



- (51) **International Patent Classification:**
B23G 1/34 (2006.01) *B23G 5/18* (2006.01)
B23G 1/02 (2006.01)
- (21) **International Application Number:**
PCT/SE2010/050223
- (22) **International Filing Date:**
26 February 2010 (26.02.2010)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
09501111-5 4 March 2009 (04.03.2009) SE
- (71) **Applicant (for all designated States except US):** SECO
TOOLS AB [SE/SE]; SE-737 82 Fagersta (SE).
- (72) **Inventor; and**
- (75) **Inventor/Applicant (for US only):** KOSKINEN, Jorma
[SE/SE]; Knutsvägen 55, SE-737 33 Fagersta (SE).
- (74) **Agent:** CARLSSON, Lars-Åke; Sandvik Intellectual
Property AB, S-811 81 Sandviken (SE).
- (81) **Designated States** (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,
KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,
NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD,
SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ,
TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE,
ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) **Title:** METHOD OF THREAD MILLING, THREAD, AND INSERT AND TOOL FOR THREAD MILLING

(57) **Abstract:** A thread milling insert includes a plurality of teeth longitudinally spaced along an edge of the insert, each tooth having a cutting edge at a tip of the tooth, a longitudinal distance between any two cutting edges being at least two times greater than a height of any tooth. A method of thread milling a workpiece involves providing a tool(23) with a thread milling insert (37), rotating a tool about an axis of the tool, the tool having a tool holder and at least one cutting edge arranged radially relative to the axis of the tool. At a plurality of circumferential positions about an axis of the workpiece, at least one of the tool and the workpiece are moved relative to each other in a direction substantially perpendicular to a direction of the axis of the workpiece while simultaneously moving at least one of the tool and the workpiece relative to each other in substantially an axial direction of the workpiece so that the at least one cutting edge forms a plurality of recesses in the workpiece, the plurality of recesses defining a helical thread.

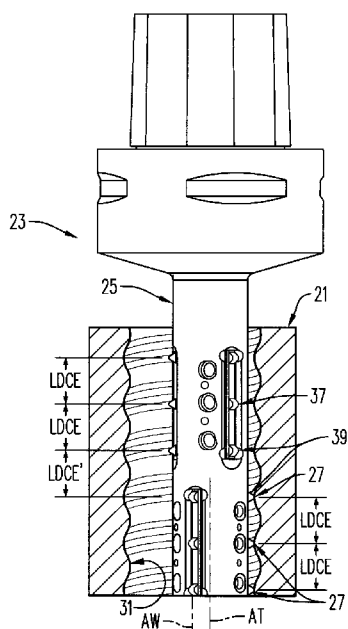


FIG. 1C



Published:

- *without international search report and to be republished
upon receipt of that report (Rule 48.2(g))*

METHOD OF THREAD MILLING, THREAD, AND INSERT AND TOOL FOR THREAD MILLING

BACKGROUND AND SUMMARY

[0001] The present invention relates generally to thread milling, milled threads, and thread milling tools.

[0002] In the typical thread milling operation, a tool with an insert having a plurality of teeth having the general shape of the thread to be milled is rotated about its axis and moved along a helical path relative to a workpiece. The thread forms that can be generated using a multi-toothed insert are generally limited to thread forms having substantially the shape of the teeth on the insert. If it is desired to obtain thread forms having unusual shapes, it is generally necessary to either form the thread with a tool having a single tooth, which increases the time necessary for forming the thread, or provide a specially adapted multi-tooth cutting insert.

[0003] It is desirable to provide a method and thread milling tool and insert for thread milling a workpiece with a rotating tool that can use the same multi-tooth inserts to create a variety of different thread forms.

[0004] In accordance with an aspect of the present invention, a method of forming a threaded workpiece comprises providing a tool with a thread milling insert rotating a tool about an axis of the tool, the tool having a toolholder and at least one cutting edge arranged radially relative to the axis of the tool, and, at a plurality of circumferential positions about an axis of the workpiece, moving at least one of the tool and the workpiece relative to each other in a direction substantially perpendicular to a direction of the axis of the workpiece while simultaneously moving at least one of the tool and the workpiece relative to each other in substantially an axial direction of the workpiece so that the at least one cutting edge forms a plurality of recesses in the workpiece, the plurality of recesses defining a helical thread.

[0005] In accordance with another aspect of the present invention, a thread milling insert comprises a plurality of teeth longitudinally spaced along an edge of the insert, each tooth having a cutting edge at a tip of the tooth, a longitudinal distance between any two cutting edges being at least two times greater than a height of any tooth.

[0006] In accordance with yet another aspect of the present invention, a thread milling tool comprises a thread milling insert comprising a plurality of teeth longitudinally spaced along an edge of an elongated body of the insert, each tooth having a cutting edge at a tip of the tooth, a longitudinal distance between any two cutting edges being at least two times greater than a height of any tooth, and a toolholder comprising an insert receiving recess for receiving the elongated body of the insert such that the plurality of teeth extend radially relative to a longitudinal axis of the tool.

