Jan. 3, 1967 W. H. WATSON ET AL 3,295,154

METAL SWAGING TOOL AND METHOD OF SEATING AND THREADING A THIN WALLED CYLINDER IN A HOLE

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Fig. 1.

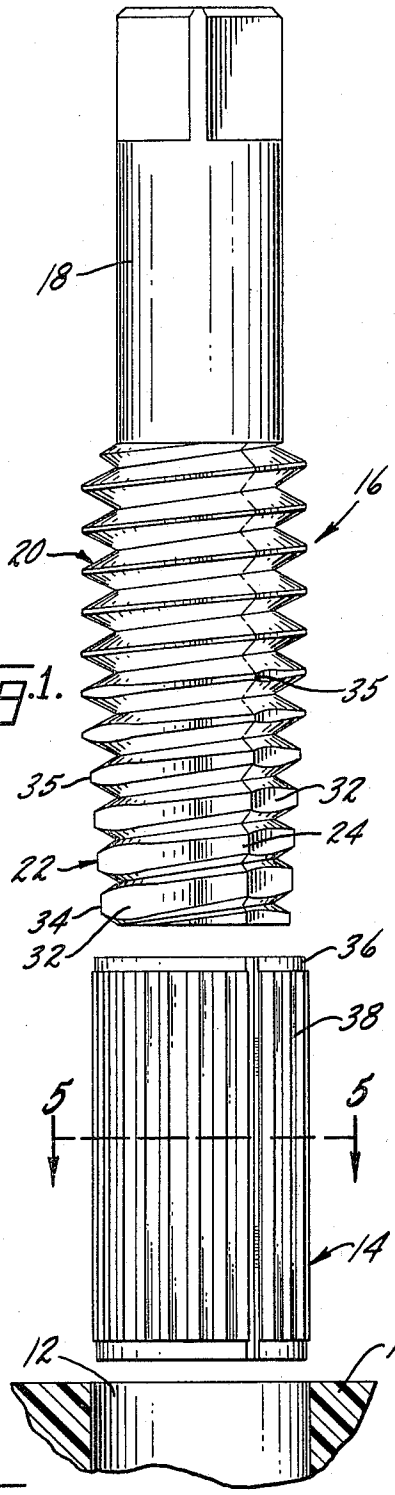


Fig. 2.

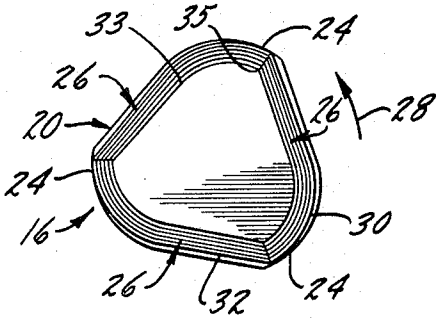
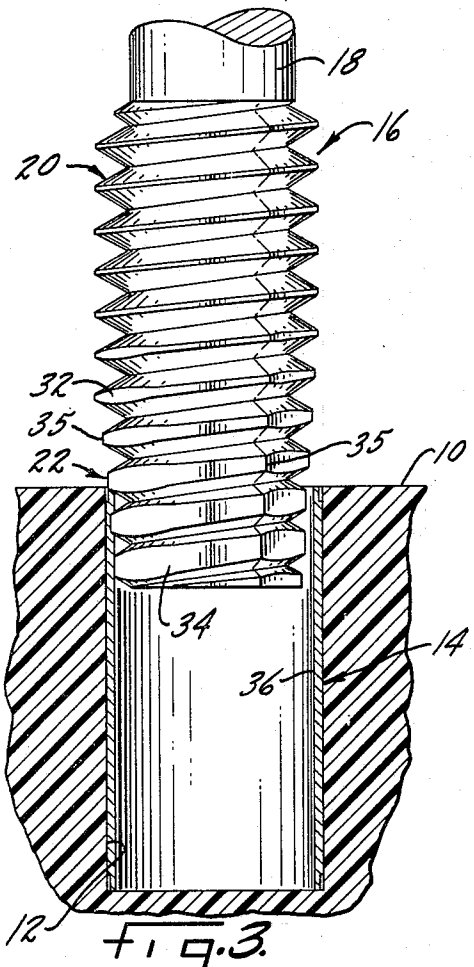


Fig. 3.



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Fig. 4.

