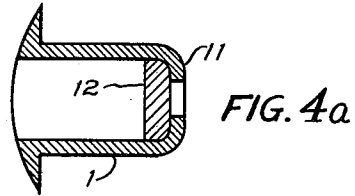
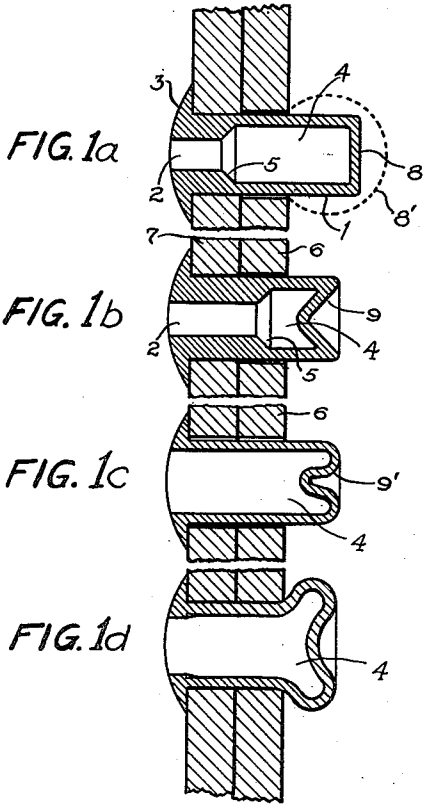
J. J. JAKOSKY

2,562,721

METHOD OF HYDRAULICALLY EXPANDING HOLLOW RIVETS

Filed Aug. 13, 1941

2 Sheets-Sheet 1



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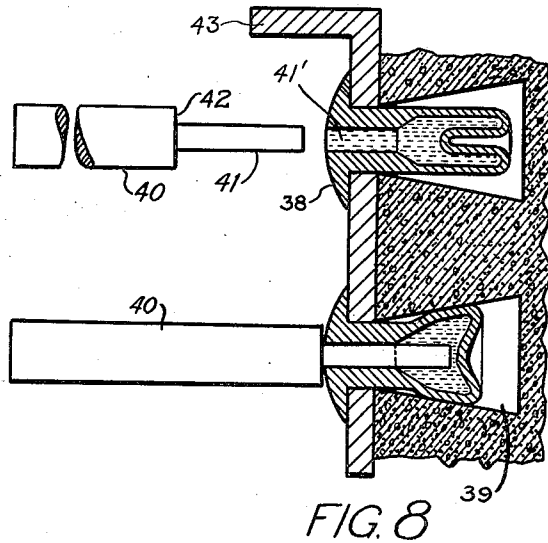
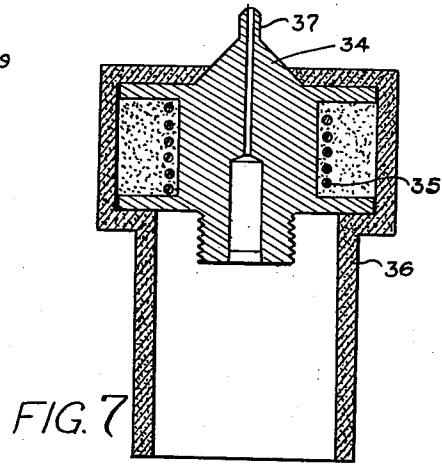
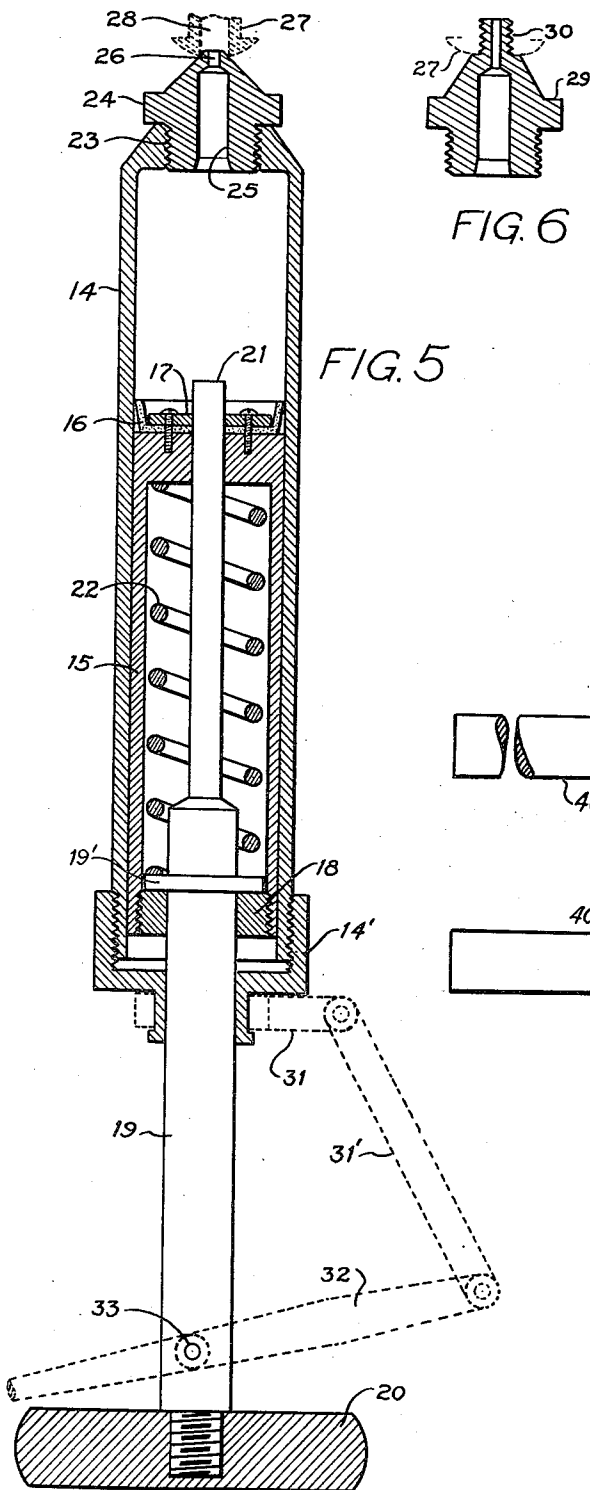
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METHOD OF HYDRAULICALLY EXPANDING HOLLOW RIVETS

