United States Patent [19]

Leonard

[11] **3,775,792**

[45] **Dec. 4, 1973**

[54] **THREAD FORMING TAP**

[75] Inventor: **Donald L. Leonard,** Lyndonville, Vt.

[73] Assignee: **Vermont American Corporation,** Louisville, Ky.

[22] Filed: **Mar. 1, 1972**

[21] Appl. No.: **230,844**

[52] **U.S. Cl.** ..... **10/152 T**

[51] **Int. Cl.** **B23g 7/02**

[58] **Field of Search** ..... 10/141 R, 152 R, 10/152 T; 85/41, 46, 48; 408/215–222

[56] **References Cited**

UNITED STATES PATENTS

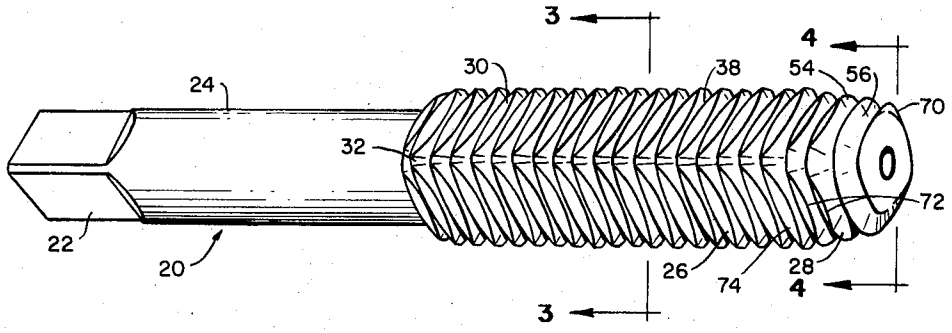
R24,572	12/1958	Welles	10/152 T
1,676,482	7/1928	LaPotterie	10/152 T
1,912,517	6/1933	LaPotterie	10/152 T
2,991,491	7/1961	Welles	10/152 T
3,171,146	3/1965	Moss et al.	10/152 T
3,226,743	1/1966	Watkins	10/152 T

Primary Examiner—Charles W. Lanham
Assistant Examiner—E. M. Combs
Attorney—Johnson, Dienner, Emrich, Verbeck & Wagner

[57] **ABSTRACT**

A tap having a threaded body of polygonal cross-sectional shape in which the thread comprises arcuate portions with V-crests separated by intervening chordal portions having truncated crests, the initial thread turns on the entrant end of the tap having a continuous sharp V-shaped crest.