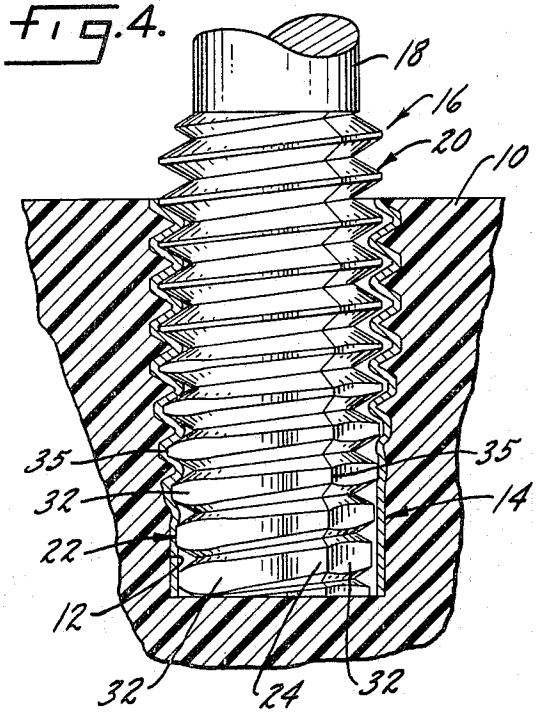
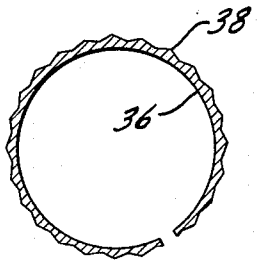


Fig. 5.



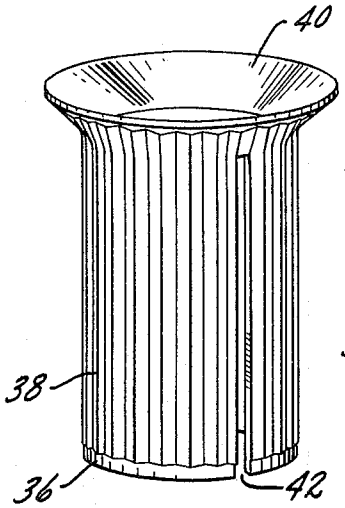


Fig. 6.

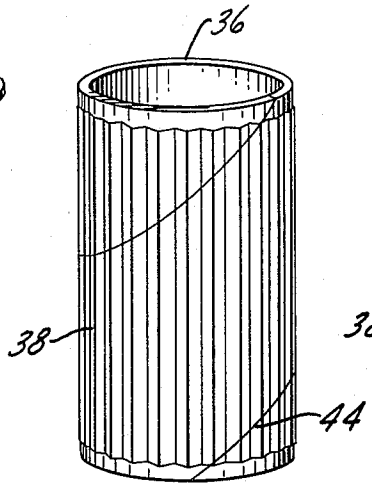


Fig. 7.

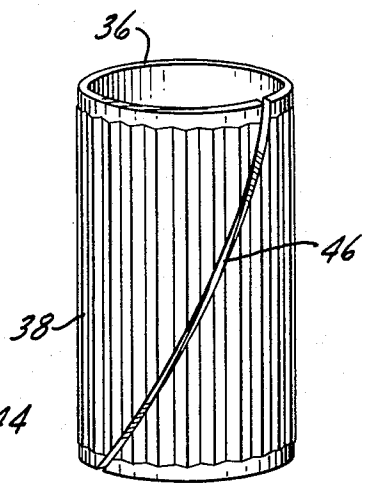


Fig. 8.

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Fig. 9.