[0007] In accordance with yet another aspect of the present invention, a threaded article is provided and comprises at least one start and a helical thread comprising at least one turn, the thread comprising a plurality of regularly spaced recesses extending substantially perpendicular to a length of the thread.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The features and advantages of the present invention are well understood by reading the following detailed description in conjunction with the drawings in which like numerals indicate similar elements and in which:

[0009] FIGS. 1A-1C are side, partially cross-sectional views of a workpiece in which a thread milling tool according to an aspect of the present invention is shown at different axial and radial positions relative to the workpiece;

[0010] FIG. 1D is a top, schematic view of a workpiece showing a thread milling tool at various positions around an internal circumference of the workpiece and FIG. 1E is a top, schematic view of a workpiece showing a thread milling tool at different radial positions relative to a longitudinal axis of the workpiece;

[0011] FIG. 1F is a side, partially cross-sectional view of a workpiece after a first pass by a thread milling tool according to an aspect of the present invention, and FIG. 1G is a side, partially cross-sectional view of a workpiece after a plurality of passes by a thread milling tool according to an aspect of the present invention;

[0012] FIG. 2A is a schematic view of an arrangement of cutting edges for forming a multi-start thread according to an aspect of the present invention, and FIG. 2B is a side, schematic view of an arrangement of cutting edges for forming a single-start thread according to an aspect of the present invention;

[0013] FIG. 3A is a perspective view of a thread milling insert according to an aspect of the present invention, FIGS. 3B and 3C are side and end views, respectively, of the insert of FIG. 3A, and FIG. 3D is a cross-sectional end view taken at section 3D-3D of FIG. 3B; and

[0014] FIG. 4A is a side view of a toolholder for a thread milling tool, and FIGS. 4B and 4C are side and bottom exploded views of a thread milling tool shown with inserts removed from insert receiving recesses on the toolholder.

DETAILED DESCRIPTION

[0015] A method of forming a threaded workpiece 21 is seen with reference to FIGS. 1A-1G. According to the method, a tool 23 is rotated about an axis AT of the tool. The tool 23 has a toolholder 25 and at least one cutting edge 27 arranged radially relative to the axis AT of the tool. The toolholder 25 is provided with a shank connected to a circumferential, planar shoulder defining the axial position of the tool 23 relative to a machine spindle (not shown). As seen, for example, in FIGS. 1A-1C, at a plurality of circumferential positions (shown in FIG. 1D as positions a-j) about an axis AW of the workpiece 21, at least one of the tool 23 and the workpiece 21 are moved relative to each other in a direction substantially perpendicular to a direction of the axis of the workpiece, i.e., radially outward from the position shown in FIG. 1A to the position shown in FIG. 1B, and radially inward from the position shown in FIG. 1B to the position shown in FIG. 1C, and as shown by the top view shown in FIG. 1E, wherein a radially inner position of the tool 23 is shown in phantom, and a radially outer position of the tool is shown in solid lines.

[0016] Simultaneously with the radially inward and outward movement, at least one of the tool 23 and the workpiece 21 are moved relative to each other in substantially an axial direction of the workpiece, i.e., substantially continuously axially downwardly as shown in FIGS. 1A-1C. In this way, the at least one cutting edge 27 forms a plurality of recesses in the workpiece. A single recess 29 is shown in FIG. 1F, i.e., formed by a single pass of the tool 23 relative to the workpiece 21. The lack of perfect symmetry of the recess 29 about a longitudinal axis of the workpiece can be explained by the fact that the tool is moving along the axis of the workpiece as the recess is formed. This can

be useful in creating a thread form. Movement of the workpiece and/or the tool relative to each other in an axial direction of the workpiece is described as “substantially” in an axial direction because the workpiece 21 will often be turned and/or the tool 23 will be controlled to move with a circumferential movement component so that the tool traces an “S” shaped recess 29 as seen in FIG. 1F to compensate for changes in the point of attack of the rotating tool as the tool and/or workpiece are moved radially relative to each other. For example, as seen in FIG. 1E, the point of attack PA1 of the tool 23 will typically lie on a line extending through the center axes of the tool and the workpiece 21 when the tool first contacts the workpiece, but will move to points PA2L or PA2R to the left or right (depending upon the direction of rotation of the tool) of the line through the center axes of the tool and the workpiece as the tool cuts into the workpiece. A plurality of recesses formed by a plurality of passes of the tool 23 relative to the workpiece 21 combine to define a helical thread 31 as shown in FIG. 1G. The resulting threaded article 21 comprises at least one start 33 and a helical thread 31 comprising at least one turn, the thread comprising a plurality of regularly spaced recesses 29 extending substantially perpendicular to a length of the thread.

[0017] Ordinarily, relative movement of the workpiece 21 and the tool 23 is accomplished by moving the tool relative to the workpiece, however, it is also possible that the workpiece may be moved relative to the tool and/or that both the workpiece and the tool will be moved relative to each other. For purposes of discussion, it will be assumed that the tool 23 moves relative to the workpiece 21, it being understood that aspects of the invention can involve the workpiece being moved relative to the tool, or both the workpiece and the tool being moved relative to each other.

[0018] In the method illustrated in FIGS. 1A-1G, the helical thread 31 is an internal thread. However, the helical thread can instead be an external thread such as shown in FIGS. 2A-2B.

[0019] As seen in FIGS. 1A-1C, ordinarily, the tool 23 has a plurality of cutting edges 27 arranged radially relative to the axis AT of the tool 23. Movement of the tool 23 and the workpiece 21 relative to each other in the direction substantially perpendicular to the direction of the axis AW of the workpiece 21 while the tool rotates about the tool's axis AT causes at least two of the plurality of cutting edges 27 to simultaneously form at

least two recesses 29 in the workpiece, assuming, of course, that neither of the cutting edges is in a previously formed recess.