23 Claims, 14 Drawing Figures



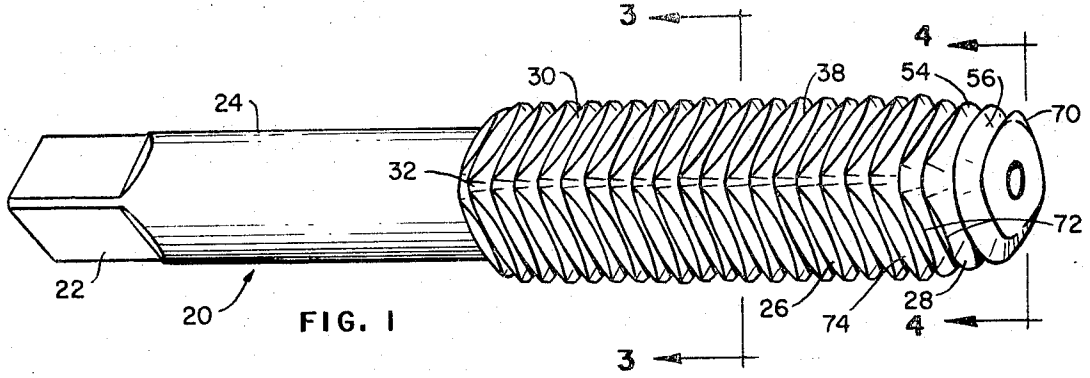


FIG. 1

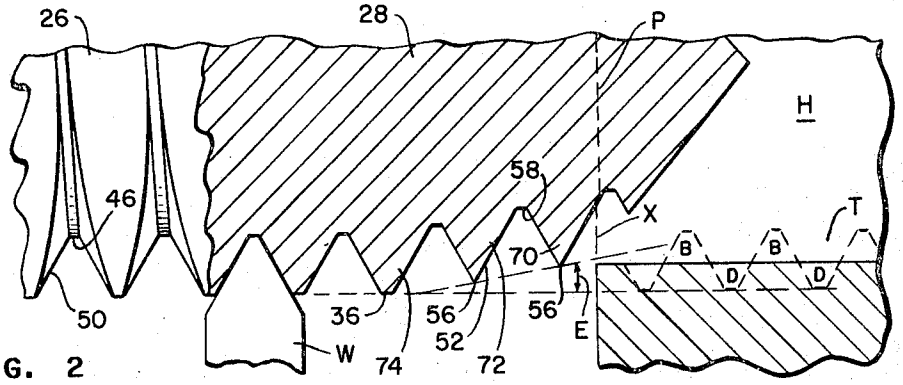


FIG. 2

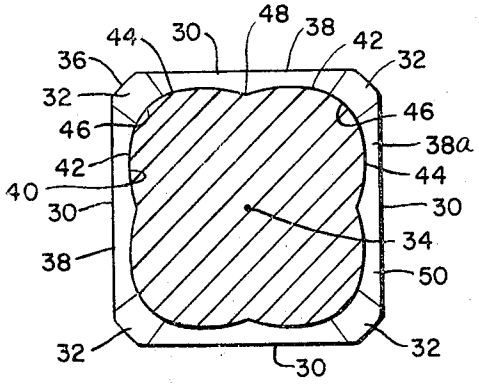


FIG. 3

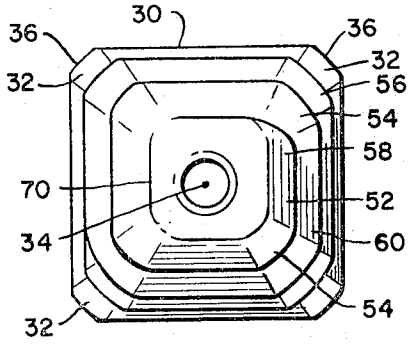


FIG. 4

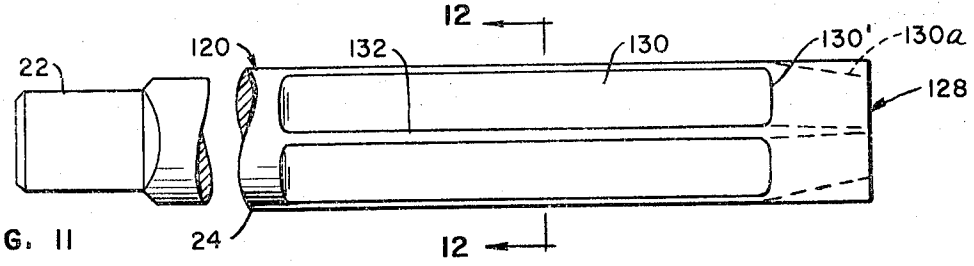


FIG. 11

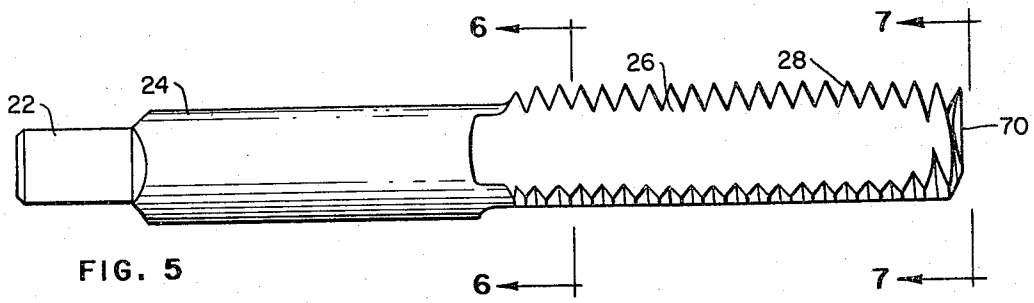


FIG. 5

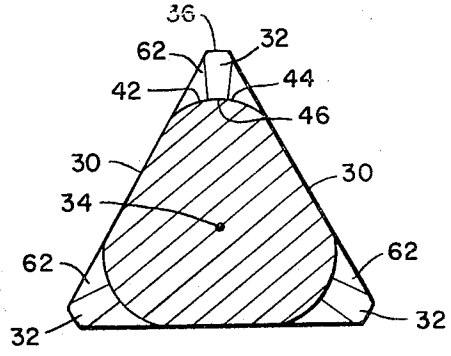


FIG. 6

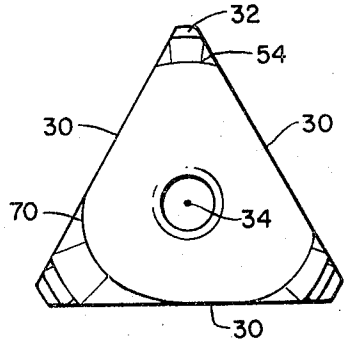


FIG. 7

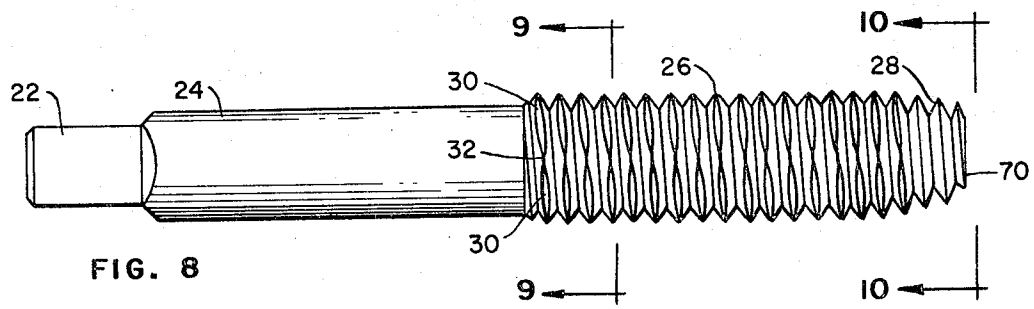


FIG. 8

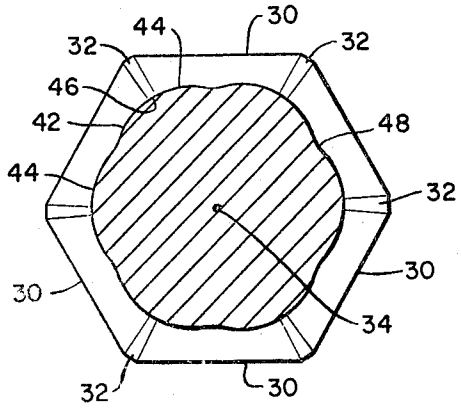


FIG. 9

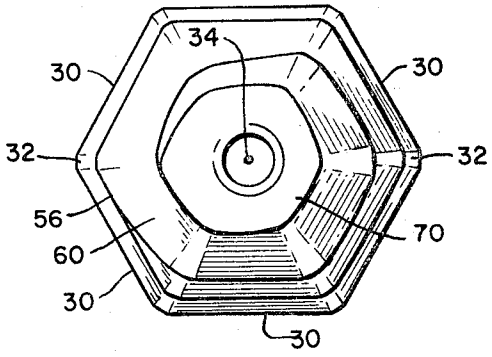


FIG. 10

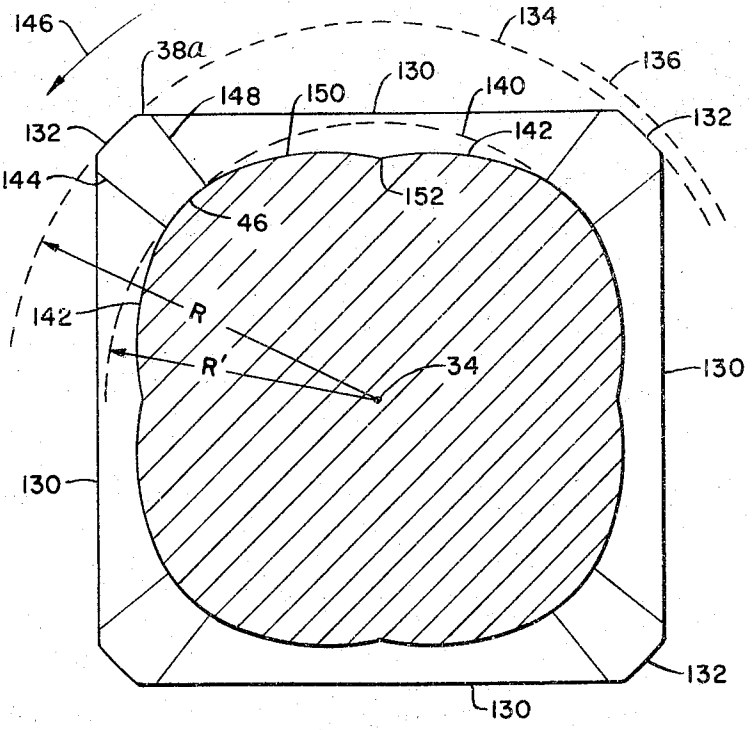


FIG. 12

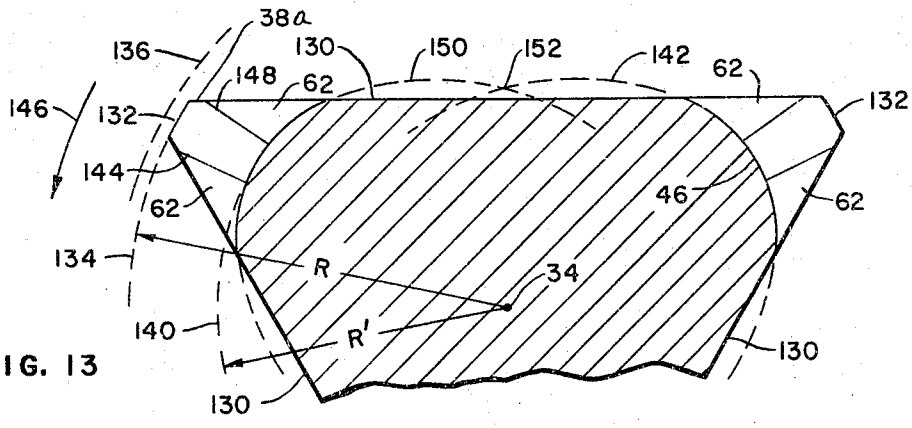


FIG. 13

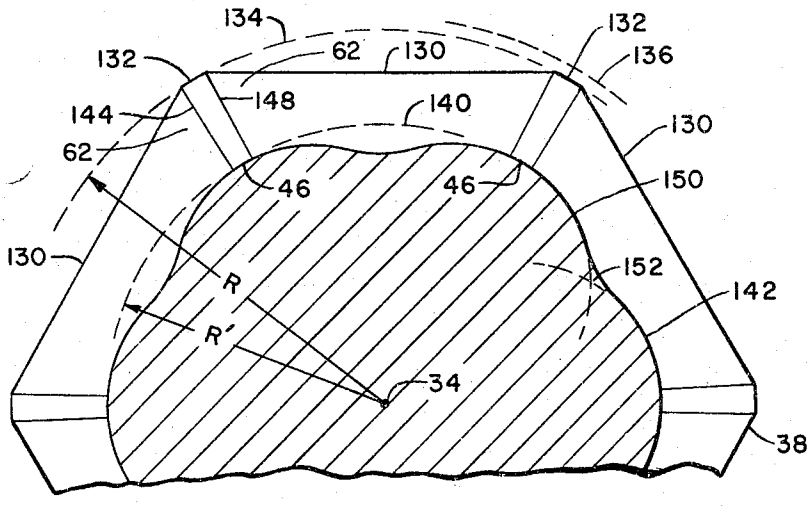


FIG. 14

THREAD FORMING TAP

This invention relates to a threading tap and more particularly to a tap of the cold forming family and one which is particularly suited for tapping in a wide variety of different materials.

Thread swaging taps are not broadly new. One commercially available form is illustrated in my assignee's U.S. Pat. No. 3,171,146 issued to Moss and King, wherein the threaded body of the disclosed tap is divided into circumferentially spaced lands by axially extending flutes. The thread portions on its lands have a cylindrical crest which is concentric with the longitudinal axis of the tap and diminishes in width into radially relieved leading and trailing edges edges; sharp V-shaped crests. Another commercially available form is illustrated in U.S. Pat. No. 2,807,813 reissued to Welles as Re 2457 wherein the threaded body of the tap has a continuous thread the turns of which comprise circumferentially spaced successively radially relieved sectors. In this prior tap the threads are substantially uniform in cross section and equal in depth taken in all planes intersecting the longitudinal axis thereof.

A principal object of the present invention is to improve upon such previously available tap constructions by providing a tap which is less sensitive to hole size, requires considerably less driving torque, is effective in a wider range of materials and has a greatly increased useful life. Taps of this invention have been successfully used to tap both non-ferrous metals and the more ductile ferrous metals as well as various steels such as stainless, titanium and high speed steel. It also has application to non-metals such as various plastics, phenolics, etc.

