March 8, 1955 J. J. BARTH 2,703,419

METHOD AND TOOL FOR SWAGING INTERNAL THREADS

Filed March 6, 1951 3 Sheets-Sheet 1

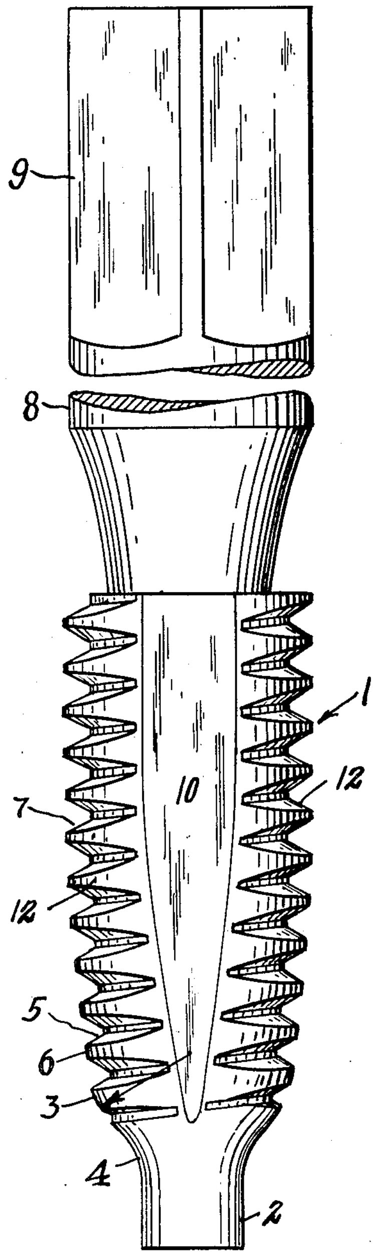

Fig. 1

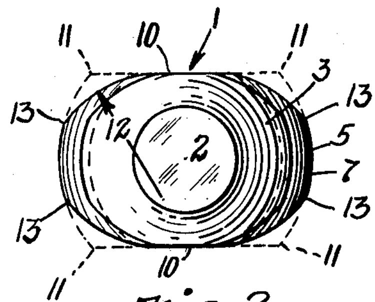

Fig. 2

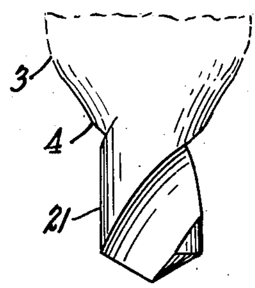

Fig. 3

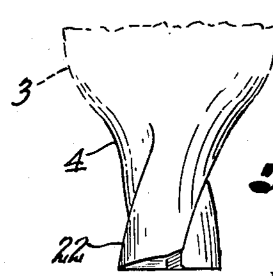

Fig. 4

INVENTOR.
JOHN J. BARTH

BY
Oberlin & Limbach
ATTORNEYS.