[0020] The threaded workpiece 21 can be formed with one or more starts, i.e., the thread can be a multiple thread as seen in FIG. 2A or a single thread as seen in FIG. 2B. FIG. 2A shows a workpiece 121 formed with two starts 33a and 33b corresponding to two threads 31a and 31b. When such threads 31a and 31b are formed by a tool with plural cutting edges 27, each thread of the threaded workpiece 21 having N starts has a pitch P, and tips 35 of the plurality of cutting edges 27 of the tool can be spaced according to the equation P/N . Thus, for the threads 31a and 31b each having pitch P with two starts 33a and 33b shown in FIG. 2A, the spacing between tips of two cutting edges can be $P/2$. For a single-start thread, where the thread has a pitch P, tips 35 of a plurality of cutting edges 27 can be spaced according to the equation NP , where N is a whole number excluding zero. Thus, multiple cutting edges 27 can be spaced at spacings of $1P$, as shown in solid lines, or other spacings, such as $2P$, or $3P$, etc., as shown in phantom lines.

[0021] By making a plurality of passes of the tool 23 relative to the workpiece 21 at the plurality of circumferential positions around the workpiece, the thread 31 becomes more and more fully formed. For many applications, the passes can be performed at 3° to 5° intervals about the axis AW of the workpiece 21. It is presently considered that performing the plurality of passes at a plurality of circumferential positions that are spaced at intervals between $20\text{-}30^\circ$ about the circumference of the workpiece 21 or some angular interval will be desirable for many applications of the thread 31.

[0022] Unlike in threads formed by typical thread mills, the helical thread 31 formed according to an aspect of the method of the present invention can have a basic shape different than a profile of the at least one cutting edge 27. As seen, for example, in FIGS. 1A-1C, the thread 31 has a generally elongated and curved shape, e.g., a rope thread, while the cutting edges 27 are more triangular and shorter in shape. By providing appropriate instructions to a conventional milling machine, such as via a computer program, threads 31 of a variety of shapes and sizes can be formed in workpieces with a single tool 23.

[0023] The cutting edges 27 are typically provided on a thread milling insert 37 such as is shown in FIGS. 3A-3D. The insert 37 comprises a plurality of teeth 39 longitudinally spaced along an edge of the insert. Each tooth 39 has a cutting edge 27 at a tip 35 of the tooth. The cutting edge 27 can comprise an entire or substantially an entire periphery of the tooth 39, or merely a portion of the tooth proximate the tip 35. As seen in FIGS. 1A-1C, the cutting edge 27, i.e., the portion of the tooth 39 that actually cuts the workpiece 21, can be a relatively small portion of the tip 35 of the tooth with a substantial non-cutting portion 41 between the cutting edge 27 and the main body 43 of the insert. A longitudinal distance LDCE between any two cutting edges is at least two times greater than a longitudinal length LLCE of any cutting edge and/or, as seen in FIG. 3B, at least two times greater, and preferably at least three times greater, than a height H of any tooth 39 as measured from the tip 35 of the tooth to a base 42 of the tooth, ordinarily where the tooth intersects with a top part 44 of a main body 43 of the insert. By selecting an appropriate longitudinal distance LDCE, a tool and insert according to an aspect of the invention can be used in a manner that facilitates formation of a variety of thread forms that can be different from the shape of the teeth 39.

[0024] As seen in FIGS. 3C and 3D, each tooth 39 can be provided with first and second cutting edges 27 on opposite first and second sides 45 and 47 of the insert 37. The insert 37 can be rotationally symmetric about a rotational centerline CL of the insert seen in FIG. 3B so that when one side of the insert gets worn, it can be turned around and the second side can be used.

[0025] Where the insert 37 is provided with, on each tooth 39, first and second cutting edges 27 on first and second sides 45 and 47 of the insert, the tooth has first and second rake surfaces 49 extending from the first and second cutting edges 27, respectively, away from the tip 35 of the tooth. The first and second rake surfaces 49 define an acute angle ANG with each other such that a narrowest portion N of the tooth 39 is remote from the tip 35 of the tooth.

[0026] First and second chip forming surfaces 51 are disposed proximate ends 53 of the first and second rake surfaces 49, respectively. The first and second chip forming surfaces 51 extend from the location proximate ends 53 of the first and second rake

surfaces 49 in a direction away from a longitudinal centerline or central plane CP (FIG. 3C) of the insert 37. The first and second chip forming surfaces 51 can be curved to facilitate chip formation. In the insert 37 shown in FIGS. 3A-3D, the plurality of teeth 39 extend from an elongated insert body 43, and the first and second chip forming surfaces 51 are at least partially formed in the body.

[0027] As seen in FIGS. 4B-4C, a thread milling tool 23 according to an aspect of the present invention comprises at least one and ordinarily a plurality of thread milling inserts 37 (FIGS. 4B-4C) and a toolholder 25 comprising one or more insert receiving recesses 57 for receiving the elongated body of the insert(s) such that the plurality of teeth 39 extend radially relative to the longitudinal axis AT of the tool. The toolholder 25 typically comprises a plurality of insert receiving recesses 57 disposed at different longitudinal positions along the tool. The recesses 57 can be longitudinally spaced such that a longitudinal distance LDCE' between a first cutting edge 27 on a first insert 37 in a first insert receiving recess 57 at a first longitudinal position along the tool and a second cutting edge 127 on a second insert 137 in a second insert receiving recess 157 at a second longitudinal position along the tool is equal to a distance LDCE between the first cutting edge on the first insert and another cutting edge 27 on the first insert.

[0028] The toolholder 25 typically comprises a plurality of insert receiving recesses 57 disposed at different positions around a circumference of the tool 23.