One of the problems faced in tapping with cold forming or swaging taps has been the high torque required to drive the tap in forming the threads by metal displacement. Usually such taps are operated in non-ferrous metals and soft steels that are ductile in nature. The large amount of torque required generates heat in the material of the part which in turn promotes galling or welding of small particles of the threaded material onto the flanks of the threads, usually in the area where the full thread is developed. Once galling starts, it is progressive in nature and shortly thereafter the tap must be removed from service for various reasons such as loss of thread size in the part, torn threads, seizure of the tap in the hole, breakage and so forth.

Hole sensitivity is a particularly bothersome problem. Economics often prevent the holes from being drilled and reamed accurately to size. In materials such as metal stampings, soft steel and non-ferrous materials, the holes are not drilled but are formed by piercing with tapered punches. The upset material remains about the hole to increase the thickness of the threaded section. However, frequently the punched holes are not true circles; the material left about the holes often has ragged edges, and it is difficult to start tapping in the heaviest deposits of material. Sometimes the holes themselves have a conical shape resulting from the taper of the punch that was used to form them. Similar problems are encountered when tapping zinc or aluminum die castings, as well as in bronze casting where tapered core pins are used. Drilled holes, when not reamed, vary substantially in size because of spindle run out, use of dull drills and other reasons. At the same time reaming adds a cost factor which it is preferred to avoid if possible. Coolants can also be a problem. In the usual thread swaging tap operation a lubricating oil is generally required to compensate for the increased heat resulting from the greater torque requirements. However, many tapping operations have facilities set up for using a water soluble coolant usually because other tools such as drills, reamers, etc., are used simultaneously in a multiple tool set-up. Taps of this invention allow for a wider use of the water soluble coolant. Moreover, taps of this invention, unlike most conventional cold forming taps, are capable of tapping blind holes without setting up a hydraulic condition because the polygonal shape of their thread body permits the coolant to readily escape.