March 8, 1955 J. J. BARTH **2,703,419**

METHOD AND TOOL FOR SWAGING INTERNAL THREADS

Filed March 6, 1951 3 Sheets-Sheet 2

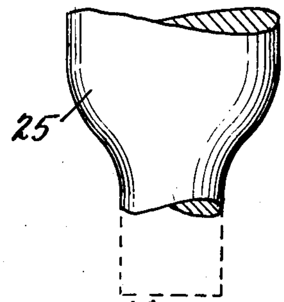

Fig. 5

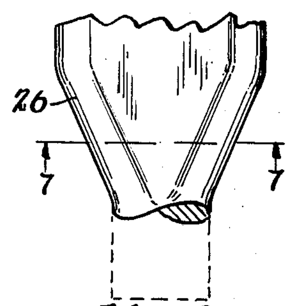

Fig. 6

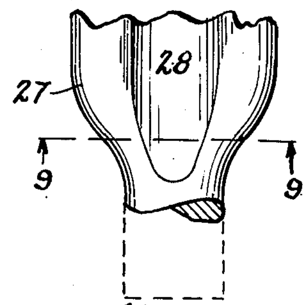

Fig. 8

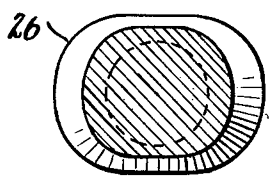

Fig. 7

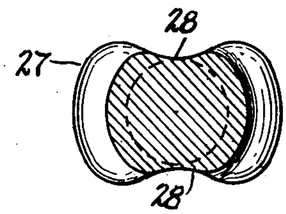

Fig. 9

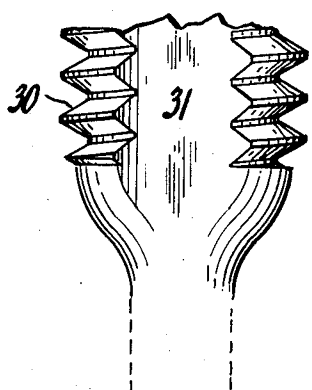

Fig. 10

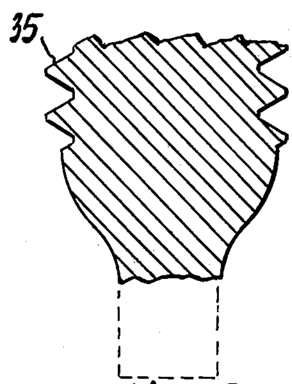

Fig. 12

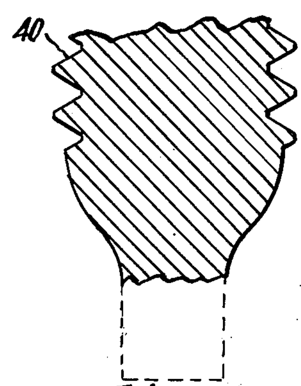

Fig. 14

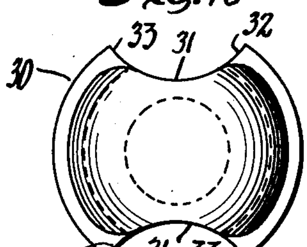

Fig. 11

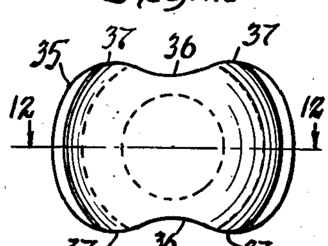

Fig. 13

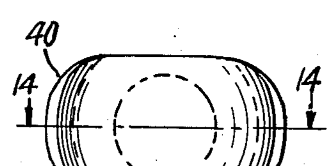

Fig. 15

INVENTOR.
JOHN J. BARTH
BY
Oberlin & Limbach
ATTORNEYS.

METHOD AND TOOL FOR SWAGING INTERNAL THREADS

Filed March 6, 1951 3 Sheets-Sheet 3

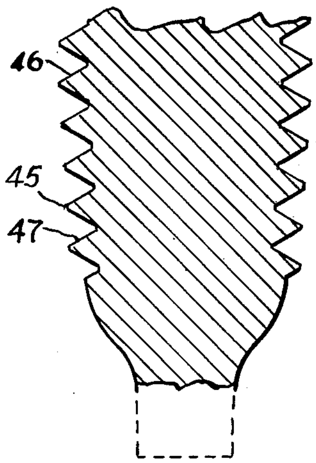

Fig. 16

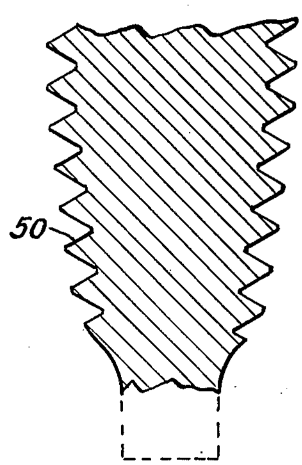

Fig. 17

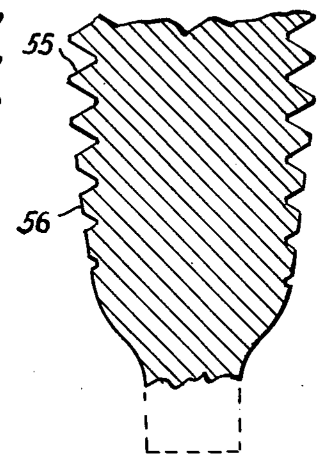

Fig. 18

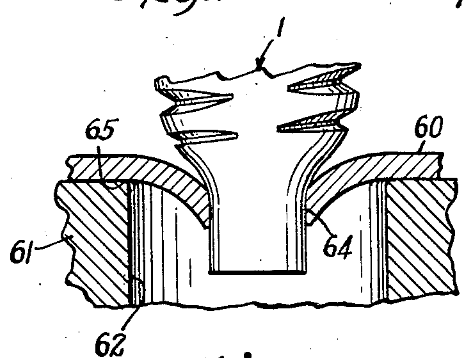

Fig. 19

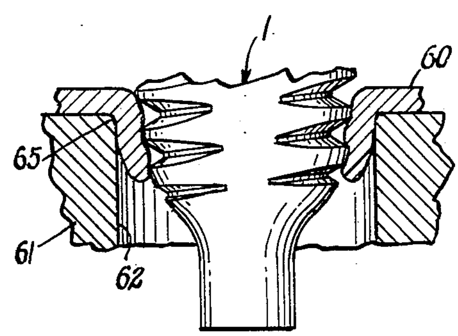

Fig. 20

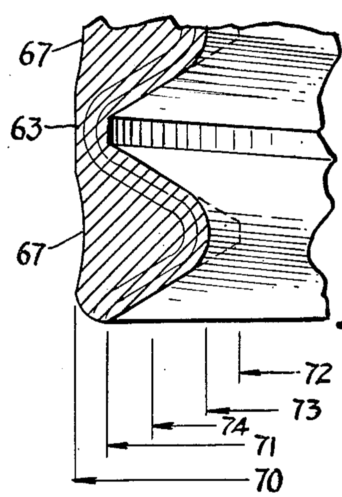

Fig. 22

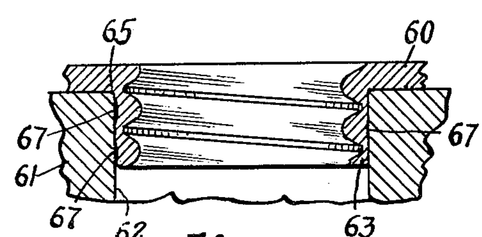

Fig. 21

INVENTOR.
JOHN J. BARTH
BY
Oberlin & Limbach
ATTORNEYS.