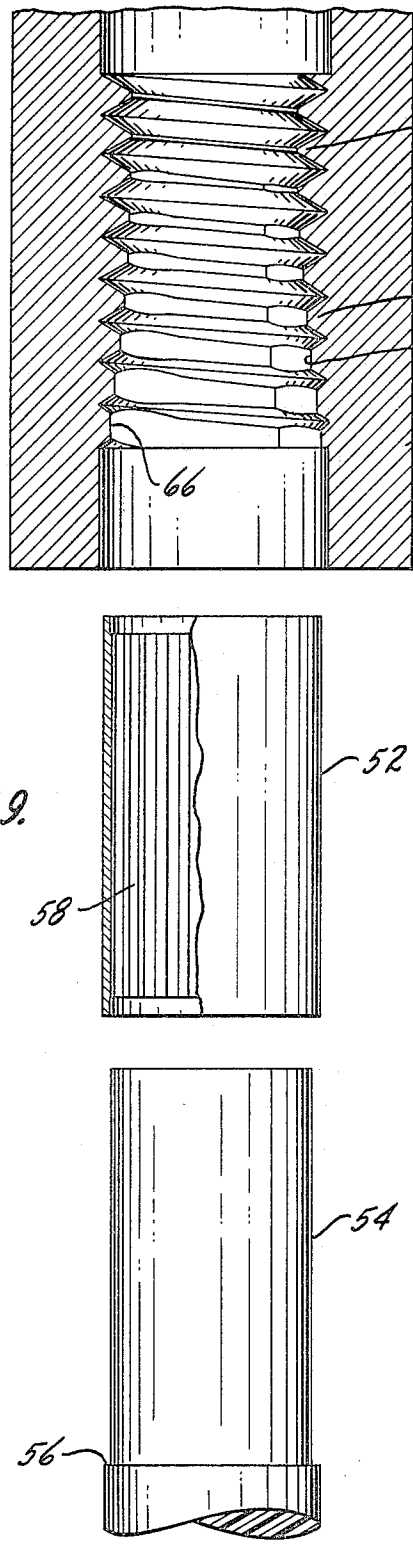
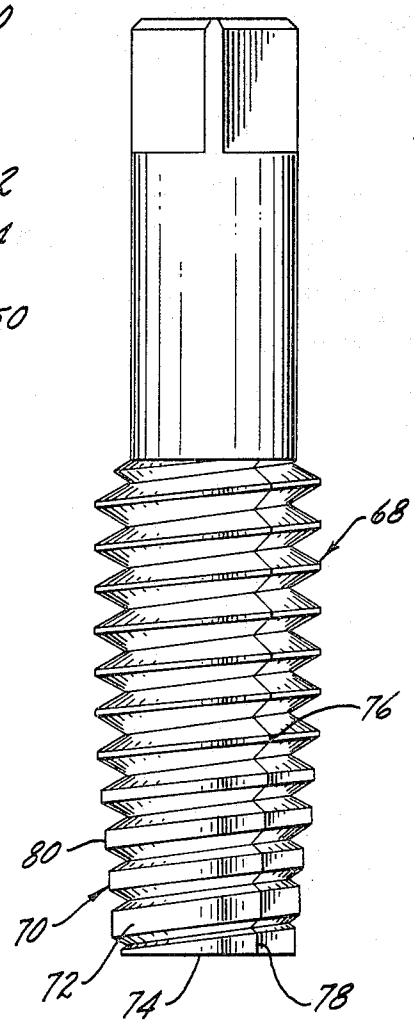


Fig. 10.



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United States Patent Office

3,295,154

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METAL SWAGING TOOL AND METHOD OF SEATING AND THREADING A THIN WALLED CYLINDER IN A HOLE

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Filed Feb. 18, 1965, Ser. No. 433,741
14 Claims. (Cl. 10—1)

This is a continuation-in-part of copending application Serial No. 181,673, filed March 22, 1962.

This invention relates to a metal swaging tool and method.

A primary purpose of the invention is a metal swaging tool which may be used in seating and threading a thin cylinder or ferrule into a cylindrical surface of a relatively soft material.

Another purpose is a tool of the type described having a first portion used in seating a ferrule and a second portion used in swaging it.

Another purpose is a metal swaging tool and ferrule combination which can be used in forming threads in a somewhat soft material in which it is difficult to produce a strong long-wearing thread.

Another purpose is a method of seating and swage-threading a ferrule within a hole.

Another purpose is an improved metal swaging tool which has minimum drag and friction as it forms a threaded surface.

Another purpose is an improved thread formation which may be used in either a tap or die.

Another purpose is an improved thread forming tool, such as a tap.

Another purpose is an improved thread forming tool or tap which does not produce chips.

Another purpose is an improved thread forming tool which is self-feeding in a new and novel manner.

Another purpose is an improved method of forming threads.

Another purpose is an improved method of forming threads in a hole or on a cylinder surface which does not produce chips.

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

The invention is illustrated diagrammatically in the following drawings wherein:

FIGURE 1 is an exploded side view of the swaging tool, ferrule and hole;

FIGURE 2 is an end view of the swaging tool;

FIGURE 3 is a side view, in section, showing the ferrule being seated by the swaging tool;

FIGURE 4 is a side view, in section, showing the tool threading the ferrule;

FIGURE 5 is a section along plane 5—5 of FIGURE 1;

FIGURES 6, 7 and 8 are perspective of different types of ferrules suitable for use in the method described;

FIGURE 9 is a side view, similar to FIGURE 1, showing a swaging die, ferrule and a cylindrical surface to be threaded; and

FIGURE 10 is a side view of a modified form of tool.