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2 Sheets-Sheet 2



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2,562,721

METHOD OF HYDRAULICALLY EXPANDING
HOLLOW RIVETSJohn Jay Jakosky, Lawrence, Kans., assignor to
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1 Claim. (Cl. 218—29)

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This invention relates generally to riveting and a particular combination of a rivet and a method for setting rivets in an improved manner. The chief purpose of the method is for fastening structural elements. A particular purpose relates to that type of rivet and method of riveting which is adapted for application and driving solely from one side of the work to be riveted together. In applying rivets to certain types of work, such as walls, small tanks, compartments and many structural members, it is often difficult to provide means for backing-up or supporting the rear side of the rivet when it is being driven. Under these conditions it is most advantageous to use a type of rivet which may be inserted and upset wholly from the exterior of the structure. There are rivets of this type in the prior art, such rivets and methods of riveting comprising essentially: (a) expansive rivets of the explosive type, (b) tubular rivets, wherein mandrels are drawn through the rivet to effect axial collapsing and/or radial expansion of the rivet shank and (c) screwing mandrels which engage internal threads on the tubular rivet, causing similar mechanical deformation to that mentioned under b. The present invention is concerned with an expansive rivet whereby the upsetting or seating of the rivet is accomplished by hydraulic means.

Another object of the improved rivet described herein is to provide a design and shape that may be made in all sizes, including the very smallest commercially used sizes, measuring a fraction of an inch in diameter, and which may be made of all metals used for ordinary rivets, such as copper, aluminum and its alloys, magnesium and its alloys, and other deformable metals.

Another object of this hydraulic expansion-type rivet is to provide a rivet that may be used with safety to persons and to property or places subjected to fire hazard.

An important object of this type of expansive rivet is its freedom from the hazards incidental to handling, transportation and storage of explosives.

Another advantage of this hydraulic expansion rivet over the explosive type, lies in the fact that it is upset or seated into position in but a fraction of the time required for the heating and detonation of the explosive rivet. From 30 to 50 of these hydraulic rivets may be installed per operator

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per minute, after the rivets have been placed in the work. This is more than three times the speed of installation for explosive rivets and ten times the speed for the conventional rivet requiring backing on one side and peening on the other.