United States Patent Office

2,703,419

Patented Mar. 8, 1955

2,703,419

METHOD AND TOOL FOR SWAGING INTERNAL THREADS

John J. Barth, Lakewood, Ohio, assignor to The Barth Corporation, a corporation of Ohio

Application March 6, 1951, Serial No. 214,110

7 Claims. (Cl. 10—152)

The present invention relates generally as indicated to a thread forming tool and method and article produced thereby, and more particularly to certain improvements in a tool for forming strong, deep, internal threads in sheet stock blanks or workpieces which are too thin to have the desired number of threads formed therein and which even though formed with tubular transverse extrusions of length corresponding to the desired number of threads, such extrusions are too thin-walled to permit forming of threads of desired depth with known types of thread-forming tools; in the method of forming such strong, deep, internal threads in thin work-pieces; and in the internally threaded articles thus formed by the use of the tool and by the practice of the method.

Hitherto, except in instances wherein the thread formed as by a self-tapping screw in a thin work-piece is adequate, it has been proposed to form a plurality of internal threads in a thin work-piece by first piercing and extruding the work-piece to provide a transverse tubular projection thereon and then cutting internal threads in such projection as with an ordinary tap, this usually being a multi-stage process involving use of separate piercing, extruding, and threading tools and, of course, in most cases, the thinning of the wall of the projection only permits cutting of very shallow threads which are considerably less than full depth. Accordingly, the increase in the number of threads made possible by the extrusion results in threads of correspondingly less depth whereby the net gain in thread strength, if any, is not appreciable. It has therefore been necessary to resort to the employment of separate nuts having the requisite number of threads of substantially full depth for threaded engagement with screws extending through punched holes in the work-pieces, and in the case of nuts formed by drawing a cup of required depth, piercing the bottom of the cup to provide a tubular projection, and cutting threads in the projection heavier stock is required and elaborate drawing equipment is required for stealing material from the area of the stock surrounding the projection. Such drawn and tapped nuts as well as other forms of nuts are not only of relatively high initial cost, but there is involved in addition the cost of welding or otherwise securing the same to the relatively thinner work-pieces.

Accordingly, it is one primary object of this invention to provide a combination tool which in a single operation is capable of forming a plurality of substantially full-depth internal threads in sheet stock blanks or work-pieces; to provide a thread-forming method which effects economies in labor and in material while at the same time the material is subjected to plastic deformation or plastic flow to refine the grain structure thereof and thereby impart superior strength characteristics to the threaded portion and which results in the formation of substantially full-depth threads although the wall thickness in the tubular projection would not permit the forming of such threads by presently known methods; and to provide a sheet stock article having an internally threaded tubular projection thereon characterized by the superiority of the threads therein by reason of their accuracy and substantial depth and the increased strength of the material resulting from plastic flow or displacement thereof.

More specifically stated, it is an object of this invention to provide a combination tool having a reduced end portion for forming a hole through the work-piece, an adjacent extruding portion for enlarging the hole while simultaneously extruding the material to form a transverse tubular extension or projection of length several times the thickness of the work-piece, and a threading portion operative to thread the extrusion preferably by plastic flow or deformation of the material of the projection.

It is a further object of this invention to provide a thread forming method which involves the steps of piercing a work-piece, extruding the work-piece to provide a transverse tubular projection, and forming internal threads in such projection by the application of rotary sliding and wedging pressure therein to induce a plastic flow of the material both radially outwardly and inwardly which not only provides threads of substantial depth but provides threads of great strength by reason of the refinement of the grain structure of the material and of the surface hardening owing to plastic flow and ironing action.

It is a further object of this invention to provide a new article of manufacture characterized in that while the stock from which the article with tubular extrusions is made is too thin to provide an adequate number of threads of required depth, such requirements are nevertheless satisfied without the preliminary expense of drawing or cupping, as above indicated, and of providing a deep draw stock when a less ductile or plastic stock might be preferred.

Other objects and advantages will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawings:

Fig. 1 is a side elevation view, on an enlarged scale, of one form of the combination tool constituting the present invention;

Fig. 2 is an end elevation of the tool as viewed from the bottom end of Fig. 1;

Figs. 3 and 4 illustrate modifications in the reduced end portion of the tool, Fig. 3 showing a drill and Fig. 4 showing an end mill, whereas in Fig. 1 the reduced end portion constitutes a piercing punch;

Figs. 5, 6 and 8 are side elevation views of modifications in the intermediate extruding portion of the tool, Fig. 5 showing a spherical extruding portion, Fig. 6 showing a tapered extruding portion of oval cross section, and Fig. 8 showing a spherical extruding portion having non-cutting flutes;

Figs. 7 and 9 are transverse cross section views taken respectively along the lines **7—7** and **9—9** of Figs. 6 and 8 to show the oval cross section and non-cutting flutes;

Figs. 10, 12, and 14 are side elevation and cross section views and Figs. 11, 13, and 15 are end elevation views as viewed from the bottom end of Figs. 10, 12, and 14, respectively, Figs. 12 and 14 being cross section views taken along lines **12—12**, Fig. 13 and **14—14**, Fig. 15, to show several modifications in the threading portion of the tool, Figs. 10—11 showing a cutting tap, Figs. 12—13 showing a non-cutting fluted tap, and Figs. 14—15 showing a non-cutting tap of generally oval cross section;