In FIGURE 1, one form of the invention is shown in which a suitable block of material **10** has a hole **12** which is to be internally threaded. The material **10** may, for example, be a plastic material or metal in which it is normally difficult to produce a long-wearing strong thread because of its softness. Positioned in line with the hole **12** is a ferrule **14** which will be described in detail hereinafter, and which is positioned within the hole **12** prior to threads being formed in the ferrule and hole. Positioned above the ferrule is a swaging tool **16**. In general,

the diameter of the ferrule is approximately the same as the hole diameter and the pitch diameter of the tool.

The tool **16** may include a cylindrical shank **18**, as is conventional, a generally cylindrical threaded portion **20** and a threaded end portion **22** which is generally tapered toward the end of the tool. The tool **16** could have axial grooves provided the working areas are formed as described. Although the member **16** will be described as a tool, for example a swaging tap, it should be understood that this member could also be a self-tapping or self-threading screw or the like.

As illustrated in FIGURE 2, the threaded portions **20** and **22** of the tool **16** may, in any 360 degrees of thread, have a plurality of radial high points **24** separated by radially relieved sectors **26**. The number of radial high points and radial sectors in any 360 degrees of thread may vary, both in number and circumferential spacing; however, it is generally impractical to use less than three, except in very small sizes. When there are only two radial high points, there is a tendency for the tool to chatter as it is not in balance. Those portions of the threads leading up to the radial high points **24**, in the direction of rotation indicated by the arrow **28**, have gradually increasing outside, pitch and root diameters. This is illustrated particularly at **30**. In general, the areas of gradually increasing outside, pitch and root diameters may begin at a point between the radial high points **24**. As illustrated in FIGURE 2, the radial high points may form an equilateral triangle or other generally equal-sided polygon depending on the number of high points, with the thread area prior to each high point gradually increasing as described above. The thread area immediately after each high point may drop off and the drop-off may be sharp or rounded. It is preferred that the thread areas immediately after the radial high points drop off so as to be out of contact with the material in which the threads are being formed. In this way there is limited contact between the tool and the material being threaded and thus minimum friction and drag on the tool. The sharply cut-back areas, indicated at **32**, may be somewhat straight, as shown in FIGURE 2, or they may be inwardly or outwardly slightly curved.

Where the relieved or drop-off area **26** is considered a straight line, it will fall off behind the high point **24** to the point of closest approach to the axis of the tap. Thereafter, it will be rising. At some point, say **33**, it begins to arc over, join, or merge into the radial high point **24**. Thus, the arcuate section or portion, from point **33** to the break line **35**, may be considered to be ever increasing in radius up to the break point **35**. To provide a tool with adequate life, we may provide a slight trapezoidal section ahead of the break line **35**, along the lines of what is shown in U.S. Patent 2,991,491, issued July 11, 1961, or the arcuate section from **33** to **35** may be ever increasing, from **33**, with the break line **35** being the point of maximum radius. While the high points **24** have been shown as axially aligned, it should be understood that they could be disposed on a spiral, either right or left hand.

Preferably the outside, pitch and root diameters, although variable within any 360 degrees of thread, are generally constant throughout the length of the cylindrical portion **20**. Stated in another way, the outside, pitch and root diameters in the portion **20** are constant along any plane that is parallel to and intersects the axis of the tool. The portion **20** is described as being cylindrical and this is normally the case, although in some applications there may be a slight back taper. The term cylindrical should include a tool with a slight back taper or back relief.