A most important object is to provide a rivet which will not require an accurately machined hole for its insertion. In use, the shank of this rivet, due to the equalization of hydraulic pressure, firmly seats itself against any unevenness or misalignment of the edges of the sheets being riveted together, causing a good firm fit which develops good shearing strength of the rivet. This is particularly advantageous when riveting materials which have a tendency to crack or check, such as the magnesium materials. Rivets seated by my invention actually "flow" or expand into the irregularities in the walls of the hole provided for the rivet.

A special feature of this improved type of rivet and method of riveting, is the ability to accurately control the amount of expansion or setting of the rivet. This feature is particularly advantageous in eliminating the difficulties due to rupturing of the rivet shank, or other mechanical failure as is often encountered in the explosive type of rivet and in some tubular types of rivet. It is prevalent commercial experience that rivets deformed in an unexpected manner do not securely hold together the structures, metal plates, etc., but are apt to be loosened easily or to be dropped off altogether. If the improperly seated rivet stays in the work, it must then be drilled out with consequent liability to enlarge the hole, causing serious decrease in the strength of the succeeding rivet or rivets necessary before a properly seated rivet is obtained.

An important feature of the invention is the ability to take advantage of the initial ductile conditions of the metal of the rivet. It is well known that hammering and any other means which compacts the structure of the metal causes "work hardening" of the rivet while it is being seated. This results in loosely seated rivets that are brittle and often crack, usually causing deformation and cracking of the sheets being fastened together. The ideal condition is approached by utilization of the hydraulic means described herein because the expansion is done usually in one single operation, and the structure

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of the metal is expanded rather than compacted.

Another noteworthy object of this invention is to provide a method of riveting whereby the rivet is expanded and seated under optimum temperature conditions. Most materials utilized in the manufacture of rivets, have a definite increase in ductility with an increase in temperature. This is particularly true of certain alloys of aluminum and magnesium. These materials are often particularly difficult to work at ordinary temperatures but have increased deformability at higher temperatures. This feature is also particularly desirable in the case of rivets made from certain plastics and other substitute materials.

A complete understanding of the invention may be obtained by reference to the accompanying drawings, forming a part of the disclosures of the specification, wherein:

Figure 1a is a sectional view showing one type of hollow rivet embodying my invention.

Figure 1b is a sectional view of another modification of a hollow rivet embodying my invention.

Figure 1c is a sectional view showing still another form of a hollow rivet embodying my invention.

Figure 1d is a sectional view showing the rivet illustrated in Figure 1c in expanded condition.

Figure 2 shows an extrudable type of hollow rivet possessing light-weight and high mechanical strength, and which may be formed or punched from sheet material.

Figure 3 illustrates a top view of a convolute type of hollow punched rivet.

Figure 3a is a sectional view taken along the line m—n of Figure 3.

Figure 4a shows a design which has been found to be advantageous for very small diameter rivets and rivets made from the less ductile materials.

Figure 4b shows another design which has been found advantageous for the smaller diameter and/or the less ductile rivets.

Figure 5 shows an improved type of hydraulic "gun" that has been found advantageous for use in this method of riveting.

Figure 6 shows a tip, provided with a thread for engaging the rivet and which has been found to be useful in certain cases.

Figure 7 shows an alternate type of tip for the "gun" whereby heating means are provided to maintain the fluid within the gun at the elevated temperatures.

Figure 8 shows a rivet filled with a plastic or other fluid-like material capable of setting in situ, and means for expanding such a rivet.

The rivets for use with this method are of the general designs shown in the figures. The head shape of the rivet may be the Brazier, countersunk or other conventional design, and the shank may be of any desired length as is governed by the thickness of the work or sheets being fastened together. When the rivet is placed in the work, the exposed portion of the shank should extend beyond the surface of the work a distance of approximately the diameter of the rivet. This distance varies, however, with the diameter and the design of the end of the shank and with the material employed in making the rivets. Generally, this distance is seldom less than $\frac{1}{3}$ or greater than $1\frac{1}{2}$ times the diameter. The exact distance may be readily determined by simple experimentation.

The shanks of these rivets are normally of cylindrical shape, with a uniform outside diameter. One simple design for the rivet is shown

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in Figure 1a. A small diameter hole or chamber 2 passes through the head 3, of the rivet. For reasons to be explained later, the area of the chamber through the head of the rivet should be less than the area of the plunger in the high pressure stage of the "gun." When this design of rivet is subjected to a high hydraulic pressure, the portion of the wall 1 which is not supported by the plates 6 and 7 and the end 8 of the rivet expands outwardly and approximates a bulbular shape as indicated by the dotted line 8'.