Fig. 16 illustrates a further modification in the threading portion of the tool, a tapered thread being shown between the straight thread and the extruding portion of the tool;

Fig. 17 shows a tapered thread partially axially overlapping the extruding portion of the tool;

Fig. 18 shows a straight threading portion chamfered so as to be substantially tangent to the extruding portion;

Figs. 19, 20 and 21 show the successive steps in the formation of an internally threaded article, Fig. 19 showing the piercing step, Fig. 20 showing the extruding step, and Fig. 21 showing the completed internally threaded article; and

Fig. 22 is a fragmentary radial cross section view showing the threads in the article of Fig. 21 enlarged several times.

Broadly stated, one aspect of this invention consists in the provision of a combination tool which has a reduced end portion optionally in the form of a piercing punch, a drill, end mill, or the like, which in cooperation with a die having a larger orifice than such tool end portion is designed to pierce the work-piece which is to be internally threaded, the tool being fed axially and rotated in the case of the drill or end mill and fed axially and preferably, but not necessarily, rotated in the case of the piercing punch; which, adjacent to the aforesaid reduced end portion, has an intermediate portion of spherical, conical, or other progressively enlarging shape and preferably of generally oval cross section or at least with rounded edges operative upon axial feeding and rotation of the tool (rotation not required when intermediate portion is of circular cross section) to enlarge the hole in the work-piece and to displace the metal to provide a transverse tubular projection of length several times the thickness of the work-piece and necessarily of wall thickness less than the thickness of the work-piece; which, adjacent to or overlapping such intermediate portion, and also preferably of generally oval cross section or with rounded corners, is formed with a threaded portion designed, upon axial feeding and rotation of the tool, to cause a plastic flow or deformation of the material of the work-piece extrusion without cutting to progressively form internal threads in the projection; and which, adjacent to the aforesaid threaded portion has finishing threads to either continue the deformation without cutting action or, if desired, the last-mentioned portion may be designed to cut in order to accurately size the threads which have been formed by plastic flow of the material.

In essence, the tool comprises three portions, namely a piercing portion, an extruding portion, and a threading portion, and in view of the several modifications which may be made in each portion, as hereinafter more particularly set forth, a multitude of different tools may be provided in accordance with the thickness and physical properties of the material of the work-piece, and it is to be noted that each tool is capable of forming internal threads in the work-piece in one simple operation.

A second aspect of the present invention, also broadly stated, concerns the method of forming internal threads in a sheet stock blank which comprises piercing, extruding, and threading the extrusion in a manner to achieve the required number of substantially full-depth threads of great strength.

A third aspect of the present invention, in its broad sense, resides in the internally threaded article as such which is provided with a transverse tubular projection having substantially full depth, strong threads contrary to what could be obtained in a work-piece of comparable thickness and using conventional methods.

With the foregoing in mind, reference will now be made specifically to the drawings, and first to Figs. 1 and 2 in which the tool **1** comprises a cylindrical piercing punch **2**, an intermediate spherical extruding portion **3** smoothly joined as at **4** to the punch **2**, a threaded portion **5** having a tapered pitch diameter and chamfered as at **6** to smoothly join the extruding portion **3**, a straight thread portion **7** adjacent the large end of the tapered thread portion **5**, a shank **8**, and a tang **9** by which the tool is rotated by a tapping machine, a drill press, or like machine tool with or without a conventional reverse gear tap attachment. As apparent, the V-threads **5** and **7** herein shown are to be regarded as merely exemplary and obviously other well known forms of threads may be substituted without departing from the spirit of the invention.

As best shown in Fig. 2, the extruding and threaded portions **3** and **5**, **7** of the tool are of generally oval cross section providing ribs or lobes of convexly curved form which resemble gear teeth whereby upon relative rotation and axial feeding of the tool **1** and a work-piece a transverse tubular extrusion is formed on the latter by a plastic flow or deformation of the material operated upon by axial and radial forces which in this case act only at diametrically opposed regions of the pierced work-piece whereby to reduce the power required to rotate the tool. By reason of the oval cross section of the threaded portions **5** and **7**, threads in the extruded tubular projection of the work-piece are progressively formed by plastic flow and under conditions of low torque on the tool. Moreover, the ribs and lobes of said portions **3** and **5**, **7** of the tool effect a rotary sliding or ironing and wedging pressure whereby to surface harden the work-piece operated upon.

One convenient manner of forming the generally oval cross section is to provide a threaded cylindrical tool blank having parallel flat sides **10**, the corners **11** of which have been rounded as by grinding with a wheel having a periphery which is concavely curved in radial cross section to a radius **12**. Accordingly, upon relative movement of the wheel and tool blank along an angle corresponding to the angle of the pitch line of the tapered thread **5**, the sharp corners **11** will be rounded and, of course, along the straight thread portion **7** the relative movement between the wheel and tool blank will be along a path parallel to the axis of the tool **1**. The edges **13** may be broken or not, as desired, there not being any cutting action thereof during the infeed movement of the tool in either event or shaving by such edges **13** during the outfeed or reverse rotation of the tool.