[0029] The inserts 37 can be secured in the insert receiving recesses 57 in any suitable fashion. Typically, the toolholder 25 is provided with a plurality of internally threaded openings 59 extending from a surface of the toolholder to the insert receiving recesses 57, and set screws (not shown) are provided in the openings to secure the inserts relative to the insert receiving recesses. The inserts 37 can be provided with recesses 61 for receiving ends of the set screws to facilitate securing the inserts relative to the insert receiving recesses via the set screws.

[0030] In the present application, the use of terms such as "including" is open-ended and is intended to have the same meaning as terms such as "comprising" and not preclude the presence of other structure, material, or acts. Similarly, though the use of terms such as "can" or "may" is intended to be open-ended and to reflect that structure, material, or acts are not necessary, the failure to use such terms is not intended to

reflect that structure, material, or acts are essential. To the extent that structure, material, or acts are presently considered to be essential, they are identified as such.

[0031] While this invention has been illustrated and described in accordance with a preferred embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

[0031] The disclosures in Swedish patent application No. 0950111-5, from which this application claims priority, are incorporated herein by reference.

WHAT IS CLAIMED IS:

1. A method of forming a threaded workpiece (21), comprising:
 - providing a tool (23) with a thread milling insert (37) according to claim 9,
 - rotating the tool (23) about an axis (AT) of the tool (23), the tool (23) having a toolholder (25) and at least one cutting edge (27) arranged radially relative to the axis (AT) of the tool (23);
 - at a plurality of circumferential positions about an axis of the workpiece (21), moving at least one of the tool (23) and the workpiece (21) relative to each other in a direction substantially perpendicular to a direction of the axis (AW) of the workpiece (21) while simultaneously moving at least one of the tool (23) and the workpiece (21) relative to each other in substantially an axial direction of the workpiece (21) so that the at least one cutting edge (27) forms a plurality of recesses in the workpiece (21), the plurality of recesses defining a helical thread (31).
2. The method of forming a threaded workpiece (21) as set forth in claim 1, wherein the tool (23) has a plurality of cutting edges (27) arranged radially relative to the axis of the tool (23), and wherein movement of the tool (23) and the workpiece (21) relative to each other in the direction substantially perpendicular to the direction of the axis (AW) of the workpiece (21) causes at least two of the plurality of cutting edges (27) to simultaneously form at least two recesses in the workpiece (21).
3. The method of forming a threaded workpiece (21) as set forth in claim 2, comprising forming the threaded workpiece (21) with N starts, where $N > 1$.
4. The method of forming a threaded workpiece (21) as set forth in claim 3, wherein each thread (31a, 31b) of the threaded workpiece (21) having N starts has a pitch P, and tips of the plurality of cutting edges (27) of the tool (23) are spaced according to the equation P/N .

5. The method of forming a threaded workpiece (21) as set forth in claim 2, wherein the thread (31) has a pitch P , and tips of the plurality of cutting edges (27) are spaced according to the equation NP , where N is a whole number not equal to zero.
6. The method of forming a threaded workpiece (21) as set forth in any of claims 1-5, wherein the helical thread (31, 31a, 31b) has a basic shape different than a profile of the at least one cutting edge.
7. The method of forming a threaded workpiece (21) as set forth in any of claims 1-6, wherein the at least one of the tool (23) and the workpiece (21) are moved relative to each other in substantially an axial direction of the workpiece (21) including a circumferential movement component so that the workpiece traces an S-shaped recess (29).
8. A computer readable medium storing a computer program implementing the method of any of claims 1-7.
9. A thread milling insert (37), comprising:
 - a plurality of teeth (39) longitudinally spaced along an edge of the insert (37), each tooth (39) having a cutting edge (27) at a tip (35) of the tooth (39), **characterized in** that a longitudinal distance (LDCE) between any two cutting edges (27) is at least two times greater than a height (H) of any tooth (39).
10. The thread milling insert (37) as set forth in claim 9, wherein each tooth (39) has first and second cutting edges (27) on opposite first and second sides of the tooth (39).
11. The thread milling insert (37) as set forth in claim 10, wherein each tooth (39) has first and second rake surfaces (49) extending from the first and second cutting edges (27), respectively, away from the tip (35) of the tooth (39), the first and second rake surfaces (49) defining an acute angle (ANG) with each other such that a narrowest portion (N) of the tooth (39) is remote from the tip (35) of the tooth (39).

12. The thread milling insert (37) as set forth in claim 11, wherein, for each tooth (39), first and second chip forming surfaces (51) are disposed proximate ends (53) of the first and second rake surfaces (49), respectively, the first and second chip forming surfaces (51) extending from proximate ends (53) of the first and second rake surfaces (49) in a direction away from a longitudinal central plane (CP) of the insert (37).

13. The thread milling insert (37) as set forth in claim 12, wherein the first and second chip forming surfaces (51) are curved.

14. The thread milling insert (37) as set forth in claim 13, wherein the plurality of teeth (39) extend from an elongated insert body (43), and the first and second chip forming surfaces (51) are at least partially formed in the body (43).

15. The thread milling insert (37) as set forth in any of claims 9-14, wherein the insert (37) is rotationally symmetric about a rotational centerline (CL) of the insert (37).

16. A thread milling tool (23), comprising:

a thread milling insert (37, 137) comprising a plurality of teeth (39) longitudinally spaced along an edge of an elongated body (43) of the insert (37, 137), each tooth (39) having a cutting edge (27) at a tip of the tooth (39); and

a tool holder (55) comprising an insert receiving recess (57, 157) for receiving the elongated body of the insert (37, 137) such that the plurality of teeth (39) extend radially relative to a longitudinal axis of the tool (23),

characterized in that a longitudinal distance between any two cutting edges (27, 127) is at least two times greater than a height (H) of any tooth.