A tap according to this invention forms threads within a preformed hole by displacement of the metal in the peripheral wall of the hole rather than by actually cutting the metal away in chips. In this respect, it operates much like prior swaging taps. However, simultaneously with the metal displacing action it also produces a small amount of dust like residue or "fines" which must be discharged from the hole being tapped.

It is a feature of taps of this invention that the turns of the thread on its body including the tapered end or point thereof, have a generally polygonal shape in cross section and that this polygonal shape may comprise from three to eight sides, or more, depending on specific torque requirements of the material being tapped and the diameter of the tap itself.

Each of the polygonal shaped thread turns on both its threaded body and its tapered end have circumferentially spaced arcuate sections or lobes with crest and root sectors of short angular extent which are centered on the axis of the tap and these crests in the threaded body correspond to the final shape of the thread groove which is to be formed. In the threaded body of the tap between these arcuate sections are truncated chordal portions, the crests of which have an essentially planar surface which present a generally elongated lenticular appearance in plan, whereas their root diameter is radially relieved. Because the resultant height of the thread through these chordal portions is therefore substantially less than the full height of the thread through the arcuate portions which are forming the thread groove in the part, they present less flank area to generate friction and their flat truncated crests create space between the tap and the forming thread for the material being displaced in the tapping action. The afore discussed galling is therefore less a problem and the torque requirements of the thread forming operation are considerably reduced. At the same time, however, the flanks of the chordal portions do perform a sizing function so that a well developed and accurately sized thread can be produced in the tapping operation.

Thus, an important feature of this invention is that the thread swaging or material displacing action of a tap is confined to circumferentially spaced V-crested arcuate sections which provide adequate work areas for thread formation. These work areas, however, are so spaced that contact of the tap thread within the forming groove (work piece thread) is regularly interrupted and/or kept low, therefore the torque requirement of the tap is materially reduced.

A further feature of the invention is that the rib-like sections constituted by the flanks of the chordal portions of the thread turns between the arcuate V-crested

work areas of the lobes structurally reinforce the lobes while minimizing generation of heat through friction.

Still another feature of the invention is that the thread turns on the entrant end of the tap in accordance with this invention are also of the same general polygonal shape; however, the first thread turns have a sharp V-shaped crest which continues into the crest of the chordal portions between the thread forming lobes to promote initial starting of the thread groove in a tapping operation.

These starting thread turns give way to transitional thread turns adjacent to the constant diametered sizing section or main thread body of the tap wherein the chordal portions of the thread turns between the arcuate portions or lobes have at least incipient truncated crests. Thus, a further important feature of the invention is the ease with which the tap is able to start a thread groove while also minimizing the generation of heat and the amount of required driving torque as the transition and first full threads develop the forming thread on the workpiece into its eventual size and shape.

In reducing the invention to practice, it was found that in taps of one-fourth to one-half inch diameters the most satisfactory results were obtained where the polygonal shape of their thread forming body comprised four or six sides, preferably the latter. In smaller size taps, however, less heat is generated where the tap bodies comprise a lesser number of sides. As the number of sides on a tap increase, the size of the discharging "fines" become smaller; however, the torque requirements increase. For minimum torque, the angular extent of the arcuate lobes is kept small and the spacing therebetween kept large. For this reason, in the smaller sized taps it was preferred to use threaded bodies of triangular or square cross section. Although in taps having these polygonal shaped thread bodies of fewer sides there are more "fines", the sharp angular disposition of the sides increases the space therebetween and the forming thread for discharge of said particles as well as space for the material being displaced.

Thus, further important features of the invention include the ability to form a thread with a good or better finish in surface texture, while requiring less torque than of prior taps.

A further feature is that the above advantages are obtained while also being able to form a thread of consistently uniform dimensions.

Still other objects and/or features of the invention are the provision of a tap which can be manufactured economically while providing numerous advantages in the forming of threads not achieved by presently available taps.

Other and further objects as well as features of the invention will be apparent to those skilled in the art from the following description of preferred embodiments which is to be taken in consideration with the accompanying drawings.

In said drawings:

FIG. 1 illustrates a first wmbodiment of the invention in tap;

FIG. 2 is a fragmented longitudinal sectional view taken through the crest of the threads on the tapered end and first few threads on the threaded body of the tap and shows the tap related to a hole to be tapped;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 1;

FIG. 4 is an end view of the tap taken along lines 4—4 of FIG. 1 looking in the direction indicated by the arrows;

FIG. 5 is a side view of a second embodiment of the invention in tap;

FIG. 6 is a sectional view taken along lines 6—6 in FIG. 5;

FIG. 7 is an end view of the tap taken along lines 7—7 in FIG. 5 and looking in the direction indicated by the arrows;

FIG. 8 is a side view of a third embodiment of the invention in tap;

FIG. 9 is a sectional view taken along lines 9—9 of FIG. 8;

FIG. 10 is an end view taken along lines 10—10 of FIG. 8 looking in the direction indicated by the arrows;

FIG. 11 is a side view of the blank used to form the tap of FIG. 1;

FIG. 12 is an enlarged view taken along lines 12—12 in FIG. 11 and diagrammatically illustrates operations performed on the blank to form a tap of this invention having a squared thread body; and

FIGS. 13 and 14 are fragmented views generally similar to FIG. 12 but related to three and six sided polygonal tap bodies respectively.

Referring now more particularly to the several views wherein like parts are identified by like reference numerals and first to FIG. 1, a first embodiment of this invention is illustrated generally at 20 which comprises a conventional squared driving end 22, a cylindrical shank 24 and a threaded body 26 having a tapered end point 28. In FIG. 1, end 28 of the tap is shown blunted and provided with an axially located hole which served as an internal center in forming the tap from its bank. This end of the tap in sizes ⅜ inch and smaller, however, is often pointed, and is illustrated in FIG. 2. When these smaller sized taps are to be used as bottoming taps, this point can be cut off along line P. The threaded body 26 of tap 20 is generally polygonal in cross section as is also its tapered end 28. In this first embodiment its threaded body 26 has four generally flat sides 30 which are separated by a similar number of rounded corners or lobes 32 which are equi-distantly spaced circumferentially about body 26 and disposed in axial alignment with the lobes comprising the remaining thread turns on said body. The threaded body 26 of the tap illustrated in FIGS. 1–4 may therefore be characterized as squared. FIGS. 5 through 7 illustrate a second embodiment of the invention in tap wherein the threaded body of the tap and its tapered end comprise a polygonal cross section with three sides and is described as triangular. In the embodiment of FIGS. 8 through 10 the illustrated tap has a six-sided threaded body and tapered end and is described as hexagonal. The thread turns on body 26 in each embodiment describe a helix centered on the longitudinal axis 34 of the tap. These turns are of constant size and shape whereas the thread turns on the outer end 28 of the tap, although also helically related, regularly decrease in diameter from said constant size turns so that said end 28 may be described as pyramidal and in the embodiment of FIG. 1 as a pyramidal frustum.