The pitch and root diameters in the portion **22** at the end of the tool are equal as described above and are equal

to the pitch and root diameters of the portion **20**. The outside or crest diameter in the end portion **22** gradually decreases from the cylindrical portion **20** toward the end of the tool. As illustrated in FIGURE 1, the threads at the end of the tool are flattened, with the radial high points being flattened the largest amount. The flattened portions are preferably generally parallel to the axis of the tool for better seating of the ferrule. In some applications, these flattened areas may be slanted with a slight back taper. It is particularly advantageous to have the flattened areas parallel to the axis of the tool as this will assist in preventing the ferrule from moving out of the hole. All pressure on the ferrule applied by the flattened area will be radial. The thread **34**, which is the first thread at the end of the tool, has the largest flattened areas and the width of the flattened areas gradually decreases toward the cylindrical portion **20**. The end portion **22** of the tool is used in seating the ferrule within the hole. These threads also perform some threading action. The first thread in the portion **20** will form the threads on the ferrule and hole to their final dimensions. It should also be noted that the crests **35** of the threads in the cylindrical portion **20** are somewhat flattened so as not to pierce the ferrule which may be referred to as crest relief. The radial high points actually do the work in forming the threads and so it is only necessary to flatten the crests at these points.

It will be noted that the flattened portions **32** vary in width or axial extent from one break line **35** to the next. A tool of this general character is made by rotating a tap blank in contact with a grinding wheel and moving the grinding wheel in and out to form the relieving technique shown in FIGURE 2 at the same time that the grinding wheel is fairly axially along the tap blank. The in and out movement of the grinding wheel may be controlled by a suitable cam. To produce the flattened areas **32** on the nose portion **22** of such a tool, the same or similar grinding wheel may be used and the control may be effected by the same or a similar cam. In the case where the flattened areas vary in axial extent or width, as shown in FIGURE 1 for example, a different cam might be used or the control between the cam and the grinding wheel might be changed. The point is that to produce the varying width flats shown in FIGURE 1, the wheel does not follow the same precise path during its in and out motion that it would in applying the radial relieving to the full thread form in the portion **20**.

FIGURES 6, 7 and 8 illustrate various forms of ferrules. In each case the ferrule may include a generally cylindrical body **36** which has a plurality of generally outwardly extending circumferentially equally spaced ribs **38**. This construction is illustrated particularly in FIGURE 5. The invention should not be limited to equally spaced ribs nor to a rib construction in general. Other knurled or roughened surfaces are satisfactory.

Considering FIGURE 6, one end of the ferrule may have a generally conical outwardly flared section **40**, which also has external ribs. The ferrule indicated in FIGURE 6 may be used where the hole is countersunk. The ferrule in FIGURE 6 may include a generally axially extending slit **42**. The slit is effective to permit the circumference of the ferrule to be increased as the tool moves into the hole and ferrule. In this way the material of the ferrule is not stretched to the point where it cannot be satisfactorily threaded.

FIGURE 7 illustrates a ferrule having a generally helically directed slit **44**. There will not be a defined axially extending gap in the ferrule after it has been threaded within the hole, but rather the ferrule will be expanded in a helical manner, with the slit **44** running through 360 degrees, more or less.

FIGURE 8 illustrates a modified helically slit ferrule in which the slit **46**, although helically directed, only runs through approximately 90 degrees.

Any one of the ferrules illustrated in FIGURES 6, 7 and 8 may have an outwardly flared conic section, as illustrated in FIGURE 6, and it is applied to FIGURE 6 merely as an example.

In using the tool **16** to thread the ferrule **14** within the hole **12**, the end portion **22** of the tool is used in seating the ferrule. As the tool enters the ferrule which is positioned in the hole, initially the tapered flattened threads, first the thread **34**, will contact the sides of the ferrule and will exert pressure in a radial direction. The flank of the thread **34** will exert an axial pressure on the ferrule. See FIGURE 3. The radial pressure will be intermittent as it will only be exerted by the radial high points **24**. The radial pressure will also be gradually increasing as the tool moves deeper within the ferrule. The flattened areas on the tapered portion **22** will push the ferrule radially outward and move it against the material **10**. The circumference of the ferrule will increase so that it is in tight engagement with the walls of the hole **12**. The ribs on the outside of the ferrule will prevent it from turning within the hole.

After the initial seating operation by the first threads in section **22**, the last few threads in this section and the first thread in section **20** will finish the threads in the ferrule and hole. As stated before, it is only the radial high points that actually perform any work. These high points may be somewhat flattened so as not to pierce the ferrule. Radial pressure is applied to the ferrule in an intermittent manner, with the maximum pressure, applied in each instance, by the threads **20** being equal. These points of maximum pressure application are generally axially aligned as the radial high points are in axial alignment. The radially relieved areas are effective to take the tool out of contact with the ferrule or material being threaded so as to reduce the drag and friction on the tool as it rotates. The ferrule, which initially has an inside diameter generally equal to the pitch diameter of the tool, will have portions forced deeper into the material **10** by the crests of the tool, while adjacent portions of the ferrule will move into the root of the tool threads.