17. A threaded article (21), comprising at least one start (33) and a helical thread (31) comprising at least one turn, the thread comprising a plurality of regularly spaced recesses (29) extending substantially perpendicular to a length of the thread.

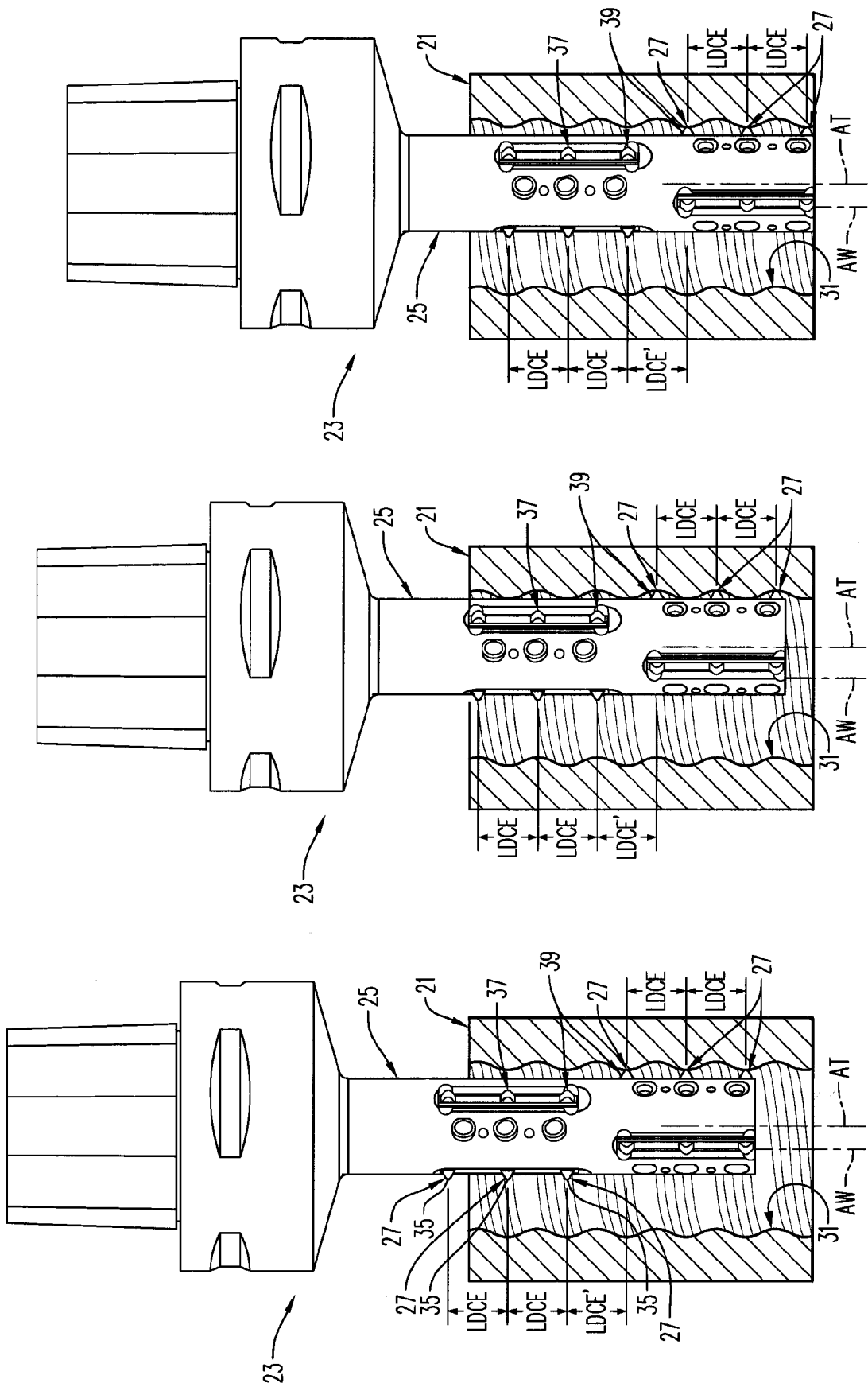


FIG. 1C

FIG. 1B

FIG. 1A

2/5

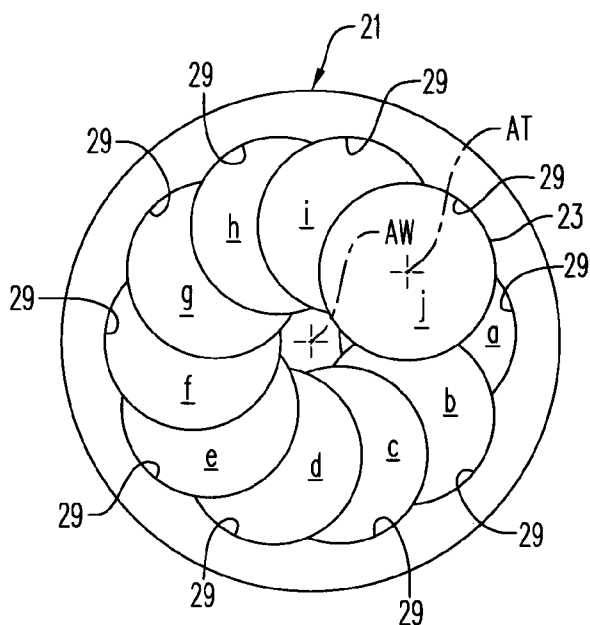


FIG. 1D

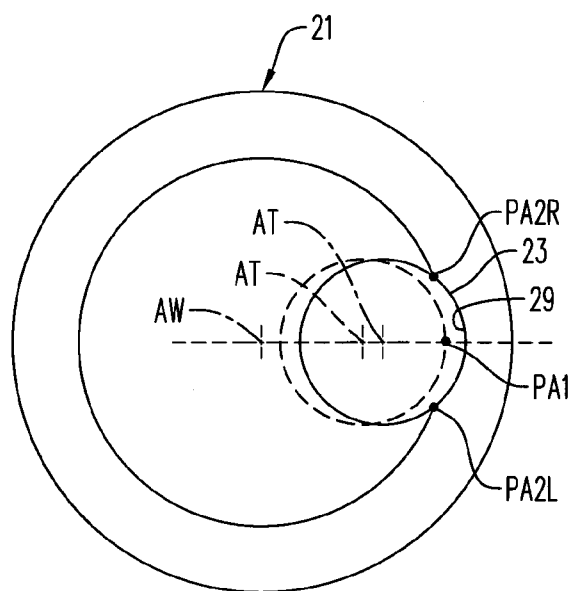


FIG. 1E

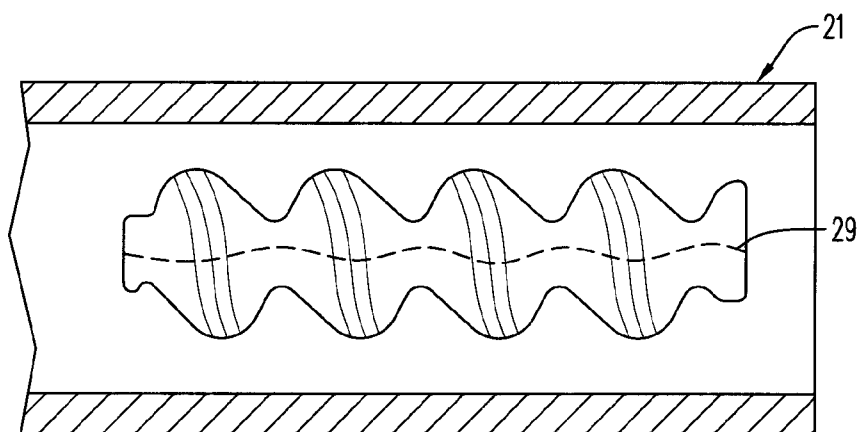


FIG. 1F

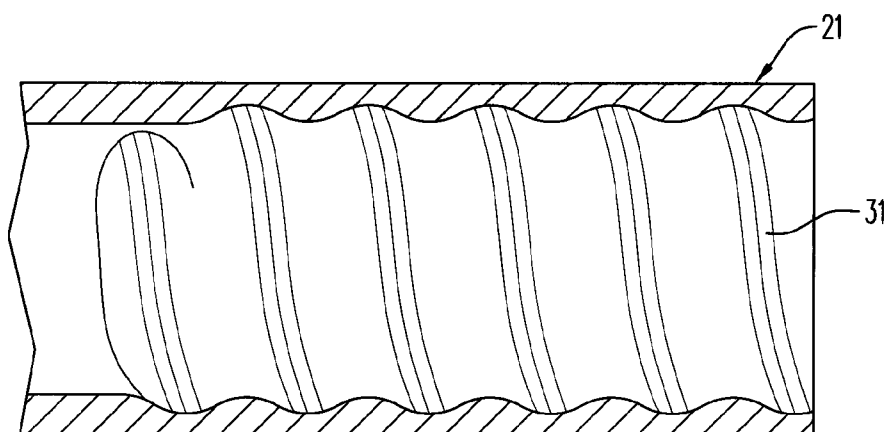


