Aug. 30, 1966 D. P. WELLES, JR 3,269,006

METHOD OF SWAGING METAL TUBES ONTO INTERNAL MEMBERS

Filed Aug. 20, 1964

Fig. 1.

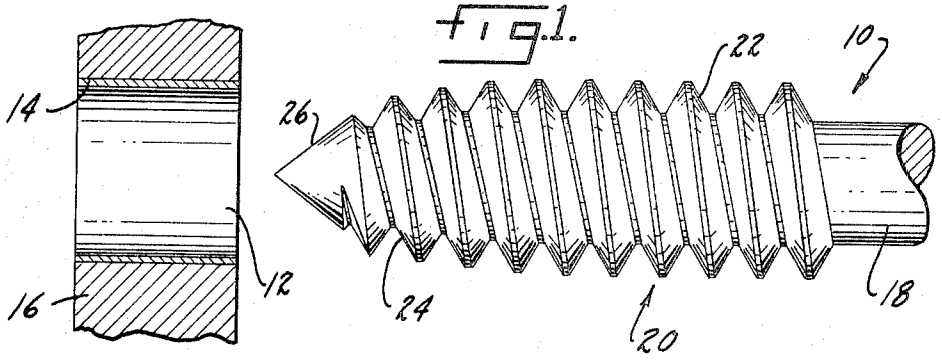


Fig. 2.

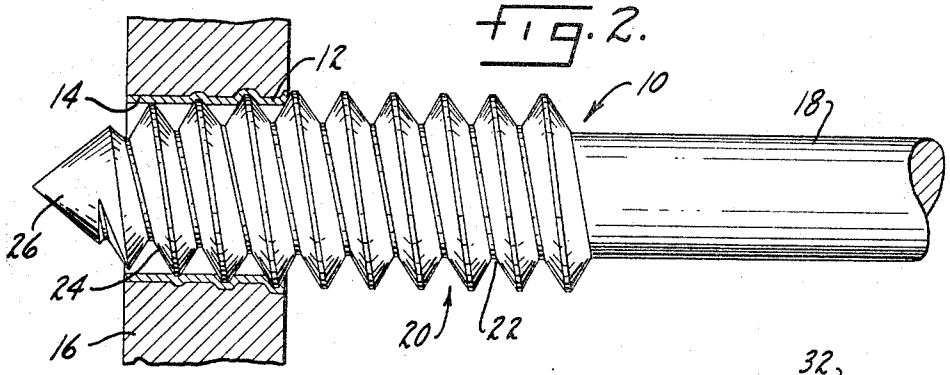
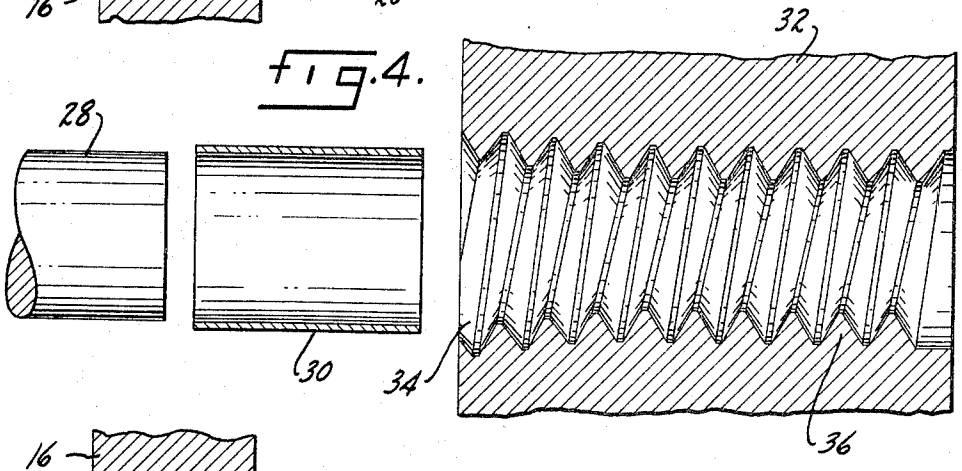


Fig. 4.