FIGURE 9 illustrates the same thread formation as used on the tool **16** applied to a die **50**. The die may be used to thread a ferrule **52** onto a cylindrical member **54**. The member **54** may have a shoulder **56** for proper initial positioning of the ferrule. The shoulder is not necessary, however. The ferrule **52** may be similar to the ferrules shown in FIGURES 6, 7 and 8, except in this case the inside surface **58** of the ferrule is roughened, knurled or ribbed.

The die **50** may have a first section or series of threads, **60**, generally similar to the cylindrical threaded section **20** on the tool **18**. The threads in this section will, in any 360 degrees of thread, have a plurality of radially relieved sectors and radial high points. The high points will have the smallest diameter, whereas in the tap type tool the high points had the greatest diameter. Those portions of the threads leading up to the radial high points in the direction of rotation of the die may have gradually decreasing inside, pitch and root diameters. As was true in the tap, the areas of gradually decreasing inside, pitch and root diameters may begin at a point somewhat midway between the radial high points, or points of minimum diameter. The radial high points, whether they be in a tap or in a die, are the points of maximum penetration into the ferrule and material to be threaded. The number of radial high points may vary, although it is in general impractical to have less than three.

Preferably the inside, pitch and root diameters, although variable within any 360 degrees of thread, are generally constant throughout the length of the threaded section **60**, along any plane that is parallel to and intersects the axis of the tool. In general, the thread formation on the die is the reverse of the thread formation on the tap type tool **16**.

The tool **50** may have a threaded end portion **62** in which the pitch, root and crest diameters vary in any 360

degrees of thread as described above. There are radial high points and radially relieved sectors. Those portions of the threads leading up to the radial high points will gradually decrease in the direction of rotation of the tool to minimum inside, pitch and root diameters.

The pitch and root diameters in the portion **22** at the end of the tool are constant along any plane that is parallel to and intersects the axis of the tool. The inside or crest diameter in the end portion **62** gradually increases from the cylindrical portion **60** toward the end of the tool. This is an outward taper. The threads in this section are flattened, with the radial high points being flattened the greatest amounts. The flattened portions **64** are preferably generally parallel to the axis of the tool for better seating of the ferrule. A forward taper in the direction of the general thread taper or a back taper may also be satisfactory. The thread **66**, which is the first thread at the end of the tool, has the largest flattened areas and the width of the flattened areas gradually decreases toward the threaded section **60**.

The operation of the tool in FIGURE 9 is much the same as the tap type tool. Initially the ferrule is positioned on the surface to be threaded. As the die moves onto the ferrule, the first thread **66** will contact the sides of the ferrule and exert inward radial pressure. The flank of the thread **66** will exert an axial pressure on the ferrule. The radial pressure will be intermittent and will only be exerted by the radial high points. As the die moves forward onto the ferrule, the last few threads in the section **62** will begin forming threads. The threads will be completed on the ferrule by the first thread or thread portion of the section **60**.

Both tools operate in the same manner. Radal pressure is applied intermittently at circumferentially spaced points and in a gradually increasing manner. After the seating step is performed by the first few threads in the cylindrical section, which is generally designated the seating section of the tool, the threads will be finished by the first thread or portion of a thread in the end or second threaded section.

In FIGURE 10, I have shown a variant form in which the cross section of the thread and the full thread form **68** may be considered to be the same, as at **20** in FIGURE 1. However, the nose or leading portion **70** is changed somewhat in that the flat or crest **72** of the threads is at a maximum axial width at the bottom or front of the tool **74** and progressively and uniformly narrows around the threads until it merges into the crest relief, for example as at **76**. Thus, from one break point to the next, as at **35** in the previous form, the width or axial distance of the flat does not vary circumferentially around the tap, but rather gradually increases or decreases, whichever way you are going, until it reaches a maximum at the front end of the tap **74** or a minimum where it merges into the crest relief as at **76**. As before, break points or lines **78**, corresponding to break points or lines **35** in the previous form, will be present. It will also be noticed that the crests of the flats, as at **80**, are disposed generally parallel to the axis of the tap so that the pressure applied by the flattened crests will have only an outward component and no axial component.