FIG. 1G

3/5

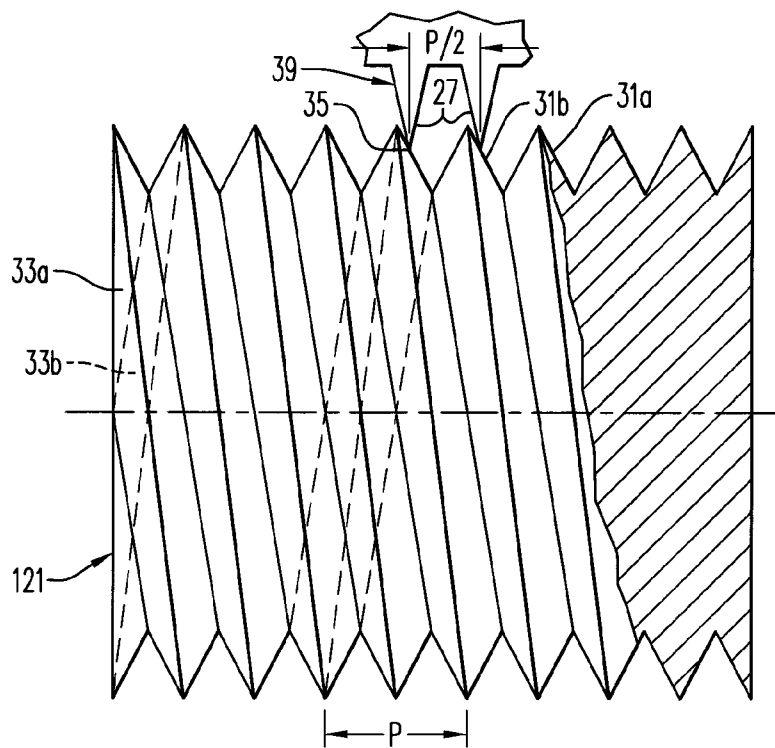


FIG. 2A

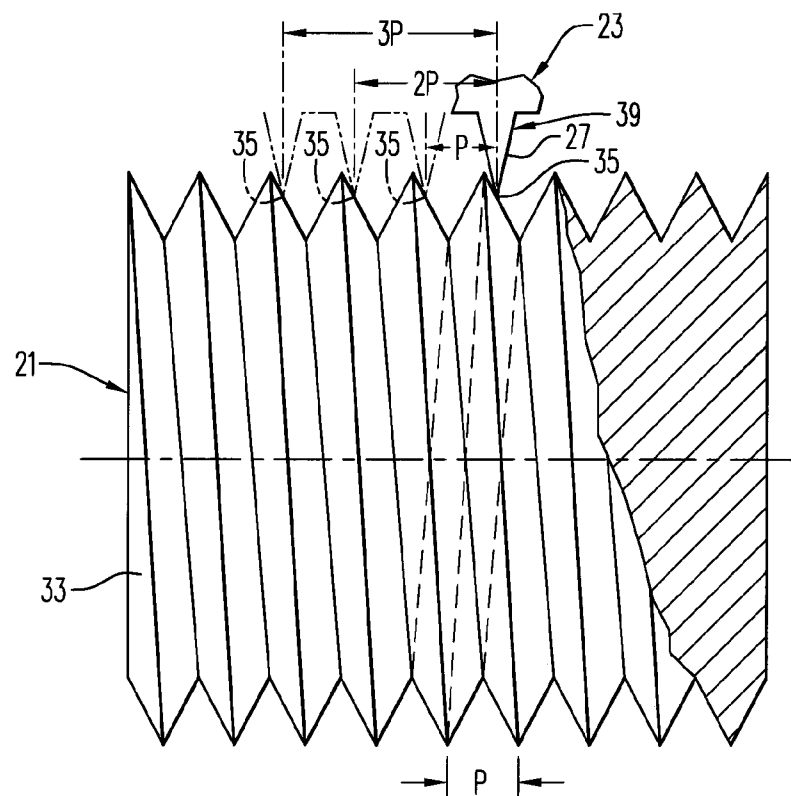


FIG. 2B

4/5

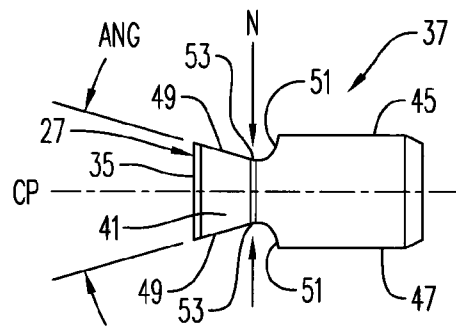


FIG. 3C

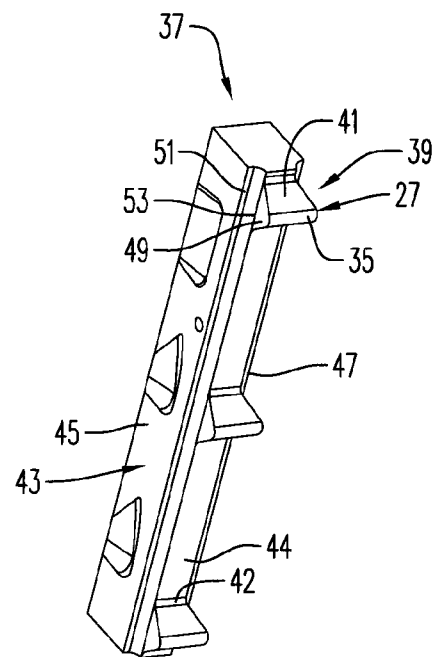


FIG. 3A