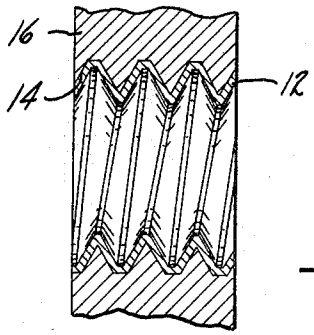


Fig. 3.

INVENTOR.
Donald P. Welles Jr.,
BY Parker & Carter
Attorneys.

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3,269,006

METHOD OF SWAGING METAL TUBES ONTO INTERNAL MEMBERS

Donald P. Welles, Jr., Rockford, Ill., assignor, by mesne assignments, to Besly-Welles Corporation, a corporation of Delaware

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1 Claim. (Cl. 29—517)

This is a continuation-in-part of Serial No. 748,210, filed July 14, 1958, now abandoned, and Serial No. 217,026, filed August 15, 1962, now abandoned.

This invention relates to a method of joining a thin wall tube to a concentric surface.

Another object is a metal working method applied to a thin wall ferrule or tube to simultaneously displace the metal from one side or surface so that the other side or surface will be deformed into locking contact with a workpiece or supporting part.

Another object is a method of locking a thin wall tube or ferrule in a hole so that thereafter it functions as the liner for the hole.

Other purposes will appear in the ensuing specification, drawings and claim.

The invention is illustrated diagrammatically in the following drawings wherein:

FIGURE 1 is an exploded side view, partly in section, illustrating the first step in my method,

FIGURE 2 is a side view, similar to FIGURE 1, showing the tool partially within the thin wall tube,

FIGURE 3 is a side view, similar to FIGURES 1 and 2, showing the tube completely seated in the hole, and

FIGURE 4 is a side view, partly in section, of a variant form.

The invention relates to a method of joining a thin wall tube and a concentric surface, for example two concentric tubes, a thin wall tube and a plate, or a thin wall tube and a plurality of plates or a thin wall tube and a casting or section of a casting. In essence, a hole may be formed in one or more plates or other members and a thin wall tube is seated in the hole. A suitable tool, such as that shown in my Patent Re. 24,572, may be used to thread or fin the interior of the thin wall tube. Because the tube is thin walled, the outer surface is distorted or expanded generally to the same extent as the inner surface. The outer surface accordingly will fuse or unite with the surrounding surface which is cooperatively distorted. In this way, a joint may be formed between a pair or plurality of plates, between a single plate and a thin wall tube or between a pair of concentric tubes.

Considering FIGURE 1, a tool **10** of the general type shown in my Patent Re. 25,572, is positioned to be inserted within a thin wall tube **12** positioned in a hole **14** in a plate **16**. The material of the tube **12** and the member **16** may be important. For example, the tube **12** should be of a material that exhibits some ductility such as copper, steel and the like, or some other material which may be cold worked. The member **16** should also be of a somewhat ductile material or a material which will not compress but will distort when subjected to pressure. Because the tube **12** is somewhat soft or ductile, it will distort as described hereinafter, and become embedded within the member **16**.

The tool **10** may have a threaded metal working surface. Such a tool may include the conventional shank portion **18** which may be formed at one end, not shown, in any suitable manner so that the tool may be driven, rotated or otherwise operated. The tool is provided with a thread formation designated generally at **20** which may be formed by a single start V-shaped thread divided into a full thread area **22** and a tapered thread area **24** leading to a point or nose **26**. In the full thread area **22**

the threads may have a constant thread depth and the pitch diameter, crest diameter, and root diameter undulate peripherally in a constant pattern. In the tapered area **24** the thread is tapered inwardly so that the crest, pitch and root diameters uniformly decrease but the thread depth remains constant and is the same as in the full thread area **22**.

The thread form or turns of the entire threaded section **20**, including the full threads **22** and the tapered threads **24**, may have longitudinally disposed relief areas. For example, the thread turns of the tapered area **24** and the full thread area **22** may be formed with varying outside, pitch and root diameters for each turn of the threads. Further details of such a thread formation are illustrated in the above-mentioned reissue patent.