One of the advantages of a tool of the type shown in either FIGURES 1 or 10 is that, due to the crests being flattened in a plane or on a line generally parallel to the axis, all of the pressure applied by the flattened crests of the tool will be directly outward and there will be no axial component of force exerted by the flattened crests tending to resist the axial movement or lead of the tool. Thus, all force or torque required to turn the tool will be effective to create threads, thereby providing a maximum efficiency. It should be understood that the flanks of the threads of the tool will apply an axial force to the ferrule during seating and swaging but that no axial force will be exerted by the flattened crests.

Further, this directly outward pressure results in a uniform stretching of the ferrule which is equal on both sides of the thread form. Thus, there is no cutting. While we refer to the pressure being outward, which it will be in the tools of FIGURES 1 and 10, it will be the opposite in a die type tool, such as in FIGURE 9.

While the tools have been shown and described as used for applying a generally cylindrical ferrule to a cylindrical surface, it should be understood that they may be used independently to produce a thread form on a solid cylindrical surface, either in a hole or on a rod. In this sense, the invention takes on the character of a metal threading tool and method.

In the form of FIGURE 1, the relieving pattern applied to the crests of the threads to form the flattened portions in the so-called tapered portion **22** is different from the relieving pattern applied to form the threads on the main somewhat cylindrical threaded portion **20**. In FIGURE 10, however, the relieving pattern used to form the main threads and also the flattened crests **72** is the same, except that the grinding wheel is uniformly moved in or out during the crest relieving on the leading portion **70**.

While the various forms shown have been related to and used with the seating of a metal or hardened ferrule in a soft material, such as plastic or aluminum, it should be understood that either or both tools may be used in a simple tapping operation where the parent or base metal itself is sufficiently hard but deformable to accept the thread formation. When used as a tap and not as a combination tap and seating tool for a ferrule, either form has the advantage of maximum efficiency due to the crests of the flattened areas lying generally parallel to the axis of the tool rather than being tapered toward the nose of the tool, which will result in a certain amount of resistance to the insertion and lead of the tool. In certain applications, a small amount of back taper on the flats may be of tremendous advantage, either in a ferrule seating operation or a pure tapping operation.

Whereas the preferred form and one variation of the invention have been shown and described herein, it should be realized that there are many modifications, substitutions and alterations thereto within the scope of the following claims:

We claim:

1. A swaging tool for forming threads on a generally cylindrical surface, said tool including a first threaded portion and a second threaded portion, each formed with a series of circumferentially spaced radially relieved sections, the thread areas between the radially relieved sectors gradually changing in crest, pitch and root diameters, in the direction of rotation of the tool, to crest, pitch and root diameters providing maximum penetration into the surface to be threaded, the crest, pitch and root diameters of the first threaded portion being generally equal in all planes parallel to and intersecting the axis of said tool, the pitch and root diameters of the second threaded portion being generally equal in all planes parallel to and intersecting the axis of said tool with the crest diameter of said second portion gradually varying toward the end of the tool in a direction radially away from the surface to be threaded, the pitch and root diameters of said second portion being constantly equal to the pitch and root diameters of said first portion, the threads on the second portion having flattened crest areas, with the width of said flattened areas gradually increasing toward the end of the tool, whereby said flattened areas gradually increase the pressure applied to the surface during the formation of the full threads, said flattened crest areas being generally parallel to the axis of the tool.

2. The structure of claim **1** further characterized in that the outside, pitch and root diameters of the first threaded portion and the second threaded portion sharply decrease after the outside, pitch and root diameters providing maximum penetration into the surface to be threaded have been reached.

3. The structure of claim 1 further characterized in that the outside, pitch and root diameters begin gradually increasing approximately midway between adjacent points of outside, pitch and root diameters providing maximum penetration.

4. A swaging tool for forming threads on a generally cylindrical surface, said tool including a first threaded portion and a second threaded portion, each formed with a series of circumferentially spaced radially relieved sectors, the thread areas between the radially relieved sectors gradually changing in crest, pitch and root diameters, in the direction of rotation of the tool, to crest, pitch and root diameters providing maximum penetration into the surface to be threaded, the crest, pitch and root diameters of the second threaded portion being generally equal in all planes parallel to and intersecting the axis of said tool, the pitch and root diameters of the first threaded portion being generally equal in all planes parallel to and intersecting the axis of said tool with the crest diameter of said first portion gradually varying toward the end of the tool in a direction radially away from the surface to be threaded, the pitch and root diameters of said first portion being constantly equal to the pitch and root diameters of said second portion, the threads on the first portion having flattened crest areas, with the width of said flattened areas gradually increasing toward the end of the tool, whereby said flattened areas gradually increase the pressure applied to the surface during the formation of the full threads, said flattened crest areas being generally parallel to the axis of the tool.