Considering now FIG. 3 with FIG. 1, the outside diameter of each thread turn on the body 26 corresponds to the outside diameter of every other thread turn thereon as does the pitch and root thereof. The outside diameter or crests 36 of the lobes 32 comprise sectors

of a circle which are centered on the tap axis **34** and have a constant angular extent which is in the order of 8° to 10°. The root of the lobe also comprises a sector of a circle centered on the tap axis **34** and are of an angular extent at least as great as the crests thereof. The crest **36** of said lobes are V-shaped. In the illustrated embodiment the apex of their V-shape is, however, blunted so that it corresponds to the shape of a standard American National Thread form. In the preferred method of manufacturing the tap, as is afterwards more clearly explained, crest **36** of the lobes **32** comprises the original cylindrical surface of the tap blank.

Between the lobes the outer embodiment of the thread extends generally linear and these portions **30** of the thread have flat or planar crests **38** which gradually narrow and merge into the V-shaped crests **36** of the lobes at either end. This gives the crest **38** of each thread turn portion **30** between the V-shaped crests **36** of the lobes a generally lenticular shape when viewed in plan as seen for example in FIG. **1.** The outer edge or crest **38** of portion **30** of the thread turns may be considered as chords, or as extending chordally, of the circular or cylindrical outer diameter of the lobes **32,** and it is this chordal disposition of the crests of portions **30** which give the threaded body **26** of the tap its aforementioned flat side and squared or polygonal shape in cross section.

The root **40** of said chordal portions **30** on the threaded body **26** is radially relieved on both the leading and trailing sides of the lobes **32** and thus relief is illustrated as along arcs **42** and **44** which at one end meet or merge into the concentric root section **46** of the lobes from whence they rapidly deepen along shortening radii until they intersect at a low point **48** substantially midway between adjacent lobes. The radial distance between root **46** and crest **36** of the lobes **32** corresponds to the height of the thread which is formed by the tap **20,** whereas the corresponding distance between the root **40** and crest **38** of portions **30** between the lobes is substantially less. The amount of radial relief at low point **48** ordinarily will not exceed one-half the thread height. Also, in the usual tap sizes, flanks **50** of the thread turns of a squared body as shown in FIG. **3** continue uninterruptedly throughout the length thereof, including its tapered end **28.**

As illustrated by FIG. **4,** the expanding helically arranged thread turns on the tapered end **28** of the tap **20** also possess a generally polygonal or squared shape in cross section as do the thread turns on the main thread body **26** and the flanks **52** of said threads are continuous. The crest **56** and root **58** of its lobes **54** comprise concentric arcs or sectors of circles centered on the longitudinal axis of the tap and of equal arcuate extent. The crests of lobes **54** unlike lobes **32** on the threaded body **26,** however, have a sharp V-shaped or knife edge throughout. Also, unlike the thread turns on body **26,** portions **60** between lobes **54** of at least the first one or two turns of the thread on said end have the same sharp V-shaped crest or knife edge. Moreover, both the crests and root of the thread turns on the end of the tap have the aforedescribed radial relief between their lobes **54** and it is this relief, as afterwards explained, which gives the turns **70** (FIG. **1**) of the thread on end **28** of the tap its characteristic polygonal shape. Although at least these first few turns of the thread are sharply V-crested throughout as described above, at least the last one or two thread turns **72** of the tapered end which may be described as "transitional" thread turns, contain incipient lenticular-shaped flat or planar chordally extending crest formations. These start to appear and progressively increase in width and length as the helical thread expands and eventually merges into the first full turn of the thread on the tap thread body **26.**

The taps of this invention may be constructed from typical unfluted cylindrical tap blanks, one of which is illustrated at **120** in FIG. **11.** Such blanks usually already have one end squared to constitute the driving end **22** of the finished tap. A size of tap blank is selected having an O.D. corresponding to the O.D. required of the lobes in the finished tap. Blank **120** is prepared for grinding the thread therein by first grinding axially aligned, equi-dimensioned rectangular flats **130** lengthwise thereof, preferably starting short of its end **22** in order to leave a cylindrical shank portion **24** in the finished tap. The grinding of flats **130** may be continued out to the opposite end **128** of the blank or it may be terminated short thereof as indicated at **130'.** Narrow portions **132** of the original cylindrical surface remain between the flat ground flanks **130.** In the finished tap the surface of the narrow portions **132** form the crest **36** of the lobes **32** whereas the surface of flats **130** form the crest **38** of the portions **30** of the thread turns between said lobes. The number of ground flats **130** therefore should correspond to the number of sides **30** required in the polygon threaded body portion of the finished tap. The width of the narrow portions **132** left between the flat portions will correspond to the angular width of the crests on the lobes **32** of the finished tap. As previously described, an angular extent of approximately 8° to 10° has been selected as providing a working area or lobe crest of satisfactory size. Within the spirit of this invention and in order to satisfy specific requirements, said angular extent, however, may be further increased or decreased. As is common in the tap industry, tap blanks **120** have a back taper of roughly 0.0003 inches per inch of body length and this back taper may be observed when grinding flats **130** therein.

As illustrated by phantom lines in FIG. **11,** end **128** of the tap blank may be provided with more steeply inclined flats **130***a* which reduce the amount of metal required to be removed by the wheel in grinding the threads which constitute the tapered end **28** of the finished tap **20.** However, flats **130***a* do not effect the formation of the end threads of the finished tap and the grinding of end flats **130***a* can be eliminated.