In using tool **1**, the same is rotated or not, as desired, and moved axially to engage a work-piece, the reduced end portion **2** punching out a disc of material from the work-piece. As the tool is axially advanced at desired rate and now rotated the extruding portion **3** enlarges the hole in the work-piece and causes a plastic flow or deformation of the material to form a transverse tubular extrusion or projection on the work-piece and then as the threaded portion **5** engages the work-piece the working of the material is continued to form internal threads and at this stage of advance of the tool, the tool is self-feeding whereby the use of a tapping machine with a lead screw or cam mechanism for feeding in accordance with the pitch of the threads **5** and **7** is not required, although the same is desirable in order to avoid application of excessive axial force and thus causing the tool to operate as a broach. If desired, the threads **7** at the upper end may be designed to cut whereby to accurately size the threaded tubular projection in the work-piece.

Having thus described in detail one embodiment of the tool, reference will now be made to Figs. 3–18 which depict various modifications in the several working portions of the tool, namely the reduced end piercing portion, the extruding portion, and the threading portion.

As previously indicated, and as shown in Figs. 3 and 4, the reduced end portion of the tool instead of constituting a piercing punch **2** as in Fig. 1 may be a drill **21** as shown in Fig. 3 or an end mill **22** as shown in Fig. 4. In the use of a tool having a reduced end portion in the form of an end mill **22**, a cylindrical recess will be cut into the work-piece blank to about one-half the thickness of the blank and the axial feeding pressure will shear out the remaining portion when the end mill is rotated and fed axially at recommended cutting speed. As evident, there are herein shown three optional forms of reduced end portions **2**, **21** and **22** and any one may be selected according to the dictates of the user of the tool and any special circumstances which may render one form preferable to the others. For example, it has been found that some work-pieces may not be conveniently punched and that drilling or milling produces a hole which is not so apt to split upon expansion, and similarly other stocks may not be particularly suited for drilling or milling for best results in the final product.

Typical alternatives for the spherical extruding portion **3** of oval transverse cross section as in Fig. 1 are shown in Figs. 5–9, the first one **25** in Fig. 5 being spherical and of circular cross section and operative to extrude the pierced work-piece whether or not the tool is rotated while fed axially; the second one **26** in Figs. 6 and 7 being frusto-conical and of generally oval cross section; and the third one **27** in Figs. 8 and 9 being of spherical form, but instead of being of oval transverse cross section as in Fig. 2, the same is provided with non-cutting flutes **28** which yet define ribs or lobes of convexly curved form.

Accordingly, with the several modifications in the reduced end portion and intermediate enlarged extruding portion as disclosed above, many different combinations may be made up including additional ones with still different reduced end portions or varied extruding portions of different shape in elevation and including three or more ribs or lobes where three or more flats or flutes are provided.

With respect to the alternatives for the threading portions **5** and **7** of the tool **1**, several are shown in Figs. 10–18.

In Figs. 10 and 11 the threading portion **30** is similar to that in a cutting tap wherein there are a plurality of flutes **31** which form cutting edges **32** and shaving edges **33** upon outfeed if no radial relief is provided. Thus, with a cutting tap as shown in Figs. 10 and 11, the pierced and extruded projection of the work-piece will have internal threads cut therein and therefore the use of this modification will more or less be restricted to instances wherein the extrusion is relatively thick so as to permit formation of threads of desired depth or to instances where shallow threads in relatively thin-walled extrusions are not objectionable.

In Figs. 12 and 13 the threaded portion **35** of the tool is fluted as at **36** with the corners **37** rounded or broken to form ribs or lobes of convexly curved form so as to avoid any cutting action as the tool is fed axially and rotated in the transverse projection of the work-piece. Of course, if desired the last few threads at the upper end of the non-cutting tap in Fig. 12 may be arranged as in Fig. 10 to cut and thus accurately size the threads which have been formed by non-cutting plastic flow action.

In Figs. 14 and 15 there is shown a tool having a non-cutting threaded portion **40** of generally oval cross section to eliminate cutting action and, as indicated with respect to Fig. 12, the threads at the upper end of Fig. 14 may be arranged for cutting to accurately size the threads formed by the non-cutting threads. In Fig. 14 the threads **40** start at the largest portion of the extruding portion whereas in Fig. 1 the threads **5** axially overlap the extruding portion **3**.

In Fig. 16 a tapered thread **45** similar to a tapered pipe thread is provided between the straight threaded portion **46** and the extruding portion of the tool whereby as the work-piece is being extruded, portions of the material will be progressively displaced radially outwardly while the in-between portions of the material will be caused to flow radially inwardly into the valleys **47** between successive crests of the tapered threaded portion **45**. Here again the cross section of the tapered thread portion is preferably of non-cutting form such as in Figs. 13 and 15, for example.

In Fig. 17 the tapered threaded portion **50** is similar to that illustrated in Fig. 16 except that such tapered threads axially overlap the extruding portion of the tool to simultaneously extrude the work-piece and to start the formation of threads therein.

In Fig. 18 the straight thread portion **55** of the tool is chamfered as at **56** so as to be tangent with the extruding portion, the threads accordingly being truncated whereby as in the other forms having tapered or tapered and chamfered threads, the tool will feed itself in accordance with the pitch of the threads **55** whereby it is not required to use the tool in a tapping machine or like machine having a lead screw or cam mechanism for feeding.