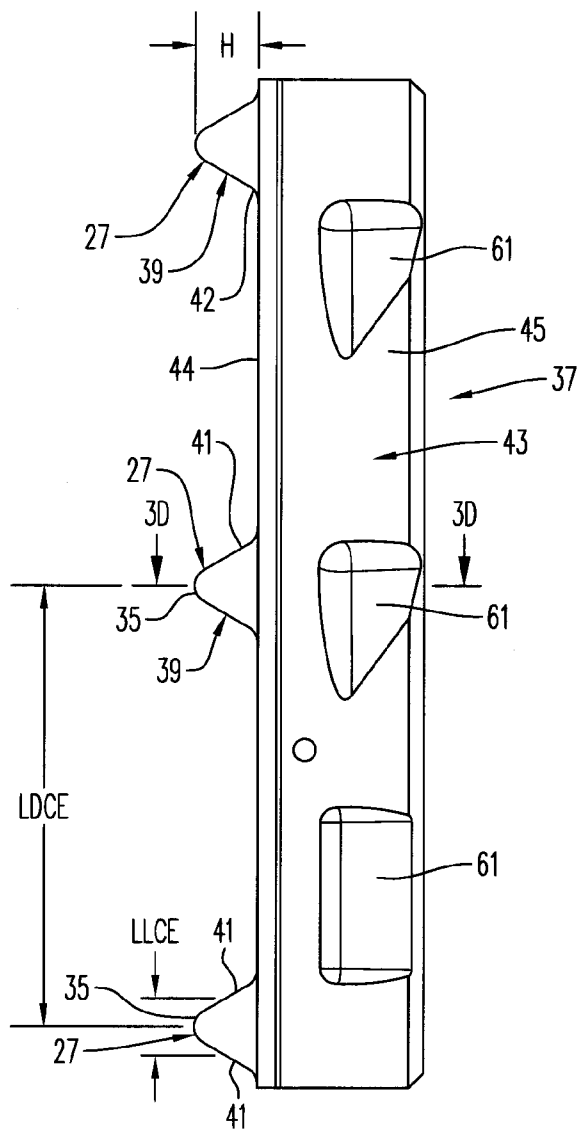


FIG. 3B

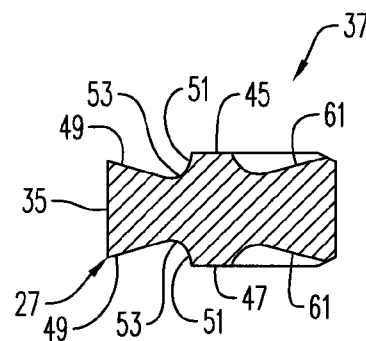


FIG. 3D

5/5

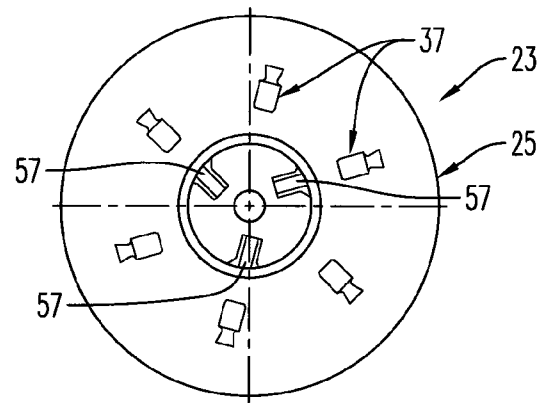


FIG. 4C

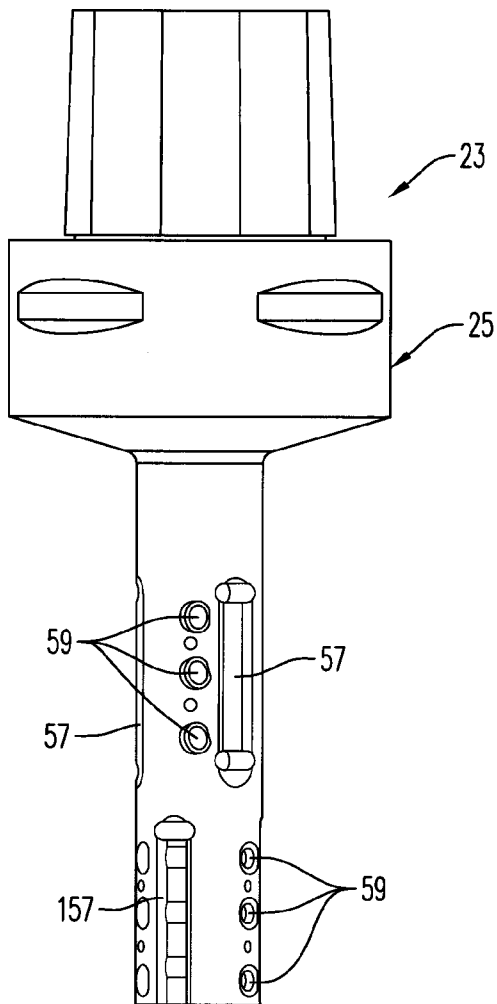


FIG. 4A

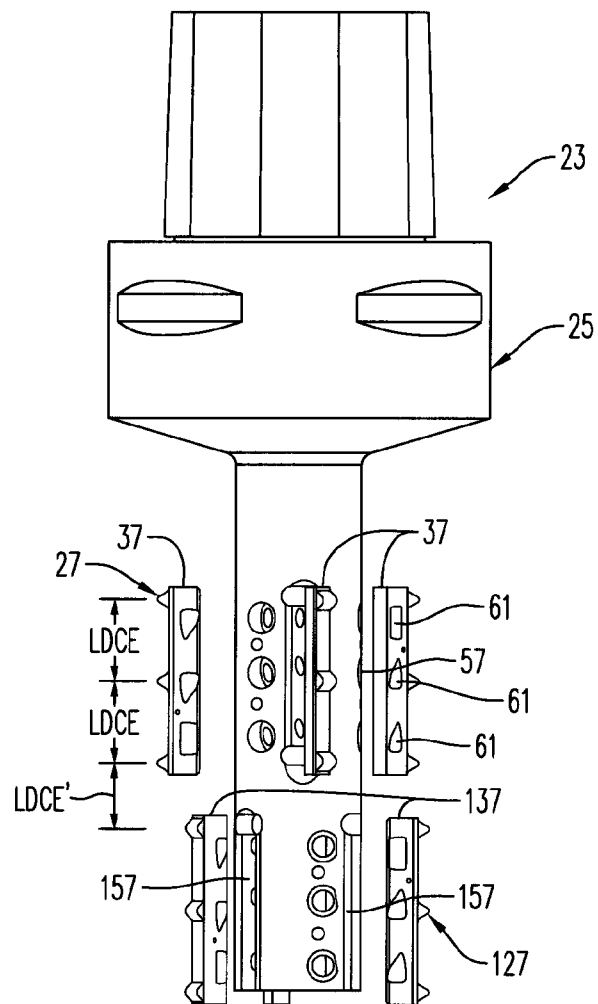


FIG. 4B