In the designs illustrated in Figures 1a and 1b the hole or passageway 2, terminates in an enlarged portion or chamber 4, in the outer end of the shank. The axial length of this enlarged portion is dependent upon the uses of the rivet. Where the holes for the rivet are accurately reamed through the work, resulting in a snug fit of the rivet, maximum shearing strength may be obtained by limiting this enlarged portion to such an axial length that the head end 5, of the cavity 4, lies well within the thickness of the second plate 6, as is indicated in Figure 1b. Where the rivet is employed for work wherein the rivet holes are not accurately reamed, as for use in punched or drilled holes, better over-all results are obtained by so proportioning the shank that it will expand radially throughout substantially its entire length. This type of design is shown by Figures 1a and 1c. When a fluid is pumped into this latter type of rivet, the shank will expand or "flow" into all irregularities, and give a full and even contact with the wall of the entire hole through the work. The hydraulic method of expansion or seating a rivet gives a more intimate and better fitting contact than any other method of expansion. Figure 1d shows the usual expanded shape of the rivet shown in Figure 1c.

The rivets may be formed by conventional production methods, including machining, punching, spinning, or pressing; the decision as to process of manufacture being dictated by conventional production methods for manufacturing articles of this type.

The rear end of the shank of the rivet terminates in a fluid tight end. This end may be substantially flat as shown by 8, in Figure 1a. In the preferred forms, the end of the rivet comprises a design such that when hydraulic pressure is applied to the inside of the rivet, the pressure will act on the end in such a manner as to cause it to aid in the radial expansion of the exposed end of the shank. Rivet ends of the preferred expansion types are shown in Figures 1b, 1c, Figure 2 and Figure 3, and Figure 4.

The chief object of the preferred design is to provide an end to the rivet, of such a construction that said end will tend to open or extrude, and thereby aid in enlarging the diameter of the rivet as the liquid is injected into the chamber. An extrudable end design is shown in Figures 1b, 1c and 2, while Figure 1d shows the average expanded shape of 1c. A convolute end design is shown in Figure 3, and is preferably die-formed from sheet material. In this design, longitudinal and axial convolutions are formed in the shank and end of the rivet. These preferred designs give a larger expansion to the end of the rivet than would normally be possible due to the stretching or yielding of the metal itself.

Figure 2 illustrates a rivet which is punched, spun, or formed from sheet material. This type

of rivet has proved very satisfactory because of its light weight and excellent holding power. Experience indicates that the rivet should be formed from material having a thickness of $\frac{1}{8}$ to $\frac{2}{3}$ the total thickness of the plates being fastened together. The diameter may be varied over wide limits, but $\frac{1}{2}$ to 2 times the total thickness of the work has been found satisfactory for most operations.

A type of construction more suitable for some smaller or heavier rivets is shown in Figures 4a and 4b. In this design the shank 1 is proportioned similarly to that previously described, but at the outer end 11 it is crimped or spun over to act as a mechanical support for a plug 12, or a bulkhead 13. Referring to Figure 4a, pumping fluid into the chamber 4 causes the plug 12, to move outward, which mechanically aids the normal expansion of the shank due to the hydraulic pressure. In Figure 4b, a pressed bulkhead 13 is fastened into position by crimping over the end 11, of the shank 1. Pumping fluid into the chamber causes the bulkhead to flatten and expand radially, which expansion aids the expansion of the shank due to the hydraulic pressure.

Various means may be employed for causing the hydraulic expansion of the rivets. Generally speaking, almost any type of hydraulic pressure pump may be employed. However, as previously stated, an important feature of the invention is the use of a substantially incompressible fluid in measured quantity; that is, a predetermined volume of the incompressible fluid is injected into the rivet. By this means, the amount of expansion of the rivet may be accurately controlled. This improved procedure prevents split rivets which are caused by the injection of too much fluid or else improperly expanded and poor seating rivets as are caused by use of too small a quantity of fluid.

The fluid may be gaseous, liquid, or plastic. Under certain requirements of use, the fluid should be capable of solidifying after the desired expansion has been effected. This may be accomplished by chemical action (grout made from Portland cement or plaster-of-Paris), by evaporation of a solvent (glycol and similar lacquers), or by cooling to normal temperatures (heated sulphur or low melting-point alloys and metals, such as solder, tin, etc.) Gaseous fluids have not proved satisfactory, however, due to their high compressibility. When gas is used, the rivets are expanded with pressure as the sole criterion or control.