In using the tool herein disclosed the sheet stock work-piece or blank **60** is supported on a die **61** having an opening **62** larger than the major diameter of the thread to be formed. The size of such opening **62** may be varied, but should be at least equal to the major diameter of the threads to be formed plus two times the minimum wall thickness between the outside diameter of the extruded tubular projection **63** and the major diameter of the threads. The tool, herein the tool **1** as illustrated in Fig. 1, is disposed coaxially with the opening **62** and when fed axially with or without rotation in the case of the piercing punch **2** and with rotation in the case of the drill **21** and end mill **22**, a hole **64** is formed in the blank and the surrounding portion of the blank is deformed to dish or frusto-conical shape about the peripheral edge **65** of the opening **62** as best shown in Fig. 19. As the tool **1** is continued to be fed axially, the dish shape is deformed to generally spherical or conical form and then finally to generally cylindrical form and in the case of the tool illustrated in Fig. 1, for example, extrusion and commencement of the forming of threads occurs simultaneously whereby after part of a thread is formed by radial outward deformation by the truncated portions of the threads **5**, and radially inward flow of the material into the valleys between successive threads **5**, continued rotation of the tool will effect axial feed thereof in accordance with the pitch of the threads **5** and **7**. The intermediate stage of the formation of the blank **60** is shown in Fig. 20.

After the tool **1** has been run through the blank, the internally threaded transverse tubular projection **63** will have a form such as illustrated in Fig. 21. Obviously, if the die hole **62** were somewhat larger, the corrugations **67** on the outer surface of the projection **63** would be more pronounced and, of course, if the die hole **62** is smaller in diameter, such corrugations **67** would be hardly visible.

Since no material of the blank **60** has been cut away other than the small diameter slug which is punched out by the piercing punch **2** or the material removed by drilling or milling with portions **21** or **22**, all of the material of the extrusion **63** is used in providing a fuller thread than otherwise obtainable.

Now with reference to Fig. 22, the dimension line **70** shows the diameter of the die hole, the dimension line **71** shows the major diameter of the thread, the dimension line **72** shows the minor diameter of a full thread, the dimension line **73** shows the inside diameter of the extrusion **63** or the outside diameter of the extruding portion of the tool, and the dimension line **74** shows the inside diameter of an ordinary extrusion for conventional tapping. As evident, the progressive outward deformation of the material in applicant's process by the crests of the threading portion of the tool causes a radial inward flow of the metal to produce a thread which is of substantially full depth without necessity of having a corresponding thick wall in the extrusion **63**.

By way of an actual example of the ordinary tapped extrusion, a blank **60** of .020″ stock was pierced with a hole of .073″ diameter; formed with an extrusion of .080″ length (including the .020″ wall of stock) and of .200″ outside diameter; and threads cut in the extrusion with a #10–32 S. A. E. Regular V-thread tap. Following are the dimensions of the threads and extrusion:

#10–32 threads:
- .190″ major diameter
- .1494″ minor diameter
- .0203″ full thread depth

Extrusion (from volume of material .200″ OD., .073″ ID., and .020″ thickness):
- .200″ outside diameter
- .177″ inside diameter
- .0115″ wall thickness
- .080″ length available for threading (including wall thickness of stock)

Tapped extrusion (#10–32 threads cut with tap):
- .005″ wall thickness (from major diameter of thread to outside of extrusion)
- 2½ threads (.080/.03125)
- 32% thread (.0065/.0203)

In contradistinction to the foregoing, the use of the present tool and method on the same .020″ blank results in the formation of about 2½ threads but such threads are of 60 to 75% full depth and greater because of the plastic flow and deformation of the material into the valleys between crests rather than cutting away material as is done with the tap. Similar results with different thicknesses of blanks, different sizes of holes **64** in the blanks, and different thread sizes have been obtained. With respect to the .073″ diameter hole **64**, this of course must be varied in accordance with the thickness and the ductility or plasticity of the particular material of the blank so as to avoid splitting of the extrusion.

As shown in Fig. 22, the working of the metal by plastic flow or deformation produces a grain structure which is generally sinuous in form thereby improving the strength characteristics of the material as compared with cut threads, and moreover the rotary sliding and wedging pressure irons smooth at least the major diameter and adjacent side faces of the threads and thus surface hardens the same while the minor diameter and adjacent side faces are of convex curved form in a radial plane, all surfaces being smooth and scratch-free.

It is further noted in Fig. 22 that the outside diameter of the extrusion **63** is substantially uniform and even if the die hole **62** is larger than the extrusion **63**, and therefore the corrugations **67** more pronounced, the valleys of the corrugations will nevertheless be of diameter to provide solid bodies of material across the pitch of the threads contrary to metal distribution as in corrugated metal pipes, for example.