5. The structure of claim 4 further characterized in that the threads are continuous and uninterrupted.

6. A method of seating and threading a thin-walled cylinder in a hole, including the steps of positioning the cylinder in the hole, applying intermittent gradually increasing radially directed pressure to the walls of the cylinder along an area substantially parallel to the axis of the cylinder with such area diminishing in size, from one end toward the other, to expand the cylinder and to seat it within the hole, then applying intermittent radially directed pressure to the walls in a generally helically directed path to internally thread the cylinder and hole.

7. The method of claim 6 further characterized in that said intermittent gradually increasing radially directed pressure and the intermittent radially directed pressure used in forming the thread on said cylinder and said hole is applied, in each instance, by gradually increasing the pressure to a maximum, and then removing the pressure.

8. The method of claim 6 further characterized in that the points of pressure application at which the intermittent gradually increasing radially directed pressure and the intermittent radially directed pressure forming the threads in the cylinder and hole are axially aligned.

9. The method of claim 6 further characterized in that the intermittent radially directed pressure used to form the threads in the cylinder and hole is applied in generaly equal amounts.

10. A method of seating and threading a thin-walled cylinder into a cylindrical surface, including the steps of positioning the cylinder in abutment with said surface, applying intermittent gradually increasing radially directed pressure to the walls of the cylinder from one end toward the other along an area substantially parallel to the axis of the cylinder with such area diminishing in size, to force the cylinder toward the material to be threaded and to seat it, then applying intermittent radially directed pressure to the cylinder in a generally helically directed path to thread it.

11. The structure of claim 4 further characterized in that the width of the flattened areas on the threads and second portion varies from one point of maximum penetration to the next.

12. The structure of claim 4 further characterized in that the width of the flattened areas on the threads of the second portion gradually and uniformly decreases in the direction of rotation of the tool until the flattened crest areas of the first portion merge into the crest of the second portion.

13. A method of threading a cylindrical surface of a member subject to plastic deformation, comprising applying radial sliding pressure in pressure areas to said surface at a plurality of generally equally circumferentially spaced locations on said cylindrical surface, the said radial pressure areas comprising portions of maximum pressure all positioned in the same helical path with the radial pressure diminishing substantially equally on opposite sides of said portions of maximum pressure axially of said cylindrical surface and said radial pressure diminishing in each direction helically of the portions of maximum pressure, and advancing said radial pressure areas along said cylindrical surface along said helical path from one end of said cylindrical surface, said radial pressure areas being substantially parallel to the axis of the cylindrical surface and increasing in pressure and decreasing in axial width from the first pressure area applied to said one end of said cylindrical surface, gradually deforming said cylindrical surface at said spaced locations throughout at least a plurality of turns of said helical path, and thereafter applying sliding pressure in pressure areas substantially equal in size and pressure to the last pressure area at a plurality of helically spaced locations, each being on said helical path and radially overlapping the initial cylindrical surface by approximately the same amount on each side thereof and advancing said last mentioned areas along said helical path to form the threaded cylindrical surface to a shape that is substantially complementary to the axial cross sectional shape of said last mentioned plurality of helically spaced areas.

14. A method of threading a cylindrical surface of a member subject to plastic deformation, comprising the steps of applying a radial sliding pressure area of limited arcuate helical extent to the surface, said pressure area comprising a portion of maximum radial pressure with the radial pressure diminishing uniformly and substantially equally on opposite sides axially of the cylindrical surface and also diminishing on opposite sides helically of the cylindrical surface, advancing a first series of such pressure areas along a helical path on the cylindrical surface from one end thereof, the areas in the first series all being disposed substantially parallel to the axis of the cylindrical surface and in the same helical path and being graduated so as to increase in pressure intensity and decrease in axial with from the first such area applied to the said one end of the cylindrical surface, and thereafter advancing a second series of such pressure areas along the same helical path on the cylindrical surface from the said one end, the areas in the second series all being disposed in the same helical path and being substantially the same in size and pressure intensity and being substantially equal to the last such pressure area in the first series and radially overlapping the initial cylindrical surface by approximately the same amount on each side thereof to thereby deform and size the cylindrical surface in a thread form which is substantially complementary to the axial cross section of the second series of such pressure areas.

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