Accurate expansion of these rivets may be obtained only by a volumetric control, utilizing a measured quantity of a substantially incompressible fluid. An improved type of "gun" or pump for accomplishing this feature is shown in Figure 5. It will be apparent that a small amount of air is entrapped in each rivet. This air normally would introduce a variable that interferes with the accurate control of the amount of expansion, due to its high compressibility. The entrapped air often forms a "cushion" that gives variable results depending upon the time interval during which the pressure is applied. These difficulties are practically overcome by first placing the rivet under sufficient pressure to cause compression of the air and some absorption into the liquid. This condition obtains at pressures in the neighborhood of 100 p. s. i. (pounds per square inch). The accurate control of the expansion of the rivet is

now obtained by forcing a given volume of liquid into the chamber. These operating conditions are obtained by means of a "duplex" gun of simple design that is light in weight and hand operated.

One preferred or duplex type of gun comprises a barrel housing 14, inside of which is a moving cylindrical piston 15. The piston preferably is provided with a pliable gasket or washer 16, held in position by the metal ring 17. At the other end of the piston is a retaining ring 18. Within the piston 15, is a movable member 19, terminating at its exposed end in a handle 20. The other end of this movable member terminates in a piston or plunger 21, of small diameter. A spring 22 bears against the shoulder 19' on the member 19, and normally holds the member 19 in the position shown in Figure 5. One end of the barrel 14, terminates in a female threaded portion 23, which receives a tip 24. The interior end of this tip contains a small cylinder 25, of predetermined volume. This cylinder and the plunger 21 are accurately machined to produce an efficient entrapment of the liquid in the cylinder upon entry of the plunger thereto. The cylinder 25 is connected by means of a small passage 26 to the exposed end of the tip. This tip is properly proportioned to fit into the opening of the rivet. Various tips having cylinders of the desired length are provided for the different sized rivets in order to secure the proper expansion for each size.

The internal diameter of the working barrel 14 and the strength of the spring 22 are such that pressure on the handle 20 will force a charge of the liquid into the cylinder 25, whereupon further pressure upon this handle will compress the spring 22 and force the plunger 21 into the cylinder 25 to hydraulically drive the liquid into the rivet.

In operation, prior to starting to upset a series of rivets the gun is filled with the desired fluid and then the tip 24 is placed coaxially and into firm contact with the rivet 27, as shown in Figure 5.

The operator pushes against the handle 20. As long as the force exerted by the fluid against the piston is less than 20 pounds, the piston 15 will move with the handle, there being no relative movement of 19 with respect to 15. As soon as the resistance to movement to the piston 15 is greater than 20 pounds in the aggregate, movement of the piston will stop and relative movement of the handle 19 with respect to the piston 15 will begin, thus permitting the plunger 21 to continue to move toward the cylinder 25.

The plunger 21, moving toward the tip of the gun, enters cylinder 25. As it does so, the liquid is trapped in the rivet and cylinder 25, so that further movement of the plunger 21 creates a unit pressure in the rivet equal to the total thrust against the handle minus the pressure absorbed by spring 22, say twenty to thirty pounds, divided by the area of the plunger. If this area is small, and too much of the available thrust against the handle has not been required in compressing spring 22 to insert plunger 21 into bore 25, a relatively large unit pressure can be built up in the rivet by a relatively small thrust on the handle.

In operation, it has been found that the average operator can exert without undue effort, a momentary force or thrust of over 50 pounds on the handle 20. This produces a net thrust on the plunger 21 of 50 lbs. minus the pressure absorbed

by the spring 22. In order to produce a final hydraulic pressure of approximately 2,000 p. s. i., which value has been found to be satisfactory for many riveting techniques, the cross sectional area of the cylinder 25 would be the net total thrust available divided by 2000. The length of the cylinder 25 determines the volume of fluid which can be forced into the rivet. This accurately measures the liquid and limits the expansion of the rivet.

In order to prevent leakage of the fluid between the tip 24 and the rivet 27, it is necessary that the force against the handle 20 be sufficiently greater than the opposing hydraulic pressure to compensate for the back pressure tending to disengage the tip and the rivet. This may be accomplished by constructing the rivet 27 so that its passageway 28, where it contacts the tip 24, is of less cross-sectional area than the cylinder 25. The rivet shown in Fig. 1a has such a construction.