The matter of selection of the particular form of reduced end portion **2**, **21**, **22** or the like (as shown in Figs. 1, 3 and 4) according to the thickness and the properties of the material of the work-piece has already been discussed. However, the size of the portion **2**, **21**, or **22** relative to the inside diameter of the extrusion **63** requires consideration, it being noted that a ratio 1:5 or smaller generally causes splitting of the extrusion **63**. Good results have been obtained with steel, aluminum alloy, brass, copper and like ductile metals using ratios of 1:2 to 1:3, the ratio in the specific example above being .073:.158. On the other hand, while no splitting occurs when the ratios are greater than 1:2, the extrusion **63** will not be of sufficient length for the desired number of threads.

With respect to the selection of one of the extruding portions **3**, **25**, **26**, and **27** as shown in Figs. 1, 5, 6—7 and 8—9 again the properties of the material of the work-piece will be controlling, it being noted, however, that extruding portions **3**, **26**, and **27** of oval cross section or of cross section defining ribs or lobes of convexly curved form exert pressure on the work-piece at circumferentially spaced areas and when rotated effect not only a plastic flow or displacement of the material but a deformation of the section of the extrusion and that such oval extruding portions form a thicker and shorter extrusion **63** than does an extruding portion **25** of circular cross section.

In general, the maximum major axis of the extruding portion will be less than the pitch diameter of the threads to be formed and specifically it has been found desirable to make such major axis approximately the same as the tap drill diameter for a 75% thread whereby the formed threads will be of substantial depth, often exceeding 75%. In the trade, the tap drill diameters are generally determined from either of the following formulae:

Diameter of tap drill = (outside diameter of stud) − (pitch of thread)

or

= (outside diameter of stud) − (.75 × 2 × full thread depth)

As to the selection of one of the threading portions **5–7**, **30**, **35**, **40**, **45**, **50**, and **55** in Figs. 1, 10, 12, 14, 16, 17, and 18, respectively, any, except cutting threads **30**, will be generally, but not necessarily, as previously explained, used where the wall-thickness of the extrusion **63** is less than necessary for cutting or otherwise forming threads of requisite depth. Such non-cutting threaded portions **5–7**, **35**, **40**, **45**, **50**, and **55** will produce fuller threads of greater strength and in actual tests the threads formed by plastic flow or deformation will strip the threads of machine screws made of comparable material, this being attributed to the cold-working of the material and surface hardening thereof. In addition, since these threaded portions effect ironing and surface hardening of the thread surfaces, severe stress between the threads of the extrusion **63** and of the machine screw does not result in seizing or galling. However, as previously indicated, the threaded portions **5–7**, **35**, **40**, **45**, **50**, and **55** may be of the cutting variety at their upper ends to clean out and size the threads of the extrusion **63**.

Another consideration in the selection of a particular threaded portion is that the provision of chamfered threaded portions **6** and **56** as in Figs. 1 and 18, and/or tapered threaded portions **5**, **45**, and **50**, as in Figs. 1, 16, and 17, facilitates the starting of the threading operation, and once started the tool is self-feeding without undue strain on the beginning portions of the threads. Moreover, the provision of tapered threaded portions as in Figs. 1, 16 and 17, makes possible the formation of fuller threads and also reduces the power required to drive the tool in that the roots of the threads thereon are not effective to deform the material of the work-piece outwardly but rather to receive and to shape the material that flows thereinto as a result of outward deformation or displacement of the material worked on by the crest portions of the threads. With imperfect threads, as on a starting tap, the threads are formed in the extrusion **63** by progressive outward deformation by the progressively narrowing truncated threads and by plastic flow of the material into the progressively widening valleys or troughs of the threads on the tool.

A still further consideration in the selection of the threaded portion is that it is preferred to have an axial overlap of the threaded portion and extruding portion as in Figs. 1 and 17, for example, whereby the major diameter of the beginning threads is performing the dual function of extruding and commencing formation of threads in the incompleted extrusion whereby the material while being deformed outwardly is at the same time moving inwardly into the valleys between the threads on the tool. Also in some cases the threading portion may have a slight taper to form threads which will tightly engage the machine screw threads to eliminate necessity of employing lock washers or the like.

Although the die hole **62** is not an integral component of the tool, it does have some bearing on the final product. Thus as previously stated, the minimum diameter of the die hole **62** is determined by the minimum wall-thickness required around the major diameter of the internal threads in the extrusion **63**, and of course when the hole **62** is of somewhat larger diameter than the minimum, the extrusion **63** will have more pronounced corrugations **67** on the outside surface thereof. Similarly, the provision of a sharp edge **65** around hole **62** may result in a burr projecting above the top surface of the work-piece **60**, a rounded edge will result in a fillet between the extrusion **63** and the blank proper, and a beveled edge will produce a countersink which will facilitate starting of a machine screw in the internal threads of the extrusion.

It has further been noted that good results have been obtained simply by providing a pair of spaced supports instead of a die **61** with a hole **62**. Also in forming threads in the wall of a tube, the piercing, extruding, and threading operations may be accomplished simply by supporting the tube on a flat or slightly concave surface.

In using the tool, a suitable lubricant will preferably be applied thereto such as lard or sperm oil for steel and copper work-pieces, soap solution for brass, copper, and steel work-pieces, petroleum jelly for aluminum work-pieces, mineral oil emulsions or a mixture of flaked graphite, beef tallow, and lard oil for steel work-pieces, etc. The present invention has its greatest application for internally threading the extrusions **63** of sheet metal blanks **60**, but obviously non-metallic blanks may be substituted. The principal requirement of the blanks is that they be ductile and have sufficient plasticity to permit displacement or plastic flow of the particles thereof without being removed from their sphere of attraction or to permit rather severe distortion or strain of the blank before rupturing.