Preferably, the pitch diameter of the threads on the tool **10** is generally the same as the initial diameter of the tube **12**. The tube **12** in turn will have the same approximate outside diameter as the hole **14** and will accordingly initially be in contact with the member **16**.

When the tool is inserted and rotated in the tube, as illustrated in FIGURE 2, first the tapered area **24** will work the crest of the threads into the inner surface of the tube in a smooth manner so as not to cut the tube. The metal of the tube will be displaced by the crowns or crests of the threads and will flow inwardly toward the root of the threads. The crests of the threads will apply radial pressure at uniformly spaced and limited axial areas with sufficient intensity to displace the material on each side of the crest axially and radially inwardly. The pressure is alternately applied and relieved because of the radial reliefs on the surface of the tool. The pressure will be applied in a uniform cyclical basis and, at first, the pressure will be uniformly increasing as the tapered area **24** moves into the hole. In effect, the tool applies metal working pressure directly to the inner surface at uniformly spaced but limited areas. As the tool or the tube within the workpiece, or both, is rotated, the width of the areas of applied pressure will increase, in this case in an axial direction, and the intensity of the metal working pressure will also increase so that the metal under or opposite the crests of the threads and those portions of the metal adjacent the crests will be displaced toward the root of the threads.

Because the tube is a thin wall tube, the outside will be deformed or distorted in somewhat the same manner as the inside. The final result is indicated in FIGURE 3 in which the tube is firmly interlocked in the hole **14**.

If the member **16** is a single plate, the tube will be interlocked with the plate, and if the material forming the member **16** is so soft that it normally does not form a good base for a screw, the tube **12** may then be used to mount a suitable securing member, such as a screw. If the member **16** represents a stack of plates, they will be joined together as they will each be interlocked with tube **12**. If the member **16** represents a concentric tube, the tubes will be interlocked or joined together.

It should be understood that the inside diameter of the ferrule or sleeve **12** is of the order of the pitch diameter of the full thread area **22**. The thickness of the metal of the sleeve is quite small. In fact, it may be substantially less than the radial distance between the pitch diameter and the crest diameter of the full thread area **22**. On the other hand, this should not be taken as a limiting factor since the ferrule wall could have a thickness on the order of this distance, or greater.

As mentioned above, the material of the tube or ferrule should be one that exhibits ductility. Copper, steel, aluminum and the like are all satisfactory, as are other materials. In addition, it is important that the parent material have somewhat the same properties. The parent material should be able to distort and be displaced as it

is subjected to both axial and radial pressure from the tube or ferrule. Materials which are compressible are not satisfactory as these materials will not distort nor be displaced as will an incompressible ductile material. For example, most woods are not satisfactory as they are compressible, there being air spaces in the fibers. When most woods are subjected to metal working pressure of the type described, with a ferrule, the wood will simply be pushed back and compressed. It will not distort and be displaced as will ductile materials.

Considering FIGURE 3, and the fact that the inside diameter of the tube should be about the same as the pitch diameter of the tool, note that both the inner and outer walls of the tube are displaced somewhat the same amount. The material of the member **16** will be cooperatively displaced or displaced approximately the same amount, both inwardly and outwardly from its original diameter. As the tube is swaged or moved into the material of the parent member **16**, the areas of this member adjacent the tube will be subjected to both axially and radially directed pressure. It is because the material of member **16** follows the displacement of the tube material that there is an exceptionally strong interlock between the two members.

I may provide any suitable external configuration on the sleeve or ferrule so that it will have a binding or gripping effffect inside of the tube sheet or workpiece **16**.

While I have shown the tube or sleeve or ferrule **12** as circumferentially continuous, it should be understood that I may use slits from one end to the other or terminating short of the ends if any particular interlock or swaging action is desired.

The particular thread form shown on the tool may be varied somewhat and it should be understood that the crest is not absolutely sharp. In fact, I prefer slight flat on the crest so that I get a metal swaging or moving action instead of a cutting action. It can be a pronounced flat or a slight flat. Also, it might vary depending upon whether you are concerned with the taper or the constant part **22**.