In one method of forming the tap threads, the thus prepared tap blank **120** with flats **130** ground therein is held between centers, rotated and translated in accordance with the pitch of the thread to be generated, as a more rapidly rotating tool or wheel W (FIG. **2**) is fed angularly into the material of blank **20** under the control of a cam (not shown). The cam functions to control inward and outward relative movement of the wheel to the blank (or conversely the blank to the wheel) so as to generate relief in the thread root as the wheel forms the root and also shapes the inclined flanks of the thread turns on either side thereof. Grinding of the threads may be commenced either at the outer end **128** of the blank or adjacent to the inner end of the flats **130.** Assuming the latter, blank **120** when mounted in the grinder is initially aligned with wheel W such that its edge initially bites into the blank midway between

two such portions **132** and to a depth below the theoretical concentric root line **140** (FIG. **12**) which contains the high point or concentric arcuate sectors **46** comprising the thread root in the lobe **32** of the finished tap body **26.** As the blank is rotated on its axis **34** wheel W is withdrawn radially under the control of the cam so that it cuts the thread root along arc **142** as it approaches O.D. portion **132.** Simultaneously, wheel W is also grinding the inclined flanks of the adjacent thread turns on either side of thr root being generated. As the trailing radial boundary of edge of the lobe indicated at **144** is reached, (considering the rotation of the finished tap to be opposite to that of the blank as indicated by arrow **146**) further outward movement of wheel W is halted. The blank, however, continues to rotate in the direction indicated by arrow **146** so that wheel W cuts arcuate portion **46** of the root across the lobe **32** concentric with the O.D. of **132** as indicated by redii R and R′ while also shaping the flanks of the lobe through section **132** on either side thereof. As wheel W reaches the leading radial edge or boundary **148** of the lobe it is moved radially inwardly of the blank by the cam so that the forming root which it continues to generate is redially relieved along arc **150** to its low point **152** (which corresponds to **48** in the finished tap of FIG. **3**) midway between the lobes or sections **132.** In the presently preferred form of the invention the concentric section of the lobe root approximates 15° so that as shown in FIG. **12** the angular extent of the root sector **46** of the lobes is greater than the angular extent of the lobe crest **36** wherefore radial bounds **148, 144** i.e., the leading and trailing edges of the lobes **32** actually lie outside the angular extent of crest **36.** As the bite of the wheel passes through low point **152** the cam again reverses direction of the wheel W so that it starts to generate the relieved root **142** on the trailing side of the next lobe. These movements of the grinding wheel W under the control of the cam are repeated so that the wheel continues to generate the concentric root section **46** of the lobes and the radially relieved leading **44** and trailing **42** sections of the thread root **40** on either side thereof as the blank is further translated to the left of FIG. **11** causing wheel W to generate the helical thread about the blank to end **130′** of its flats.

Simultaneously, with each pass of wheel W about the blank **120,** the wheel is completing formation of the preceding thread turn by generating the second flank thereof as it is generating the first flank of the succeeding thread turn. The inclination at which the wheel W grinds said first and second flanks is so related to the depth at which it grinds concentric root section **46** that the two flanks of the completed thread intersect along an arc **136** which is outside the O.D. of sections **132.** A narrow section of cylindrical surface **32** is therefore left which constitutes the crest **36** of the lobes **32.** The width of crest **32,** as well as the inclination of the low flanks is selected to correspond to that required of the finished tap to form the root of an American National Thread form. As previously indicated, the cam directed movement of wheel W is halted at least through the angular extent of section **132** of the blank so that concentric root sections **46** of the lobes generated by wheel W have an angular extent greater than that of the O.D. blank sections **132** and the crests **36** of the lobes have parallel sides in plan. However, under some circumstances the radial relief generated by wheel W along arcs **142** and **150** may be continued into the root of the lobe **32** even to the radial bisector of the lobe. For example, in the larger size taps having more than eight lobes, the physical dimensions of the tap may be such that the reduced angular extent of the concentric sector comprising the lobe root cam does not present a wear problem and in fact may be preferable because of the further reduction in surface contact. In this event arc **136** along which the two flanks of the lobe intersect is no longer concentric with the outside diameter of the flank section through the full extent thereof and the sides of the lobe crests **36** do not retain their above-described parallel relation. Instead the lobe crests assume a more lenticular appearance in plan, their trailing and leading ends narrowing from parallelism in proportion to the developed radial relief in the lobe root.

As wheel W forms the flanks of the thread turns between the lobes (sections **132** of the blank) it also cuts through the chordal flats **130.** The flanks of the thread portions **30** formed by wheel W between the lobes are therefore truncated and the crest **38** of these portions not only retain the flat surface of flats **130,** but they also have a lenticular shape in plan as a result of said truncation. As illustrated in FIG. **1,** the flat crest **38** of these portions **30** appear widest at their mid point where the truncation is the deepest and converge inwardly at their two ends where the truncation is more shallow, merging into the blunter V-shaped crests **36** of the lobes **32.**

As the blank **120** id translated to the left (FIG. **11**) and wheel W nears the end **130′** of the flats **130,** wheel W is caused to feed deeper into the material of the tap blank along an angle of declination E (FIG. **2**), preferably of the order of **8** to **15** degrees, so as to form the thread turns on the tapered end **28** of the finished tap. At the start of said declination, the first turns of the forming thread will have incipient lenticular crests as seen in FIG. **1.** This is because as these first thread turns are formed, the wheel W does not immediately reach deep enough into the blank and at the top of its withdrawal stroke it still breaks through at least some portion of the flats **130.** However, as the wheel is fed deeper into the blank, these lenticular crests become progressively smaller and eventually disappear. The number of "transition threads" thus formed will be determined by where in advance of the end **130′** of the flats and the angle at which the inclination of wheel W is directed in generating the thread turns on the tapered end or point **28.** As the bite of wheel W reaches deeper into the material of the blank **120,** arc **136,** along which the flanks of the lobe intersect, drops below the O.D. of the sections **132** so that the blunted V-shape of the crests of the lobes in the threaded body **26** is replaced by the knife edge or sharp V-shape which characterize crests **56** of the lobes **54** in the tap point **28.** As the wheel continues to bite deeper into the material of the blank a point is reached where the intersection (or arc **136**) of the thread flanks lies wholly within the material of the blank. When this occurs the crests of the portions **60** between the lobes **52** on the tapered tap end or point **28** also take on the sharp V-shape or knife edge of the lobe crests **56.** In accordance with the invention, the length of the tapered end **28** and number of thread turns generated therein need only be sufficient that at least the last turn of the thread on the tapered end of the tap has a knife edge crest throughout. This last thread is indicated at **70** in FIGS. **1** and **4,** for example, and is referred to as the "starting thread" on

the tap. At least the beginning portion of the starting thread **70** should also have a diameter less than the I.D. of the hole to be tapped (FIG. 2).