Some types of work will not allow a thrust against the rivet of sufficient force to create the proper expansion pressures or to give the necessary seal between the tip 24 and the head of the rivet. Where sufficient pressure may be exerted to expand the rivet but insufficient pressure to give the necessary seal may be exerted a special tip 29, as shown in Figure 6, is provided with a male threaded member 30 to engage a corresponding female threaded portion of the rivet. Where it is desired to minimize the thrust against the work the operator may hold the barrel 14 with one hand and minimize the thrust while the handle 20 is being operated. A similar effect is obtained by means of the lever attachment shown by the dotted lines of Figure 5. An extension 31 fastens to the rear end of the gun, and by means of a connecting link 31', pivotally supports a lever 32 which engages the movable member 19 by means of a pin connector 33. By applying a force against the free end of lever 32, the desired results are obtained without a thrust against the work which in the case of thin, unsupported sheets may be of sufficient magnitude to cause damage. Usually, the thrust against the head of the rivet is not undesirable as it presses into close contact the structure being riveted together, with a resultant tight riveted joint.

Certain materials from which rivets are made handle better at elevated temperatures. This is particularly true for magnesium and certain aluminum alloys. For instance, magnesium may be used as a rivet material only with great difficulty due to its tendency to become brittle or "work hardened." At temperatures of 300° F. to 500° F. however, magnesium may be worked much more advantageously. The improved results at the higher temperatures are obtained by the method illustrated in Figure 7. The gun is used with a special tip 34. This tip is provided with an electric or other heating device 35. A heat insulating cover 36 extends over the tip and the working barrel 14 of the gun. The temperature of the fluid within the gun is maintained at the desired value by regulating the current flow through the heating coil 35. The tip 34 may also be provided with a plain or screw extension 37, if desired. Due to the relatively high specific heat of the liquid as compared to the rivet material, the fluid quickly raises the the temperature of the rivet and thereby allows the expansion to take place at an elevated temperature. For this work, I have found it advantageous to employ a liquid that will not be unduly decomposed at the

elevated temperatures, such as an SAE No. 50 lubricating oil, and certain low melting-point metals such as solder, tin, etc.

A simplified procedure for using these expansion rivets is shown in Figure 8. This procedure advantageously may be employed where only occasionally riveting is being done. It eliminates the cost of the gun, but is not as rapid for production work.

The rivet is shown at 38, after being inserted into a tapered hole 39. It will, of course, be apparent that the rivet would function for the purposes of fastening sheets, and other riveting operations. A seating tool 40 is provided with an extension 41. The diameter of the bore 41' of the rivet and the length of the extension 41, allow accurate control of the expansion of the rivet since these two factors govern the volume of liquid displaced. In use, the rivet is filled with the desired liquid and the extension 41 is placed against the rivet opening. A blow, preferably cushioned by use of a heavy rubber mallet, is now given the tool 40, and the extension driven in to the shoulder, 42.

For this purpose, I have found that it is advantageous to employ liquid of the following three types: (1) a plastic material, such as soft rubber compounds; (2) a thermo-plastic material that is solid at ordinary temperatures, but has the desired fluidity at elevated temperatures, such as sulphur, resin, pitch and various organic plastics, and (3) a solidifying material, as previously described.

The second classification described above allows the rivet to be worked at a higher temperature, which is desirable for certain materials as previously described. Both the second and third classifications give added mechanical strength to the rivet due to the solidifying of the liquid medium with resultant re-enforcing of the rivet. It will, of course, be seen that any of these liquid materials may be employed with the gun previously described. Generally speaking, however, such materials are not required for the usual riveting operations. One exception exists however in those riveting tasks where an objection may be raised to the use of rivets having the small opening in the head. Under such conditions, it is advantageous to use a liquid or fluid mass that will harden or become set in situ after the riveting operation has been completed. Such a procedure has the advantage of filling the rivet cavity to close the opening, and at the same time giving added mechanical strength to the rivet.

Although I have shown and described certain specific embodiments of the invention, it will be apparent that many modifications are possible. This invention, therefore, is not to be limited to the specific embodiments described herein but shall include all that is new over the prior art within the spirit of the appended claim.

I claim:

The method of riveting which comprises providing a rivet having in the shank thereof a cavity provided with a single access opening, the exposed shank walls defining said cavity having at least one reentrant portion therein, inserting a nozzle in said opening to close the same, and forcing fluid-like material capable of setting in situ under pressure into the cavity through said nozzle to extend said reentrant portion of said exposed shank walls.

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