Also, I may provide some sort of an irregular or discontinuous thread formation. It does not have to be completely continuous since I may see fit to break the thread formation at the low points or in the radial reliefs, if this is desirable for any reason.

Further, no particular effort need be made to line up the radial reliefs or make them parallel on an axial direction. I may skew them slightly or put them on a slight helix, if desired.

From the position of FIGURE 2, the tool may be passed on through or it may be backed out, as the case may be. The outside of the insert does not necessarily have to form a tight or interference fit with the inside of the hole in the workpiece, but it is preferably snug. In fact, it may require forcing in under pressure, although there may be sufficient clearance so that I merely drop it in place and then the tool serves to swage the ferrule integrally into the cylindrical walls of the hole.

The result of this swaging operation is to allow the grain fibers to follow the contour of the threads to thereby strengthen the parent material.

Although the invention has been described in general as being satisfactory to initially work the inner surface of a tube and thereby distort the exterior, it should be realized that it is also possible to work the exterior surface and thereby distort the interior so that it will grip and be interlocked with some member inside of it, for example another tube or a rod. In other words, the invention is equally applicable to a tool, such as a tap or to a die.

In FIGURE 4, I have shown a variation in which the workpiece **28** is in the form of a rod or tube, solid or hollow. A ferrule or sleeve **30** is slipped on the tube and

may have an inside diameter on the order of the outside diameter of the rod or tube or workpiece. In fact, I may provide a shoulder on the workpiece against which the inner end of the tube or ferrule may abut. In any event, I may use a swaging tool or die **32**, roughly the reverse of the tap type tool shown in FIGURES 1 through 3, to swage or form the exterior of the ferrule or sleeve into a thread configuration so as to distort or swage the interior surface of the ferrule into locking contact with the exterior of the workpiece. The swaging tool or die in this case may be formed with an initial threaded or working portion **34** which flares outwardly and a second portion **36** behind it which may be considered to be a constant diameter or the like.

In the various forms shown, the intial portion, meaning the tapered portion **24** in FIGURE 1, or the flared portion **34** in FIGURE 4, may have radial reliefs of the type shown in U.S. Patent No. Re. 24,572, while the following area or constant or cylindrical portion, as at **22** in FIGURE 1, or **36** in FIGURE 4, does not necessarily need radial reliefs and, in fact, may be merely a constant or uniform thread formation. But I find it convenient to apply the radial reliefs throughout the length of the threads. Since the die type swaging tool in FIGURE 4 may be considered to be just the reverse of the tap type swaging tool in FIGURE 1, it should be understood that I may also run lubricating or fluid conducting grooves down the radial reliefs dimensioned so that they do not perform a cutting or chipping action. For example, such grooves might be run down the low points of the tap in FIGURE 1 and the high point of the die type tool in FIGURE 4. As in the case of the FIGURE 1 arrangement, the ferrule may require a press fit or axial pressure to get it on the workpiece **24** or it may slide on easily.

Whereas the preferred form of the invention has been shown and described herein, it should be realized that there are many modifications, substitutions and alterations thereto within the scope of the following claim.

I claim:

A method of interconnecting a relatively thin wall tube formed of a ductile meaterial to a concentric surface formed of a generally incompressible distortable material and having a diameter on the order of the diameter of the tube surface adjacent it, including the steps of supplying a tube of sufficient ductility and thickness such that it will deform radially when subjected to radially directed metal swaging pressure, initially positioning the thin wall tube in contact in concentric relationship with the concentric surface and on the outside thereof, thereafter directly applying metal working and swaging pressure to the outside surface of the tube, the pressure being applied at spaced, but limited axial areas, alternately applying and relieving such pressure and the intensity thereof on a uniformly cyclical basis to displace the inner and outer surfaces of the tube both inwardly and outwardly from their orginal diameters by approximately the same amount and to cooperatively displace the material of the concentric surface, the pressure being of sufficient intensity relative to the material and wall thickness of the tube and material of the concentric surface such as to interlock the tube with the concentric surface, with said concentric surface being displaced both inwardly and outwardly, following the inward and outward displacement of the tube inner surface as said pressure is applied.

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CHARLIE T. MOON, *Primary Examiner.*