Considering now FIG. **13** with FIGS. **5, 6** and **7**, and also FIG. **14** with FIGS. **8, 9** and **10**, it will be seen that polygonal tap bodies having a lesser as well as a greater number of sides can also be formed by essentially the same method as above-described in connection with the squared tap of FIGS. **1-4** and discussed in connection with FIGS. **11** and **12**. Thus, FIGS. **5, 6** and **7** illustrate a second embodiment of the invention in which the thread body **26** of the tap and its tapered end **28** have three equi-distantly spaced and sized lobes **32** and chordal sides **30**; while FIGS. **8, 9** and **10** illustrate s similar tap but one having six such equi-distantly spaced and sized lobes **32** and chordal sides **30** in its thread body and tapered end. The root and crests of the lobes **32** in each of these further embodiments are also concentric as in the first described embodiment of the FIGS. **1–4**, and the angular extent of their concentric root section **46** is at least as great as that of the crests **36** and may be greater. In practice, good results have been found where in the case of the triangular tap the concentric root sector **46** of the lobes approximates 20° or twice that of the crests. In larger size taps having a greater number of lobes it is presently preferred to reduce the angular extent of the root concentric sectors to more nearly correspond to that of the lobe crest. The best results in terms of low torque requirement are considered to be obtained when the concentric root sectors of the lobes have an angular extent when totaled together which does not exceed 60°. It will be appreciated that the included angle between the flat crests **38** of chordal thread portions **30** between lobes **32** of the taps varies with the number of lobes and thereby changes the rake or disposition of the leading edge of said lobes which the flat chordal crest **38** of said portions **30** effectively constitute. This is readily apparent from a comparison of FIGS. **3, 6** and **9** which comprise cross sections taken through the thread body **26** of each of the three illustrated embodiments.

In the embodiment illustrated by FIGS. **5, 6** and **7** wherein the polygonal threaded body **26** is triangular, the inclination of flats **130** which are initially ground on the periphery of its tap blank and from crests **36** of the chordal portions **30** of the finished tap are so sharply angled with respect to each other (60°) that the radially relieved thread root along arcs **142** and **150** is incompletely generated, the major length of said arcs including low point **152** in effect lying above the chordal flats **130** as shown in FIG. **13**. However, the radial relief ground below the flats to either side of the concentric sections **46** of the lobes **32** is sufficient that a pair of generally triangular flank sections **62** appear between the lobes. These triangular shaped truncated flank portions **62** at the leading and trailing sides of the lobes **32** in effect present the characteristic lenticular shape in plan and being planar or flat as well as chordal constitute the equivalents of chordal crests **38** as above discussed in connection with the first described embodiment. Also, as is apparent from FIG. **7**, in this embodiment of the tap having a triangular thread body **26**, the turns of the thread on the point **28** of the finished tap with the possible exception of the last or starting thread turn **70** (depending on the diameter size of tap) have lenticular shaped flat chordal crests between their knife edge crested lobes **54**.

On the other hand, as illustrated by the third embodiment seen in FIGS. **8, 9, 10** and **14**, as the number of sides on the polygonal thread body **28** of the tap is increased above three, assuming the tap diameter and angular extent of the lobe crests to be kept constant, not only does the included angle between said sides increase, but the characteristic lenticular shape of its crests **38** narrow and become more elongated. This occurs because the flats **130** are cut closer to the O.D. of the tap blank and wherefore the theoretical crest line of the tap thread formed through these areas more close approaches the flats **130**.

In use, the taps of this invention are rotated in the bore of the hole of a workpiece to be threaded, said hole being identified at H in FIG. **2**. The sharp knife edge shape of the crest of the lobes on the starting thread **70** of the tap, promotes initial starting of the thread groove in the wall of the hole while the radial relief provided said thread turn in both the root and crest of its portions **60** between lobes **54** interrupts or relieves the forming action so as to minimize starting torque. At the same time, the full flank height of the starting thread turn holds the tap thread in the started thread groove T. Referring to FIG. **2**, it will be seen that the I.D. of the hole H in the workpiece although less than the initial portion of the starting thread **70** is smaller than the O.D. of the thread in lobes on body **26**. As the thread on the tap point increases in diameter, the threaded groove T which is is forming in the workpiece is widened and deepened as each lobe on the expanding helical thread engages and passes therethrough. Starting torque is also reduced by reason that as the thread on the point of the tap expands, the physical spacing of the lobes also increases. It will be appreciated that the thread groove is fully developed and shaped by the time the first full turn **74** on the tap body has been moved therethrough.

Nevertheless the lobes **32** and flanks of the chordal portions **30** therebetween on the succeeding thread turns of the body portion **26** serve to guide and also to hold the tap in its initial centered position within the tapping hole as they pass through the groove and so that each succeeding turn of the thread groove in the bore is accurately located and sized as it is formed.

The action of the thread tap in forming the thread groove is largely obtained by displacement of the ductile metal D or other material of the bore wall which builds up the thread wall as illustrated at B in FIG. **2**. This displacing action of the tap is indicated by the lobes **54** in the tapered end **28** which deepen the forming thread groove to nearly its final size and then by the lobes **32** of the first thread **72** on the full-diametered thread body **26** which finally shape and size the groove. This final shaping and sizing of the groove (by shifting of material D to B on either side of the forming thread groove T) is considered to be the combined effect of the lobe crests **36** and the tapered flat portions (**38*a*** in FIGS. **12** and **13** and **62** in FIG. **14**) of the crest of the chordal portions **30** which lead the crest **36** of said lobes **32**. Although the explanation therefore has not yet been fully established, it is evident that the angular disposition of said lead portions **38*a*** (**62** on the triangular tap bodies) inpart a negative rake to the lobe crests **36**, which being flat and also wedge-shaped may impose a secondary minor shearing or cutting action on the sides and roots of the forming thread groove producing the "fines" which are present. It is noted that as

the number of the sides of the polygonal body are increased while keeping other factors such as lobe angle and tap diameter constant, the particle size of the "fines" diminish and this is consistent with the fact that as the number of sides increase on the polygonal thread body the lenticular shape of the crests **38** becomes more narrow and therefore less blunt while the angular disposition of said portions **38** of the chordal crests **30** adjacent to the lobe crests decreases with a corresponding change in negative rake.