In conclusion, the use of the present tool saves time and material, avoids necessity of separate fasteners, and makes possible fuller, stronger threads in sheet stock extrusions than can be obtained by ordinary tapping processes in walls of the same thickness. Also, since the extrusions are of larger inside diameter than the minor diameter of full threads, the power required is less and the percentage of broken tools is materially reduced, this being common practice in ordinary manufacturing where the tapping of soft materials results in tearing off of the threads to some extent if the tap drill diameter is too small. Likewise, the practice of the present method which induces plastic flow of the material and ironing thereof results in superior internally threaded sheet stock articles having the desired number of threads of desired depth of greater strength and quality than tapped, ground, rolled, or milled threads. As to quality, it has been noted that the thread surfaces are hard and smooth and that class 1 or 2 screws have a class 4 or tighter fit therewith by reason of the slight spring-back of the extrusion **63** which is strengthened and hardened as a result of the plastic flow or deformation of the material during the extrusion and thread-forming steps of the method.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

1. The method of forming internal threads in an opening of a work-piece of wall thickness less than necessary for the requisite number of threads to be formed, comprising forming an integral tubular transverse projection on the work-piece by plastic deformation of the material surrounding such opening radially outwardly and axially along a helical path and at circumferentially spaced areas, during the formation of such projection commencing the formation of internal threads by causing

plastic deformation of the material of the work-piece radially outwardly and inwardly along a helical path and at circumferential spaced areas, and then completing the formation of the internal threads by continued plastic deformation as aforesaid.

2. A tool for forming internal threads in a relatively thin walled work-piece having a hole therethrough comprising an extruding portion of progressively increasing size designed to enter the hole in the work-piece and to deform the material surrounding such hole to form a tubular transverse projection in the work-piece upon relative rotation and axial movement of the tool and work-piece, and a threading portion adjacent the large end of said extruding portion designed to form threads in such tubular projection of the work-piece upon relative rotation and axial movement of said tool and the work-piece, said threading and extruding portions being provided with ribs therealong which are of convexly curved form in transverse cross-section to form such internally threaded projection by plastic flow of the material of the work-piece surrounding the hole, said threading and extruding portions being partially axially overlapped whereby to be operative simultaneously to form the tubular projection while threading of the projection is commenced.

3. A tool for forming in a single operation internal threads in a workpiece of wall thickness less than necessary for the requisite number of threads to be formed, comprising a reduced end portion for forming an opening through the workpiece, an adjacent enlarged portion adapted to enlarge the opening in the workpiece while transforming the material surrounding the opening into a tubular projection having the requisite length, and a threading portion adapted to form threads in the projection upon relative rotation of the tool and the workpiece, said enlarged portion and threading portion comprising a plurality of ribs therealong of convexly curved transverse cross-section operative upon relative rotation and axial feeding of said tool and workpiece to induce plastic deformation of the latter to the form of an internally threaded tubular projection without cutting away of material and by pressure exerted at circumferentially spaced areas on the material surrounding the opening of the workpiece, said enlarged portion and threading portion being partially axially overlapped to commence formation of threads simultaneously with the formation of the tubular projection.

4. A tool for forming in a single operation internal

threads in a workpiece of wall thickness less than necessary for the requisite number of threads to be formed, comprising a reduced end portion for forming an opening through the workpiece, an adjacent enlarged portion adapted to enlarge the opening in the workpiece while transforming the material surrounding the opening into a tubular projection having the requisite length, and a threading portion adapted to form threads in the projection upon relative rotation of the tool and the workpiece, said enlarged and threading portions being partially overlapped axially whereby to be operative simultaneously to form the tubular projection while threading of the projection is commenced, and said enlarged and threading portions being provided with ribs of convexly curved form in transverse cross-section whereby to form such internally threaded tubular projection in the work-piece by pressure without cutting action, applied at circumferentially spaced points around the work-piece.

5. The tool of claim 4 wherein said threading portion where overlapped with said enlarged portion includes chamfered threads.

6. The tool of claim 4 wherein said threading portion where overlapped with said enlarged portion has threads of tapered pitch diameter.

7. The tool of claim 4 wherein said threading portion where overlapped with said enlarged portion has chamfered threads of tapered pitch diameter.

References Cited in the file of this patent

UNITED STATES PATENTS

1,539,628	Bayer	May 26, 1925
1,638,230	Alsaker	Aug. 9, 1927
1,676,482	De Lapotterie	July 10, 1928
1,912,517	De Lapotterie	June 6, 1933
1,941,175	Johnson	Dec. 26, 1933
1,990,718	Swanstrom	Feb. 12, 1935
2,026,859	Baynes	Jan. 7, 1936
2,157,354	Sherman	May 9, 1939
2,300,310	Poeton	Oct. 27, 1942
2,372,011	Remington et al.	Mar. 20, 1945
2,376,927	Luce	May 29, 1945
2,441,580	Mageoch	May 18, 1948
2,556,174	Evans	June 12, 1951

FOREIGN PATENTS

366,297	Italy	Dec. 23, 1938