The reduced driving torque required of taps of this invention is a particularly important feature thereof. This reduction in torque requirement obtains not only as a result of the radial relief generated in the root and crest of the thread turns between the lobes **54** and the tap point **28**, but also is due in large part to the chordal disposition of the flat crest **38** on the full diametered turns of the thread on the body of the tap. These flat chordal crests **38** not only interrupt the engagement of the lobe crest **36** to relieve torque, but also provide space through which the metal displaced by the lobe crests may rapidly move. They also provide for the discharge of "fines" without galling or clogging of the thread. Of particular importance, is the reduction of flank contact with the sides of the forming thread groove in the bore wall with accompanying reduction in the amount of heat generated as a result of torque required to overcome said frictional contact. This heat has been a major contributor to the problem of galling which has previously characterized tapping operations in ductile metals. When compared to a tap such as disclosed by U.S. Pat. No. 2,807,813, reduction in flank contact has been calculated to be in the order of 30 or 35 per cent.

In practice, it has been found that the number of sides on the polygonal thread body of the tap will be determined by the use to which the tap is to be put and also the diameter of the tap itself. For example, taps with a squared thread body have proved particularly effective when tapping non-metallic and most non-ferrous metals while a tap with a hexagonal thread body is presently preferred for tapping in many ductile ferrous metals. As earlier alluded to, when thread tapping with polygon taps of this invention, the number of sides have a direct bearing on the particular size of the "fines". Although it is therefore desirable to use taps with as many sides as possible so as to keep the particular size of the "fines" as small as possible, the larger included angle between the sides which also results as the number of sides is increased means that flank surface area of the threads on the tap is also increasing which in turn means greater torque requirements and increased generation of heat.

It will also be appreciated that the diameter of the tap effects the physical spacing of the lobes about its thread turns. The further apart are the lobes, the less is the friction developed by the tap in its threading action, other factors such as speed of rotation being constant. In the size of taps commonly used by the manufacturing industry having need for taps of the cold forming family, it has been found that taps of this invention having polygonal threaded bodies with from three to eight sides are the most useful; and in tap sizes of ¼ inch diameter or more, taps with hexagonal threaded bodies are to be preferred. In tap sizes smaller than No. 10, taps having either a squared or triangular threaded body have preference. In tap sizes smaller than No. 4, the triangular shape of the threaded body is preferable in order to obtain as great a physical spacing of the lobes as is possible. In tap sizes having a diameter greater than ¼ inch, the threaded bodies may have as many as eight sides and possibly more because of the increased physical spacing of the lobes which said larger diameters permit.

From the above description it will be apparent that all of the recited objects, advantages and features of the invention have been demonstrated as obtainable in a tap of a construction that is highly practical, as well as economical, to manufacture.

Having described my invention, I claim:

1. A tap comprising a longitudinal body of generally polygonal shape in cross section having a tapered end and a thread helically arranged about said body and tapered end, the turns of the thread on said longitudinal body being of constant size and shape and consisting of circumferentially spaced lobe portions with V-shaped crests and intervening chordal portions with truncated flat crests, the crests of said lobes on the longitudinal body embodying sectors of a circle defined by equal radii centered on the tap longitudinal axis and the truncated flat crests of the intervening chordal portions being equidistantly spaced from said longitudinal axis, merging into the V-shaped crests of the leading and trailing parts of the lobe portions at either end thereof and presenting elongated lenticular configurations in plan therebetween, the root of the thread turns on either side of the lobes being relieved along radially decreasing arcs which merge into the root of the lobes.

2. A tap as claimed in claim **1** wherein the V-shaped crests of the spaced lobe portions correspond to the American National thread form.

3. A tap as claimed in claim **1** wherein the lobe portions have concentric crests and root sectors centered on the axis of the tap.

4. A tap as claimed in claim **3** wherein the concentric root sectors of the lobes are of greater angular extent than their concentric crests.

5. A tap as claimed in claim **1** wherein the truncated crest of each chordal portion of the thread is generally planar.

6. A tap as claimed in claim **1** wherein the thread turns on the longitudinal body have at least three V-shaped crested lobe portions and a corresponding number of intervening chordal portions.

7. A tap as claimed in claim **6** wherein the longitudinal body has a generally pyramidal shaped tapered entrant end and the starting turn of the thread thereon has a sharp V-crest.

8. A tap as claimed in claim **1** wherein the longitudinal body has at least four equi-dimensional sides, said sides being separated by rounded corners which comprise said lobe portions of the thread turns and are centered on the longitudinal axis of the tap and equidistantly spaced from said axis.

9. A tap as claimed in claim **8** further having a generally pyramidal tapered entrant end.

10. A tap as claimed in claim **9** wherein at least the first thread on said tapered entrant end has a sharp V-shaped crest.

11. A tap as claimed in claim **10** wherein at least the last turn of the thread on said tapered entrant end has circumferentially spaced chordal portions with truncated crests between arcuate portions with sharp V-crests.

12. A tap as claimed in claim 1 further having a supporting shank at one end of said threaded body.

13. A tap as claimed in claim 12 wherein the thread on the body of the tap is continuous into the tapered end thereof.

14. A tap as claimed in claim 12 wherein the first turns of the thread on the tapered end thereof have a continuous V-shaped crest.

15. A tap as claimed in claim 1 wherein at least the turn of the thread on the tapered entrant end immediately adjacent the tap body has circumferentially spaced arcuate portions with the V-shaped crests and intervening chordal portions with truncated crests presenting an elongated lenticular configuration, said arcuate and chordal portions being aligned with corresponding portions on the thread turns of the tap body.

16. A tap as claimed in claim 15 wherein the first turns of the thread on the tapered entrant end of the tap have a V-shaped crest.

17. A tap as claimed in claim 1 wherein the lobe crests of each thread turn have a much shorter angular extent that do the intervening chordal portions.

18. A tap as claimed in claim 17 wherein the lobe crests of each thread turn have a total angular extent of less than 60°.

19. A tap as claimed in claim 1 wherein the radial relief of the root of the chordal portions continues to a maximum low point midway between adjacent lobes.

20. A tap as claimed in claim 1 wherein the thread turns on the tapered end of the tap are of a similar polygonal shape to those on the longitudinal body but regularly decreasing in diameter from the constant size thereof.

21. A tap as claimed in claim 20 wherein the thread turns on the tapered end of the tap have circumferentially spaced lobes with intervening chordal portions of reduced radial height, said lobes on the tapered end having knife edge V-shaped crests comprising sectors of a circle centered on the tap longitudinal axis.

22. A tap as claimed in claim 21 wherein the lobes of the thread turns on the tapered end have concentric root and crest.

23. A tap as claimed in claim 22 wherein the crest and root of the thread turns between the lobes on the tapered end are radially relieved.

* * * * *